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## **Spatio-temporal analysis of air quality index: A case study in Delhi and Chennai city from 2013 to 2020**

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**Abstract**---The Air Quality Index (AQI) is a significant tool of risk communication and reporting system. The main aim of the paper is to comparatively analysis the air quality index of both the Delhi and Chennai. The objective of the study is to compute the AQI of both the cities and to compare it. For both the cities data for the computation of the AQI are taken from the secondary source from Central Pollution Control Board (CPCB) and Tamil Nadu Control Pollution Board (TNP). It is found that in both the city main source of pollution are from both anthropogenic and natural genesis. The pollutants which make the reading of AQI severe is emitted from the transportation sector such as emission from the vehicles, road side dust particles followed by the pollutants from the industries and construction site. In Delhi sandstorms from the desert regions during the summer season and bursting of firecrackers in diwali are responsible for shooting the AQI during March and November month respectively. During monsoon season the AQI value become less in Delhi. In Chennai the AQI value does not very much, throughout the year it remains constant with slight degradation during Diwali and Pongal celebration. The

metrological and geographical factors does not much play important role in reading of AQI. The only way to control air pollution is through framing the reasonable policies and strategies and applying it practically in the field and planting lots of trees.

**Keywords**--air quality index, pollution control board, meteorology and geographical location, policies.

## Introduction

In world out of thirty worst polluted cities, twenty one are from India. Six cities from india are in top ten and Delhi city is in the No.1 rank (Chatterji, 2020). Megacities of India are among the most polluted cities in the World (Kandlikar and Ramachandran, 2020). It has been estimated by the UNEP that globally unhealthy air are breathed by 1.1 billion. Unhealthy air is associated with many health related issues such as asthma, respiratory diseases, lung infections, and COPD. It has been estimated by the WHO that each year around the globe around 4.6 million lost life. It requires the proper analysis of data and interpretation for the understanding of quality of air. The important tool for representing status of air quality uniformly is Air Quality Index. For measuring and assessing the relative change is ambient air quality AQI is used.

The significant prominent sources of air pollution in Delhi and Chennai city are dust from the road and construction site, emissions from the vehicles and industries. For the management and control of quality of air, meteorology has an practical and important application. Its impact was first felt in the London air pollution disaster incident in foggy December of 1952, where 4000 people died due to tragic incident (Sorbján, 2003). The tragic accident was the result of heavy consumption of coal for industrial power and home heating which led to release of enormous sulfur pollution in the atmosphere. The pollutants from fossil fuels and automobiles causes many disease and affect human health (Thiyagarajan, A..2003). The chemical smoke from the firecrackers during diwali festivals increase the pollutants level in the city two to ten times (Krishnan, M.A.,2019)

## Study Areas

For the purpose of the comparative AQI study, the two study areas taken are Delhi and Chennai. The Delhi have an area of 1483 sq.km (CPCB, 2012). The Delhi is a landlocked city situated in between the Aravali range and the Himalayan Mountains and surrounded by Haryana and Uttar Pradesh. The coordinates of the Delhi city are 76°50'24" to 77°20'37" E longitude and 28°24'17" to 28°53'00". On the western side of the Yamuna river major parts of the city lies. The altitude of the city from the mean sea level is 213 to 305 meter. The city has extremist type of Climate. The maximum temperature in the city is during summer month (March to August) where maximum temperature reaches upto 36 to 47°C. In the city winter month starts from November month and temperature falls to 7 °C or even lower during December and January. The average annual rainfall is 670 mm, with most of the rainfall occurring during monsoon season

from July to August. (National Environment Engineering Research Institute, 2003).

Located in the Coast of Coromandel the Chennai city is the gateway and Capital city of Tamil Nadu. The city is also known as the automobile capital, software hub and technological city. The latitudinal extent of the city is 12°50'49" to 13°17'24" N and longitudinal extent of the city is from 79°59'53" to 80°20'12" E. The three major river passings across the city are Kosasthalaiyar, Cooum and Adyar. The Buckingham Canal is man-made which runs from North to South through the Metropolis. The three large lake in the city are Sholavram, Red Hills and Chembarambakkam (Tamil Nadu Pollution Control Board, 2021). The Chennai Metropolitan Area covers an area of 1189 sq km. According to 2011 census the most densely populated city in state of Tamil Nadu is Chennai. The city experience the tropical hot and wet climate and it remains hot and humid almost throughout the year. As the city is located in the tropic region Extreme variation in the climate is not seen. January month experience the minimum temperature of 18-20°C and maximum temperature is experienced in the months of May to June with around 38-42°C. The city receive rainfall twice in the year, during July and December.

### Database and Methodology

The secondary data of the air pollutants are mined from the Central Pollution Control Board (CPCB) and Tamil Nadu Pollution Control Board (TNPCB). To calculate the Air Quality Index (AQI) of the Delhi and Chennai, below given formula from the table is referred. The minimum three pollutants are required. Out of the concentrations of three pollutants, concentration of either PM<sub>10</sub> or PM<sub>2.5</sub> is mandatory (Figure 1.1). With the AQI value public can know about the air pollution level and its potential risk to health. (Rajamanickam and Nagan, 2018).

Calculation of AQI					
Date DD-MM-YYYY	Station City State				
Pollutants	concentration in µg/m <sup>3</sup> (except for CO)	Sub-Index	check	Air Quality Index	
PM10	24-hr avg	<input type="text"/>	0	0	<b>AQI =</b> <div style="border: 1px solid black; padding: 5px; display: inline-block;">Atleast 3 inputs*</div>
PM2.5	24-hr avg	<input type="text"/>	0	0	
SO2	24-hr avg	<input type="text"/>	0	0	
NOx	24-hr avg	<input type="text"/>	0	0	
*CO (mg/m <sup>3</sup> )	max 8-hr	<input type="text"/>	0	0	
O3	max 8-hr	<input type="text"/>	0	0	
NH3	24-hr avg	<input type="text"/>	0	0	
<small>* Concentrations of minimum three pollutants are required; one of them should be PM10 or PM2.5          * The check displays "1" when a non-zero value is entered</small>					
<b>Good (0-50)</b>	Minimal Impact		<b>Poor (201-300)</b>	Breathing discomfort to people on prolonged exposure	
<b>Satisfactory (51-100)</b>	Minor breathing discomfort to sensitive people		<b>Very Poor (301-400)</b>	Respiratory illness to the people on prolonged exposure	
<b>Moderate (101-200)</b>	Breathing discomfort to the people with lung, heart disease, children and older adults		<b>Severe (401-500)</b>	Respiratory effects even on healthy people	

Figure 1.1. Formula to Calculate the AQI  
Source: Central Pollution Control Board, 2021

To calculate the Air Quality Index (AQI) of the Delhi and Chennai, the above given formula from the figure is referred. Range of AQI value and its associated colour band are used to determine the effects of air pollution on the human health. If the

AQI value of air pollution ranges from 0-50, it is good and is indicated by the dark green colour and air pollution has minimal impact on the health. If its range is from 51 to 100, air pollution is satisfactory and it is indicated by the light green colour and it cause a minor breathing discomfort to sensitive people. If its range is from 101 to 200, it is moderate in nature, it is indicated by the light yellow colour and it cause a breathing discomfort to the people with lung, heart disease, children and older adults. If the colour is dark yellow, it ranges from 201 to 300, the air pollution is poor and it causes breathing discomfort to people on prolonged exposure. If the AQI ranges from 301 to 400 it is indicated by the light red colour and it is very poor because on prolonged exposure it causes respiratory illness to the people. The severe air pollution is represented by the red colour, its value is above 401 and even on healthy people it can cause respiratory effects.

## Result and Discussion

The results of the study for the delhi and Chennai are discussed separately and at last comparison is done. The increase in the AQI level increase the mortality of both the children and adult with posing higher risk to pregnancy (Buka, et.al, 2006).

### Air Quality in Delhi in 2013 to 2020

For the calculation of AQI in different location in Delhi in 2013, reading of four annual air pollutants concentration i.e.  $\text{NO}_2$ ,  $\text{SO}_2$ ,  $\text{PM}_{10}$  and  $\text{PM}_{2.5}$  were analyzed. It is observed that in the city  $\text{PM}_{2.5}$  and  $\text{PM}_{10}$  concentration are the main determinant factor of air pollution (Figure 1.2).

