COMPARATIVE STUDY ON AIR QUALITY MONITORING OF STATIONS IN CHENNAI DURING PRE AND POST-LOCKDOWN OF COVID-19 PANDEMIC

Nisha Khanam [1] , Charumathi M [2] , Priya V S [3] , Dhamodharan S [4], Roja R [2] , Henry Daniel B K [2] , Roshan P[2] and Subash V [2]

[1] Assistant Professor (Sr.Gr), Department of Civil Engineering, B.S.Abdur Rahman Crescent Institute of Science and Technology, Chennai, TamilNadu.
[2] Final year students, Department of Civil Engineering, B.S.Abdur Rahman Crescent Institute of Science and Technology,Chennai, TamilNadu.
[3] Associate Professor, Department of Civil Engineering, B.S.Abdur Rahman Crescent Institute of Science and Technology, Chennai, TamilNadu.
[4] Assistant Professor (Sr.Gr), Department of Civil Engineering, B.S.Abdur Rahman Crescent Institute of Science and Technology, Chennai, TamilNadu.

[1] nishakhanam@crescent.education(corresponding author), [3] priya@crescent.education, [4]dhamodharan@crescent.education

Abstract:- *The comparative study aims to analyze the air quality monitoring data of four stations in Chennai i.e. Royapuram, Kodungaiyur, Koyambedu, and Perungudi during the Pre and Post lockdown of the COVID-19 pandemic period. The study primarily focuses on the levels of particulate matter ($PM_{2.5}$ and PM_{10}) and other air pollutants such as nitrogendioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO). The study involved data collection from multiple air quality monitoring stations in Chennai, and statisticalanalysis was conducted to analyze the trends and patterns of air quality during the pre-lockdown and post-lockdown periods (i.e. from the year 2019 to 2022). The findings of the study highlight that there was a significant improvement in air quality during the lockdown period due to reduced vehicular and industrial emissions. The study also provides insights into the potential measures that could be implemented to maintain better air quality standards in the future. Our study focusedon analyzing the air quality index (AQI) from the data gathered from four different monitoring stations in Chennai, India. We investigated the changes in AQI levels for $PM_{2.5}$, PM_{10}, SO_2, NO_2, and O_3 during the above periods. Finally, results indicate that the AQI levels for all monitored pollutants represent a significant decrease during the lockdown period when compared to the pre-lockdownperiod. The biggest decreases were observed in $PM_{2.5}$ and PM_{10}.*

Keywords: *Air Quality Index, COVID-19 confinement, Kriging.*

1. Introduction

When contaminants that are damaging to both human health and the environment—such as gases, particles, biological molecules, etc.—are released into the air, it is called "air pollution." Calculating the Air Quality Index (AQI) for daily average pollutant data allows one to determine the level of pollution and the data is also used for reporting the daily air quality. It gives information on how clean or filthy the air is as well as any potential negative health effects. Even from one hour to the next, the state of the air might vary from day to day. The quality of the air at a given location is a direct function of both the airflow patterns in