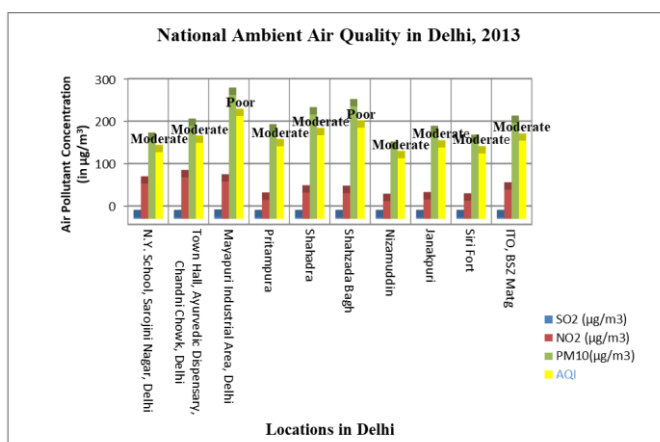


Figure 1.2. Graph Representing Air Quality Index of Different Locations in Delhi, 2013

Source: Prepared by Author based on CPCB, 2021

From the above figure 1.2, it has been observed that out of 10 stations surveyed in Delhi in 2013, eight stations shows moderate air pollution and two stations are poor in air quality. The stations that show moderate air quality are Sarojini Nagar, Chandni Chowk, Pritampura, Shahzada Bagh, Nizamuddin, Janakpuri, Siri Fort and ITO. The Mayapuri Industrial Area and Shahadra are showing poor

air quality. In 2013 in Delhi it is ascertained that the main pollutants, influencing the air pollution in the city is  $PM_{10}$ . The administration in Delhi identified the firm in delhi that causing the air pollution and promised to relocate them to new region (Narain and Bell, 2006). In 2014 the four concentration of air pollution in city was collected from the ten different locations of city and those locations are from Sarojini Nagar, Chandni Chowk, Mayapuri Industrial Area, Pritampura, Shahadra, Shahzada Bagh, Nizamuddin, Janakpuri, Siri Fort and ITO (Figure 1.3)

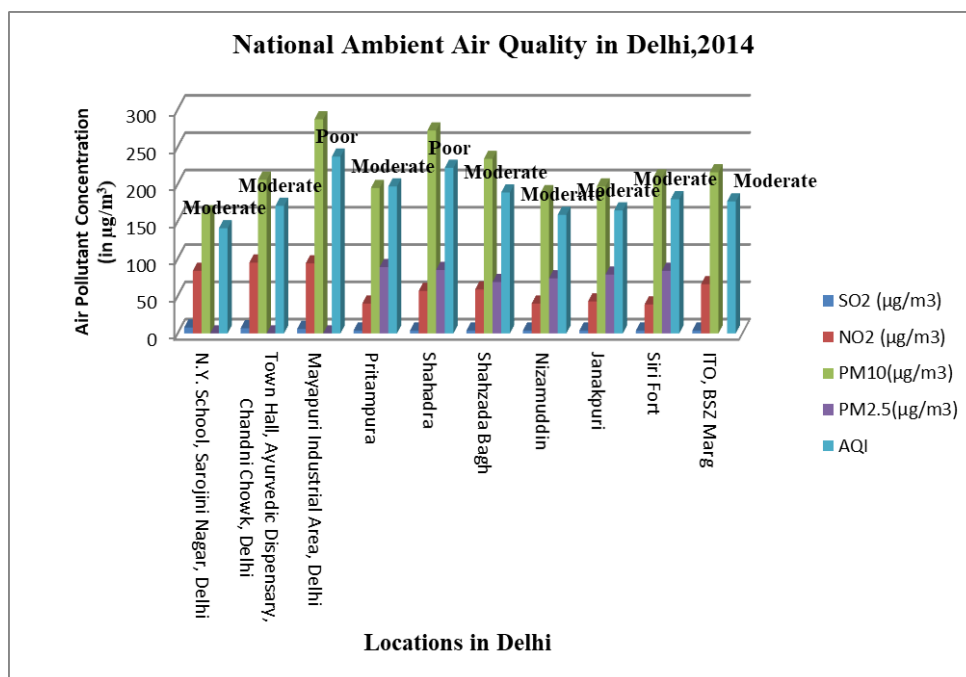


Figure 1.3. Graph Representing Air Quality Index of Different Locations in Delhi, 2014

Source: Prepared by Author based on CPCB, 2021

From the figure 1.2 it has been analyzed that the main pollutants affecting the air pollution in different location of Delhi are  $PM_{2.5}$  and  $PM_{10}$ . Overall average air pollution in the city was moderate in 2014. Out of ten stations eight showed moderate and two were poor in reading. The locations having the moderate air pollution are Sarojini Nagar, Chandni Chowk, Pritampura, Shahzada Bagh, Nizamuddin, Janakpuri, Siri Fort and ITO. Mayapuri Industrial Area and Shahadra showed the poor air pollution. The peoples residing in those two locations showing poor air quality had breathing discomfort on prolonged exposure to poor air pollution. In 2014 concentration of  $SO_2$  is good and it had minimal impact on human health, the concentration of  $SO_2$  is good to satisfactory except in the Chandni Chowk and Mayapuri Industrial region where it is showing moderate which reading value is more than 80. In 2015, samples of air pollutants have been collected from 9 different locations of the city. The stations from which the concentrations of pollutants are collected are Sarojini Nagar, Chandni Chowk, Mayapuri Industrial Area, Pritampura, Shahadra, Shahzada Bagh, Niazamuddin,

Janakpuri and Siri Fort. The four data collected for the calculation of AQI are  $\text{SO}_2$ ,  $\text{NO}_2$ ,  $\text{PM}_{10}$  and  $\text{PM}_{2.5}$  (Figure 1.4).

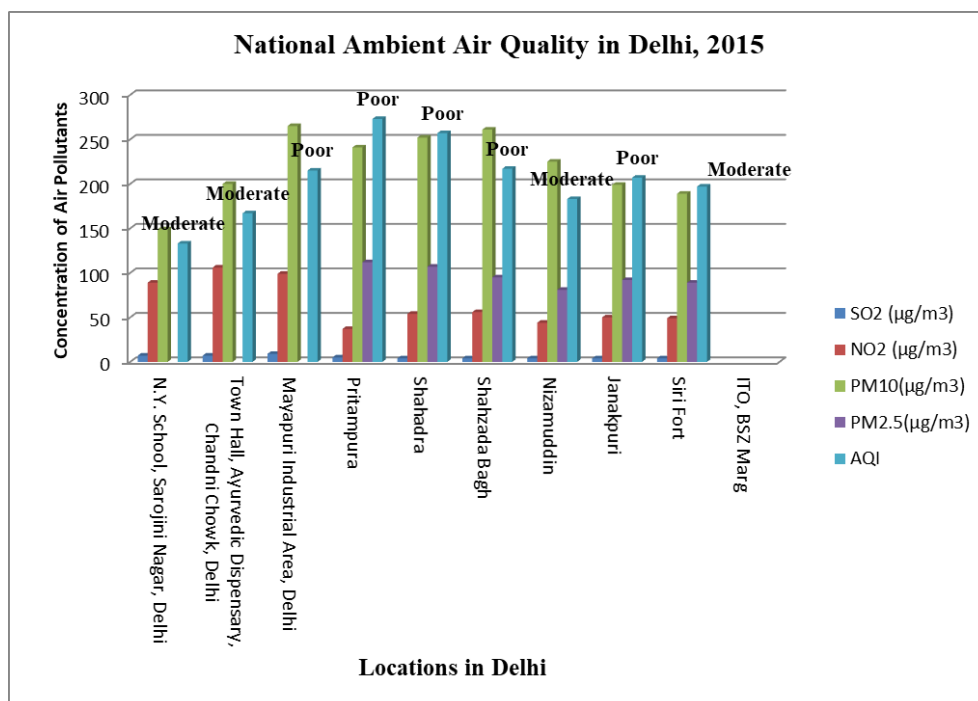


Figure 1.4. Graph Representing Air Quality Index of Different Locations in Delhi, 2015

Source: Prepared by Author based on CPCB, 2021

From the above AQI reading it's clear that in 2015 the quality of air in the Delhi begins to deteriorate. Emissions from vehicles and industries are the major sources of pollutants. More than 50 percent of the stations surveyed showed the poor AQI. The stations showing the poor air quality are Mayapuri Industrial Area, Pritampura, Shahadra, Shahzada Bagh and Janakpuri. Out of nine stations surveyed, five stations shows poor air quality and four shows moderate. The stations showing the moderate air quality are Sarojini Nagar, Chandni Chowk, Nizamuddin and Siri Fort. The data from stations ITO was not available in 2015. The impacts concentration of  $\text{SO}_2$  is negligible as in all stations its amount is good and less than 10. The concentration of  $\text{NO}_2$  is poor in Chandni Chowk and in rest of the stations it is below moderate. The main culprits of poor air pollution are due to presence of  $\text{PM}_{2.5}$  and  $\text{PM}_{10}$ . The range of concentration of  $\text{PM}_{10}$  in 2015 is in between moderate to poor with the Industrial region of Mayapuri showing the worst record. In 2016, concentration of air pollutants has been taken from nine different locations of Delhi. The stations from where the reading for four pollutants  $\text{SO}_2$ ,  $\text{NO}_2$ ,  $\text{PM}_{10}$  and  $\text{PM}_{2.5}$  are taken are Sarojini Nagar, Chandni Chowk, Industrial region of Mayapuri, Pritampura, Shahadra, Shahzada Bagh, Nizamuddin, Jankpuri and Siri Fort. The data from ITO were not available in 2016 (Figure 1.5)

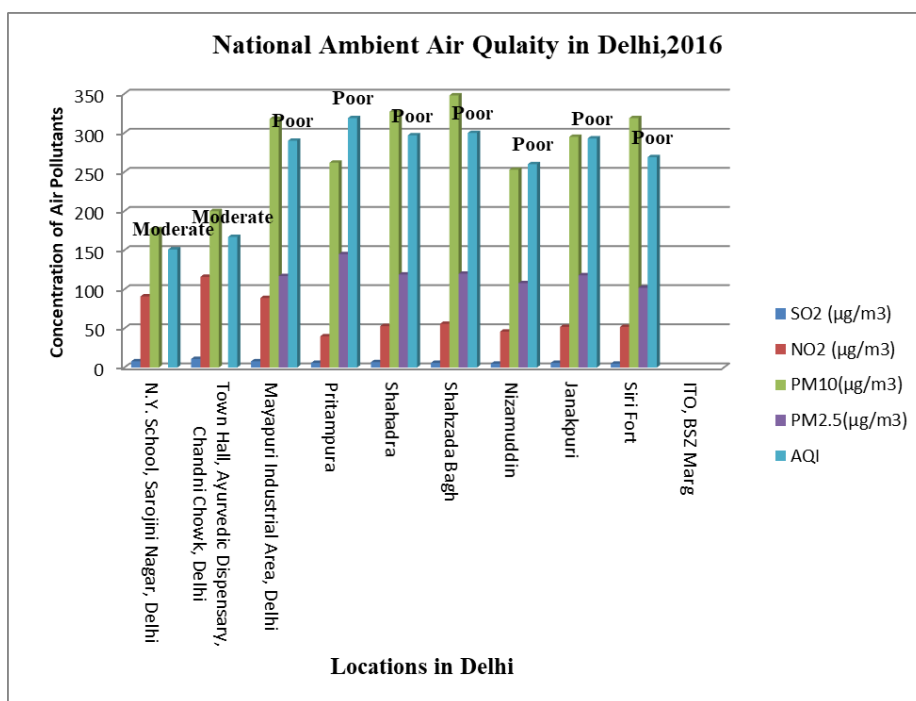


Figure 1.5. Graph Representing Air Quality Index of Different Locations in Delhi, 2016

Source: Prepared by Author based on CPCB, 2021

The quality of air is worsening in 2016 in comparison to other years since 2013. The air quality becomes bad to worst from 2015 to 2016. Out of the nine stations surveyed it is found that seven are showing poor air quality index and two showing moderate AQI. It is to be mentioned that if the AQI is poor, people tends to feel discomfort in breathing on prolonged exposure to it. In case of moderate AQI there will be the breathing discomfort to people with lung and heart disease. Children and older adults also tend to infected if the AQI range from 101 to 200. The stations showing the poor air quality are Industrial regions of Mayapuri, Pritampura, Shahadra, Shahzada Bagh, Nizamuddin, Janakpuri and Siri Fort. Out of all the stations Pritampura is the worst hit region. Only Sarojini Nagar and Chandni Chowk are the moderately affected by the air pollution in 2016. Concentration of PM<sub>10</sub> and PM<sub>2.5</sub> are the determination factor of AQI in city. Concentration of SO<sub>2</sub> is good and NO<sub>2</sub> is under limit and ranges from good to moderate with the value hovering from 40 to 116. In 2017 data have collected from the nine different locations throughout the Union Territory. The different locations from where the data on air pollutants are collected are Sarojini Nagar, Chandni Chowk, Mayapuri Industrial Area, Pritampura, Shahadra, Shahzada Bagh, Nizamuddin, Janakpuri, Siri Fort and ITO (Figure 1.6).

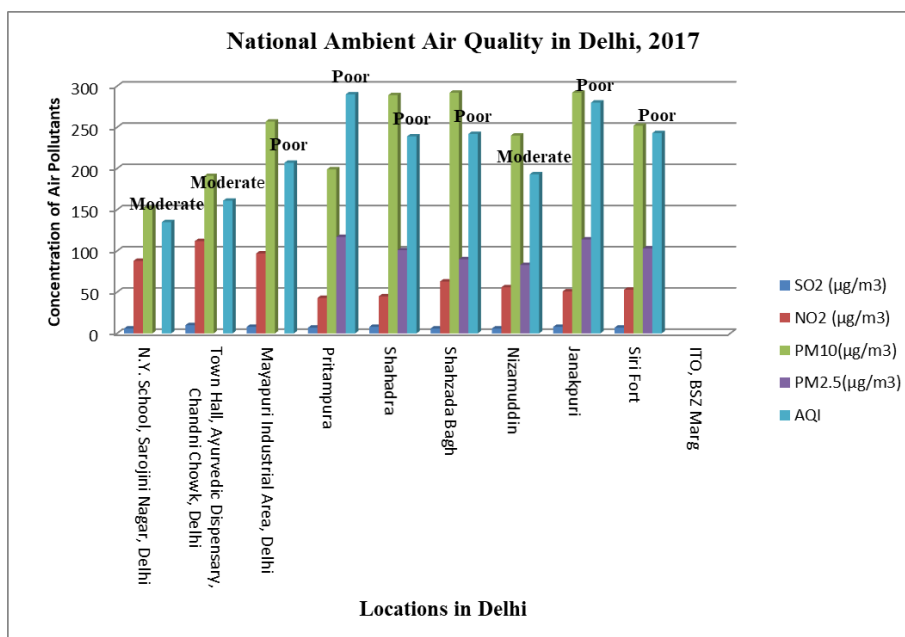


Figure 1.6. Graph Representing Air Quality Index of Different Locations in Delhi, 2017

Source: Prepared by Author based on CPCB, 2021

In 2017 overall air quality in the city is poor. It is observed that six stations are poorly affected and three moderately. The stations which are poorly affected are Industrial regions of Mayapuri, Pritampura, Shahadra, Shahzada Bagh, Janakpuri and Siri Fort. Sarojini Nagar, Chandni Chowk and Nizamuddin regions are moderately affected. As usual the impact of concentration SO<sub>2</sub> in air pollution is minimal with its limit less than 11 in all the stations. The concentration of NO<sub>2</sub> range from 43-112 µg/m<sup>3</sup> and its impact to air pollution is satisfactory to moderate. In 2018 from nine stations four concentration of air pollutants were taken. The locations from where the reading were done are Sarojini Nagar, Chandni Chowk, Pritampura, Shahadra, Shahzada Bagh, Nizamuddin, Janakpuri, Siri Fort, Naraina Industrial Area. The data taken for reading were concentration of SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub>. The data from Mayapuri Industrial area and ITO were not available on that year (Figure 1.7).



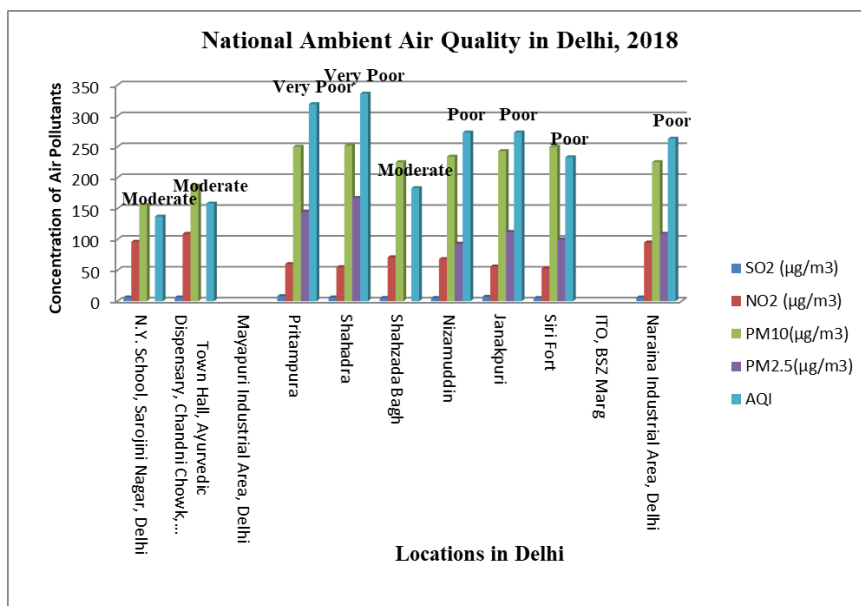


Figure 1.7. Graph Representing Air Quality Index of Different Locations in Delhi, 2018

Source: Prepared by Author based on CPCB, 2021

It is observed from the above figure that in 2018, the air pollution in Delhi was badly hit. Pritampura and Shahadra were poorly affected by the air pollution. The regions of Sarojini Nagar, Chandni Chowk and Shahzada Bagh were moderately affected. Nizamuddin, Janakpuri, Siri Fort and Naraina Industrial area are poorly affected. Due to exposure of air pollution the residents of Pritampura and Shahadra are vulnerable to respiratory illness on prolonged exposure to it. People with lung, heart disease, children and older adults of Residents of Sarojini nagar, Chandni Chowk and Shahzada Bagh may feel breathing discomfort on exposure to surrounding air pollution. On prolonged exposure to air pollution the people of Nizamuddin, Janakpuri, Siri Fort and Naraina Industrial Area suffer discomfort in breathing. In 2019, the concentration of 4 air pollutants SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub> were taken from nine different locations of the city. The stations from where the data were taken are Sarojini Nagar, Chandni Chowk, Pritampura, Shahadra, Shahzada Bagh, Nizamuddin, Janakpuri, Siri Fort and Naraina Industrial Area (Figure 1.8).

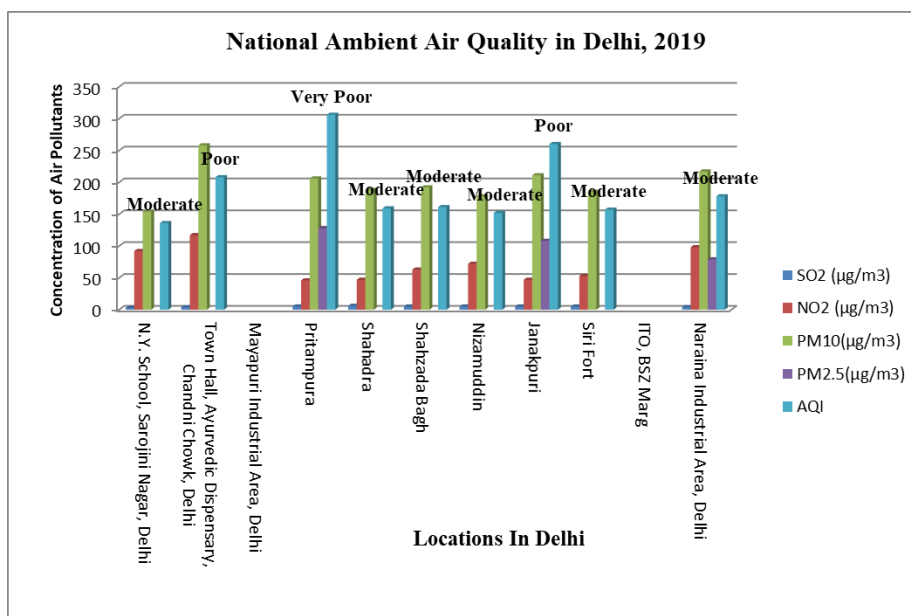


Figure 1.8. Graph Representing Air Quality Index of Different Locations in Delhi, 2019

Source: Prepared by Author based on CPCB, 2021

In 2020, concentration of SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub> were taken only from 7 stations. The stations from where the readings were done are Pritampura, Shahadra, Shahzada Bagh, Nizamuddin, Janakpuri, Siri Fort and ITO. The data from Sarojini Nagar, Chandni Chowk, Mayapuri Industrial Area and Naraina Industrial area were not available in 2020. The data from ITO, BSZ Marg is available for the first time since 2013 (Figure 1.9).

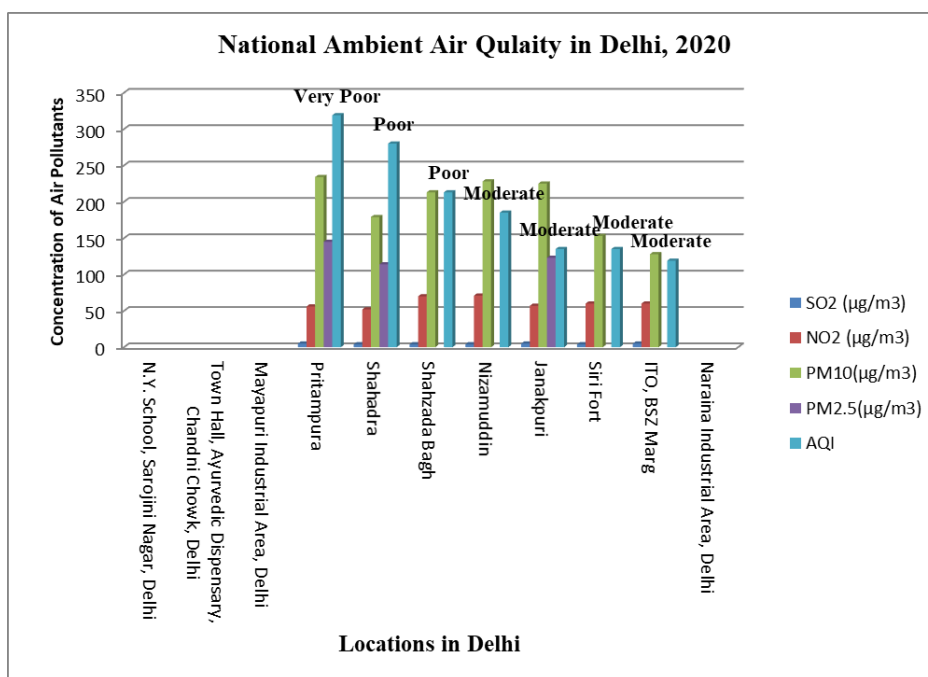


Figure 1.9. Graph Representing Air Quality Index of Different Locations in Delhi, 2020

Source: Prepared by Author based on CPCB, 2021

Comparison to 2019 the air quality in 2020 shows slight improvement. Only one station Pritampura shows very poor air quality, two stations Shahadra and Shahzada Bagh shows poor air quality and rest Nazamuddin, Janakpuri, Siri Fort and ITO are moderately affected by air pollution. On prolonged exposure people residing at Pritampura will suffer from respiratory complexities. On prolonged exposure there will be breathing discomfort to the people residing in Shahadra and Shahzada Bagh. Children, senior citizen and weak lung and heart disease will encounter breathing discomfort in the region of Nizamuddin, Janakpuri, Siri Fort and ITO.

### Air Quality of Chennai City from 2013 to 2020

The air quality guidelines and air quality index aim to protect populations from the adverse effects of air pollution (World Health Organization, 2021). During Diwali festival In Chennai, particulate matter PM<sub>2.5</sub> emissions due to smoke from firecrackers reach about three times higher than prescribed air quality standard, though other reading of other pollutants were within permissible limits (Krishnan et.al. 2020). In Chennai the air pollution parameters were taken from the 12 stations located throughout the city. In Chennai in 2013, the reading of air pollutants has been taken from the total 10 stations. The concentrations of pollutants taken for the calculation of AQI are SO<sub>2</sub>, NO<sub>2</sub> and PM<sub>10</sub>. The stations from which the reading were taken were from Kathivakkam, Manali, Thiruvottiyur, Madras Medical College, Taramani, Thiruvottiyur, Adiyar, Kilpauk, Thiyagaraya Nagar and Anna Nagar (Figure 1.10)

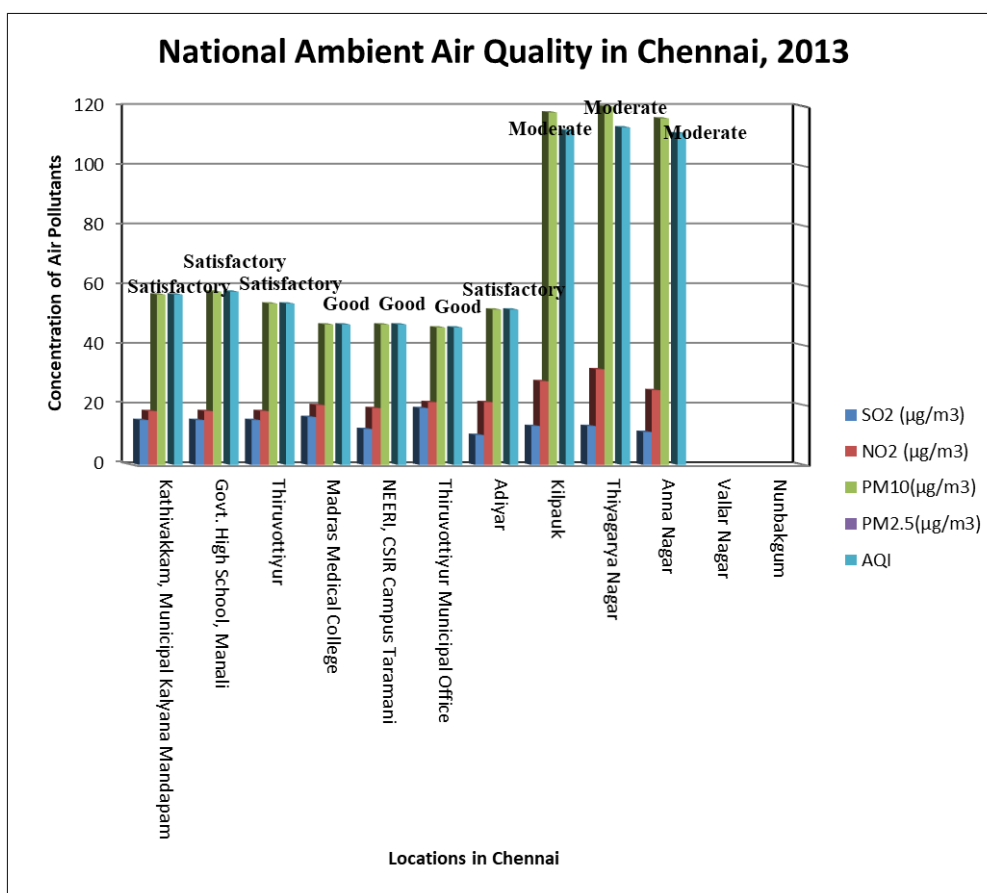


Figure 1.10. Graph Representing Air Quality Index of Different Locations in Chennai, 2013

Source: Prepared by Author based on CPCB, 2021

From the above graph it is ascertained that the air quality in Chennai is much better than the Delhi. Here in 2013 in Chennai AQI ranges from satisfactory to moderate. The worst range of air pollution in Chennai on 2013 was of Moderate category where the reading of AQI range from 101 to 200. The locations of Kathivakkam, Manali, Thiruvottiyur and Adiyar had satisfactory air pollution, Madras Medical College shows good, Kilpauk, Thiyagaraya Nagar and Anna Nagar shows moderate. The location having the good air quality have minimal impact. Sensitive people will face minor discomfort in breathing in the three regions having satisfactory AQI. People with weak lung and heart disease, children and older adults will encounter discomfort in breathing in the three regions showing moderate air pollution. In the city concentration of SO<sub>2</sub> range from 10 µg/m<sup>2</sup> to 16 µg/m<sup>2</sup> which indicate its presence is fall under the category of good. The concentrations of NO<sub>2</sub> also fall under the category of good. The concentration of PM<sub>10</sub> range from good to moderate category and the concentration of PM<sub>2.5</sub> is not available in 2013. In 2014 three concentration of air pollutants SO<sub>2</sub>, NO<sub>2</sub> and PM<sub>10</sub> are taken from the ten stations from all over Chennai city. The ten stations from where the data are taken are Kathivakkam, Manali, Thiruvottiyur, Madras

Medical College, Taramani, Thiruvottiyur, Adiyar, Kilpauk, Thiyagaraya Nagar and Anna Nagar (Figure 1.11)

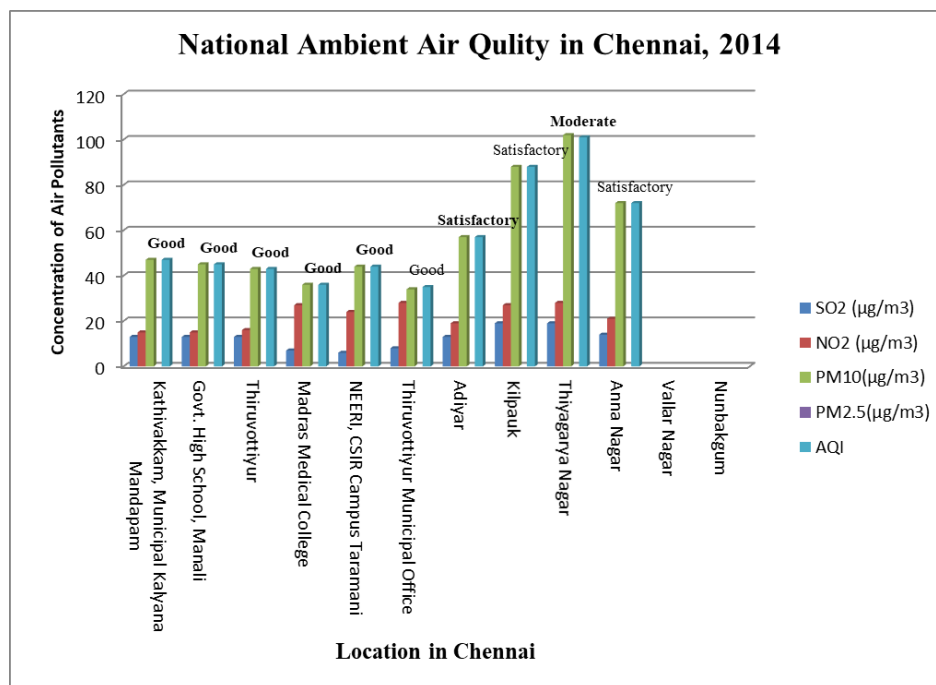


Figure 1.11. Graph Representing Air Quality Index of Different Locations in Chennai, 2014

Source: Prepared by Author based on CPCB, 2021

In the city the quality of air pollution in 2014 is becoming better than 2013 (Figure 3.10). It has been observed that six stations Kathivakkam, Manali, Thiruvottiyur, Madras Medical College, Taramani and Thiruvottiyur Municipal Office indicate good AQI. The people residing in those six localities are least impacted by the grudge of air pollution, its impact is minimum if the AQI ranges from 0-50. Adiyar, Kilpauk and Anna Nagar are the three station which AQI falls under the category of Satisfactory. Here the AQI ranges from 51-100, Healthy Peoples residing in these locations are not impacted by air pollution however the sensitive people may suffer from minor breathing discomfort. The only station having the moderate air pollution is Thiyagaraya Nagar. Healthy adult residing in this regions will not any problem due to air pollution. In 2015 the reading of four concentrations of air pollutants i.e. SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub> are taken from eleven stations. The eleven stations in Chennai from where the concentrations of air pollutants are taken are Kathivakkam, Manali, Thiruvottiyur, Madras Medical College, Taramani, Thiruvottiyur Municipal Office, Adiyar, Kilpauk, Thiyagarya Nagar, Anna Nagar and Vallar Nagar (Figure 1.12).

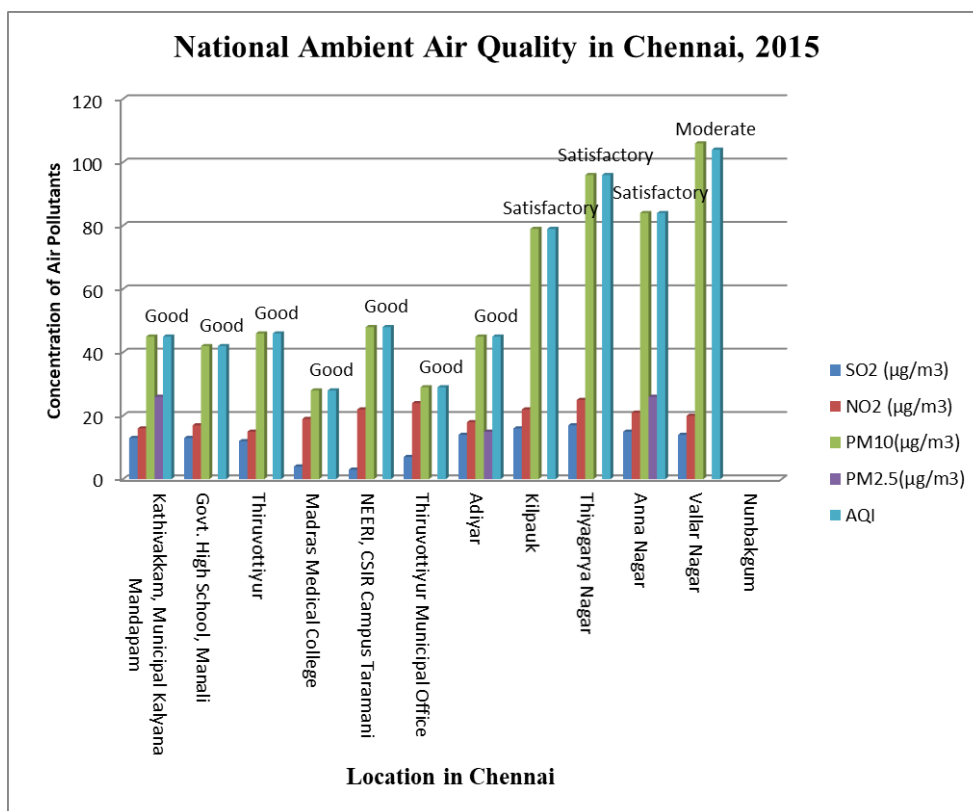


Figure 1.12. Graph Representing Air Quality Index of Different Locations in Chennai, 2015

Source: Prepared by Author based on CPCB, 2021

It has been observed that in 2015 the seven stations are showing good AQI, three stations showing satisfactory and only one showing moderate. The locations having the minimal impact of air pollution are Kathivakkam, Manali, Thiruvottiyur, Madras Medical College, Taramani, Thiruvottiyur Municipal Office and Adiyar. The citizen residing in this locations are least affected due to air pollution. The three stations showing the satisfactory air pollutions are Kilpauk, Thiyagaraya Nagar and Anna Nagar. Healthy people residing in this region will not have comorbidities due to air pollution but sensitive people may encounter discomfort in breathing. The only station showing the moderate air pollution is Vallar Nagar. In this station only people with lung and heart disease, senior citizen and children will at the discomfort in breathing. In 2016 study of ambient air quality has been done from the eleven locations in Chennai. The stations from where the parameters are collected are Kathivakkam, Manali, Thiruvottiyur, Madras Medical College, Taramai, Thiruvottiyur Municipal Office, Adiyar, Kilpauk, Thiyagaraya Nagar, Anna Nagar and Vallar Nagar. The three concentrations of pollutants taken for the study are SO<sub>2</sub>, NO<sub>2</sub> and PM<sub>10</sub>.

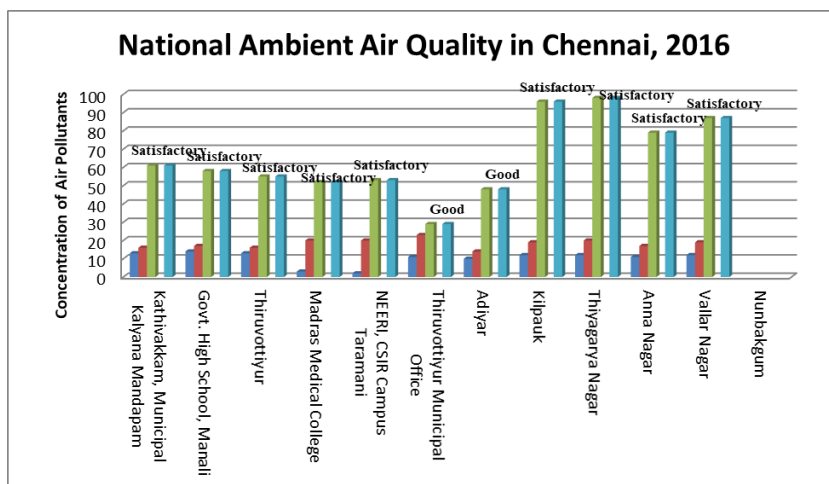


Figure 1.13. Graph Representing Air Quality Index of Different Locations in Chennai, 2016

Source: Prepared by Author based on CPCB, 2021

From the Figure 1.13 it has observed that overall air quality in 2016 is deteriorating than 2015. Except two stations showing good all the locations are showing satisfactory AQI. The two locations showing good AQI are Thiruvottiyur Municipal Office and Adiyar and the nine stations showing satisfactory AQI are Kathivakkam, Manali, Thiruvottiyur, Madras Medical College, Taramani, Kilpauk, Thiyagaraya Nagar, Anna Nagar and Vallar Nagar. In Chennai air pollution related disease to healthy people is negligible in 2016 however sensitive people residing in satisfactory AQI region may encounter minor breathing discomfort. The concentration of SO<sub>2</sub> range from 2 µg/m<sup>3</sup> to 14 µg/m<sup>3</sup> which indicate that it falls under the category of good (0-40). The concentration of NO<sub>2</sub> is also good because it fall within the range of good (0-40). As the range of PM<sub>10</sub> is from 29 µg/m<sup>3</sup> to 98 µg/m<sup>3</sup> its falls under the category range of good to satisfactory. In 2017 four air pollutants concentration namely PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, and NO<sub>2</sub>, are taken from ten locations of the Chennai city. The ten locations from which data on air pollutants are taken are Kathivakkam, Manali, Thiruvottiyur, Madras Medical College, CSIR Campus, Taramani, Thiruvottiyur, Adiyar, Kilpauk, Thiyagaraya Nagar and Anna Nagar. Concentration of PM<sub>2.5</sub> was available only from the taramani locations.

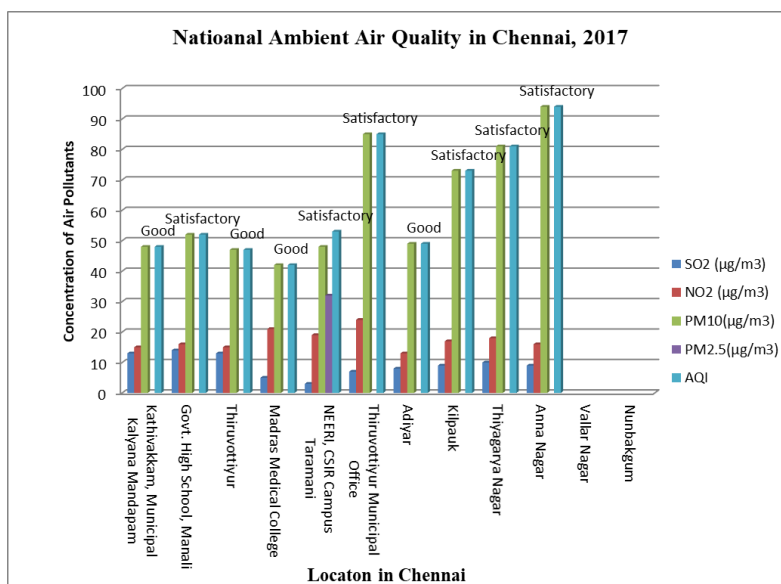


Figure 1.14. Graph Representing Air Quality Index of Different Locations in Chennai, 2017

Source: Prepared by Author based on CPCB, 2021

In 2017 concentration of air pollutants are not available from Vallar Nagar and Nunbakgum. Four locations are showing good AQI and rest are showing satisfactory (Figure 1.14). The stations showing the good air quality are Kathivakkam, Thiruvottiyur, Madras Medical College and Adiyar. The stations showing the satisfactory AQI are Manali, CSIR Campus Taramani, Thiruvottiyur Municipal Office, Kilpauk, Thiyagarya Nagar and Anna Nagar. All the healthy people residing on Chennai in 2017 will not suffer from any air pollution related disease however the sensitive people residing in satisfactory locations may encounter minor breathing discomfort. The concentration of SO<sub>2</sub> and NO<sub>2</sub> falls under the category range of good as its value is less than 40. The concentration of PM<sub>10</sub> range from 48 µg/m<sup>3</sup> to 94 µg/m<sup>3</sup> that is why its range from good to satisfactory. The concentration of PM<sub>2.5</sub> is good. In 2018 concentration of ambient air quality has been taken from twelve locations. The locations from where the data are taken are Kathivakkam, Manali, Thiruvottiyur, Madras Medical College, Taramani, Thiruvottiyur, Adiyar, Kilpauk, Thiyagaraya Nagar, Anna Nagar, Vallar Nagar and Nunbakgum. The four concentrations taken for the study are SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub> (Figure 1.15).



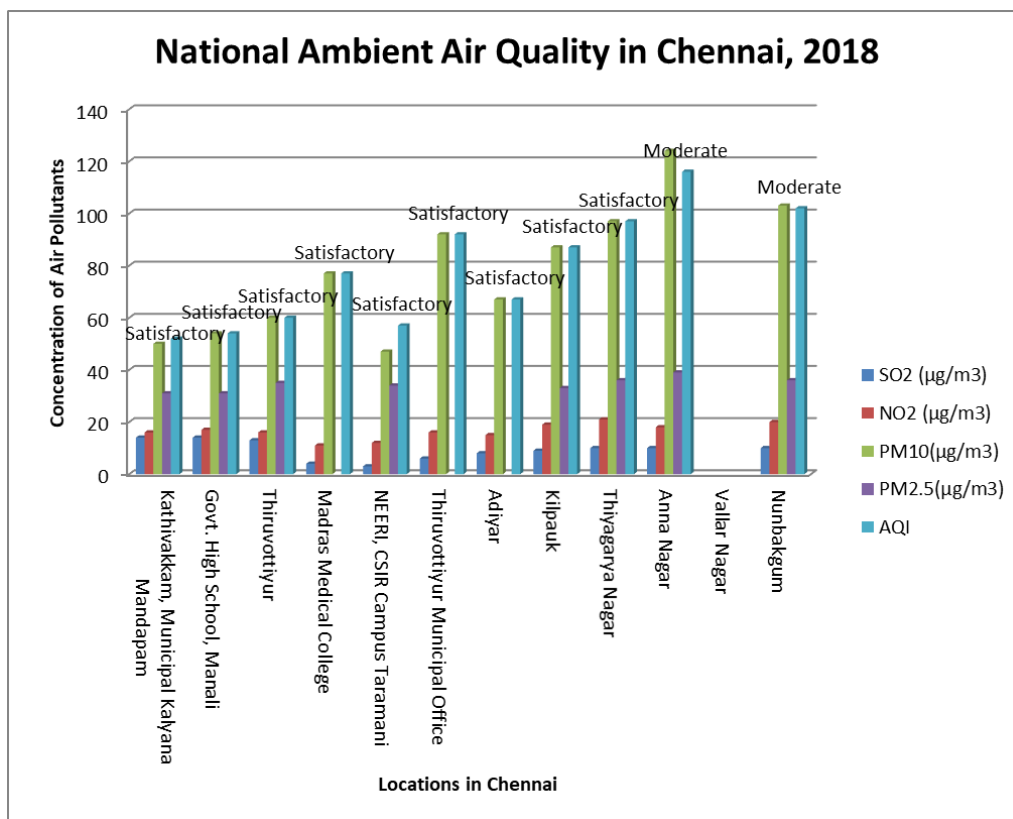


Figure 1.15. Graph Representing Air Quality Index of Different Locations in Chennai, 2018.

Source: Prepared by Author based on CPCB, 2021

The air quality in Chennai is worsening from 2017 to 2018. The air quality is satisfactory in nine locations and moderate in two locations. The locations having the satisfactory air pollution are Kathivakkam, Manali, Thiruvottiyur, Madras Medical College, Taramani, Thiruvottiyur, Adiyar, Kilpauk, Thiyagaraya Nagar, Anna Nagar and Nunbakgum. The healthy people residing in these regions will not have any air pollution related disease but the sensitive people may encounter breathing discomfort. Anna Nagar and Nunbakgum are the only locations which are moderately affected by the air pollution. Healthy people will not have any problem but the people with weak heart, lung, children and old aged people will encounter breathing discomfort. In 2019, the concentrations of air pollutants have been taken from the eleven different locations from all over the Chennai City. The locations taken for the study purpose are Kathivakkam, Municipal Kalyana Mandapam, Manali, Thiruvottiyur, Madras Medical College, Taramani, Thiruvottiyur, Adiyar, Kilpauk, Thiyagaraya Nagar, Anna Nagar and Nunbakgum. The concentrations of four pollutants taken for the study are PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub> and NO<sub>2</sub>. The data from the Vallar Nagar are not available in 2019 (Figure 1.16).

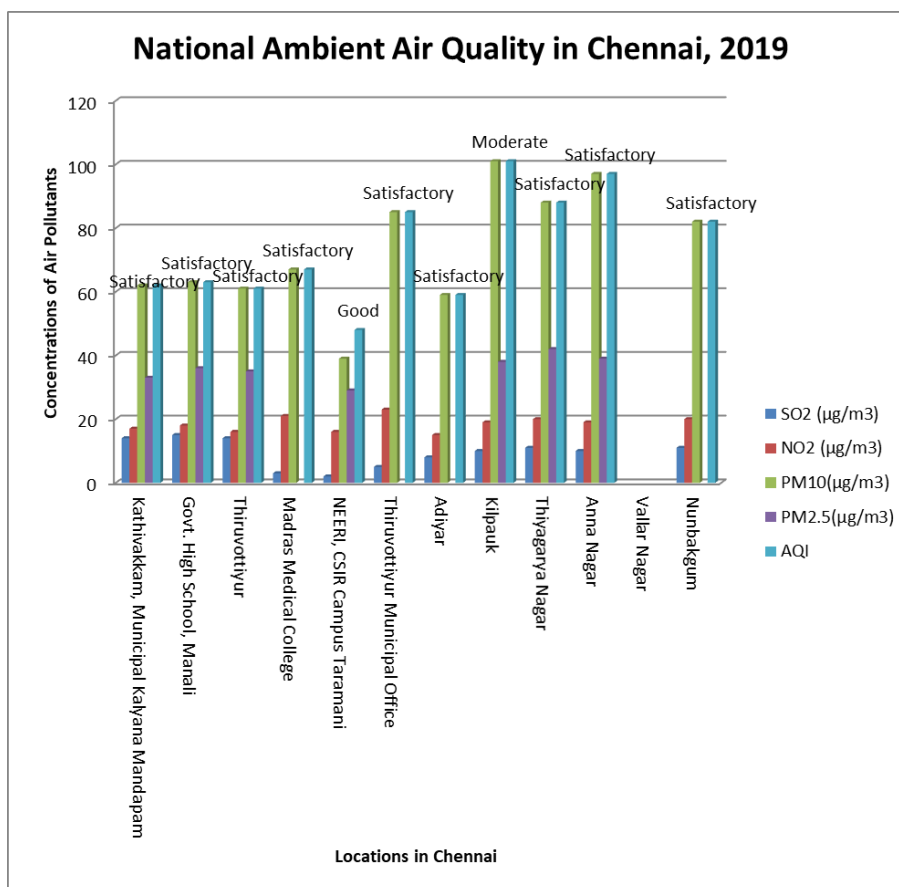


Figure 1.16. Graph Representing Air Quality Index of Different Locations in Chennai, 2019

Source: Central Pollution Control Board, 2021

From the figure 1.16 it has been observed that except for single good and moderate location, all the station in the city are satisfactory. In 2019 the satisfactory locations are Kathivakkam, Manali, Thiruvottiyur, Madras Medical College, Thiruvottiyur Municipal office, Adiyar, Thiyagaraya Nagar, Anna Nagar, Vallar Nagar and Nunbakgum. In those site healthy people don't encounter any air pollution related complications however sensitive people encounter minor discomfort in breathing. In Taramani regions there was a minimal impact of air pollution and at Kilpauk, people with weak heart, lung, children and senior citizen will face breathing discomfort. In 2020 concentration of air pollutants were taken from eight location of Chennai city. The locations taken for the analysis were Kathivakkam, Municipal Kalyan Mandapam, Manali, Thiruvottiyur, Adiyar, Kilpauk, Thiyagaraya Nagar, Anna Nagar and Nunbakum. The four concentrations of the pollutants taken for the study were SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub> (Figure 1.7)

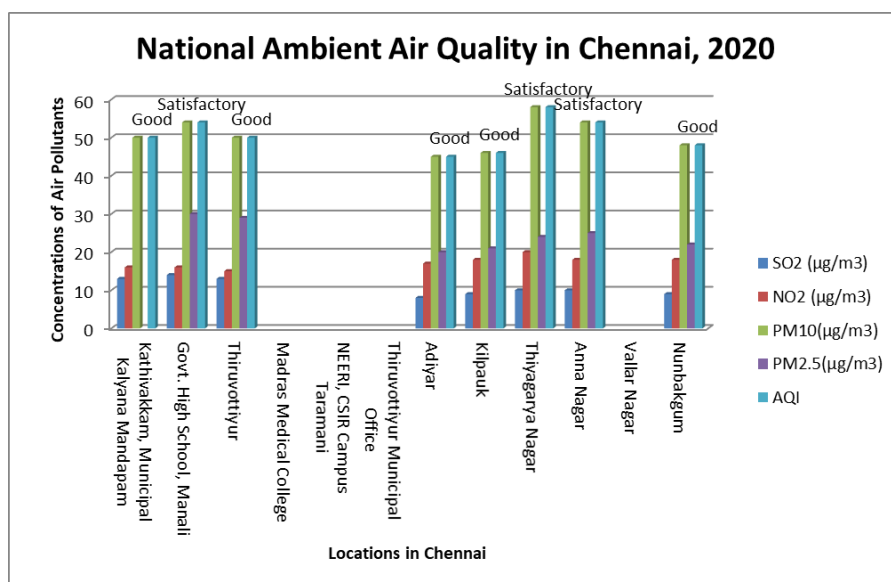


Figure 1.17. Graph Representing Air Quality Index of Different Locations in Chennai, 2020.

Source: Central Pollution Control Board, 2021

The air quality index of concentration of air pollution ranges from good to satisfactory (Figure 3.16). It has been observed that out of eight stations surveyed five stations Kathivakkam, Thiruvottiyur, Adiyar, Kilpauk and Nunbakgum are good in air quality and rest three locations Manali, Thiyagaraya Nagar and Anna Nagar indicate satisfactory air quality. The entire healthy citizen residing in the city during 2020 will not encounter any air pollution related complexities. The concentration of air pollutants will have minimal impact on the location showing good air quality however the sensitive people residing in the satisfactory location may encounter minor breathing discomfort. In 2020 datas are not available from Madras medical College, CSIR Campus Taramani, Thiruvottiyur Municipal Office and Vallar Nagar. In the study of all the surveyed location it is observed that concentration of SO<sub>2</sub> is good because its concentration range from 8 µg/m<sup>3</sup> to 14 µg/m<sup>3</sup>. The concentration of NO<sub>2</sub> is also good as it range from 15 µg/m<sup>3</sup> to 20 µg/m<sup>3</sup> and less than 40. In 2020 concentration value of PM<sub>10</sub> is clustered as it range is from 45 µg/m<sup>3</sup> to 58 µg/m<sup>3</sup>. It fall under the category of good to satisfactory. As from all the location concentration of PM<sub>2.5</sub> range in between 20 µg/m<sup>3</sup> to 30 µg/m<sup>3</sup> its presence is under control and good.

## Conclusion and Summary

Over the past twenty years the quality of air in India has deteriorated significantly. It is observed that the quality of air in Delhi is deteriorating since 2013 to 2016 but after 2016 slowly its quality is improving. Delhi air quality is one of the worst air qualities in the world. It is found that whenever data of PM<sub>2.5</sub> is available in the location it the main factor determining the AQI and in the absence of it PM<sub>10</sub> replace its role. In Delhi average annual AQI is lowest in 2013 and highest in 2016. In 2013 its value was 181 which indicate moderately

polluted, the people with weak heart, lung, children and aged people may encounter breathing problem when exposed to it. In 2016 the average AQI value was worst with 260.67. It falls under the range of 201 to 300 which is poor. People may encounter breathing discomfort when prolonged exposed to it.

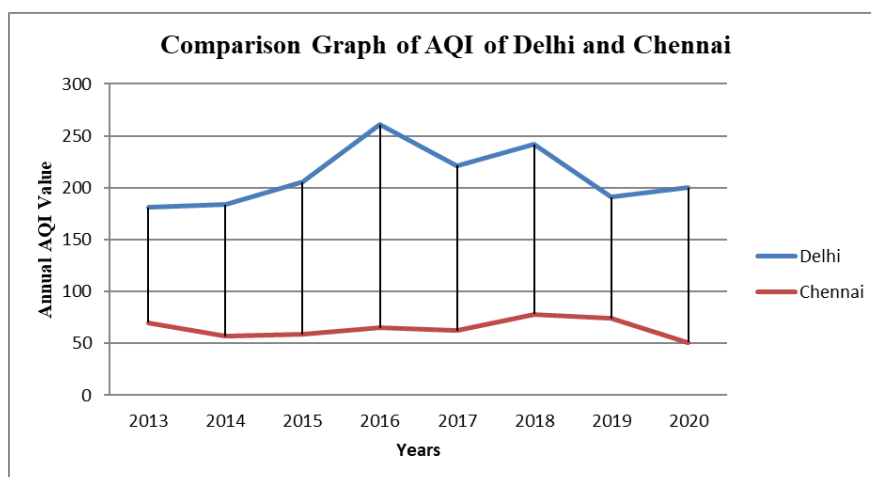


Figure 1.17. Graph showing the Annual AQI value since 2013 to 2020 in both Delhi and Chennai

Source: Central Pollution Control Board, 2021

In Chennai the annual average AQI is more or less constant since 2013 to 2020. Its value is lowest in 2020 with 50.63 which is slight 0.63 greater than good category (0-50). The healthy people will not encounter any problem however sensitive people may encounter minor breathing discomfort. The highest values in the city hover at 78.27 in 2018. It is satisfactory where only sensitive vale may encounter minor breathing discomfort. Unlike Delhi in Chennai in spite of presence of  $PM_{2.5}$  in the atmosphere of location concentration of  $PM_{10}$  is the main determining factor of AQI .

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### Declarations

Conflict of Interest: The authors declare that there is no conflict of Interest. The paper work is genuine and not taken from any other works.

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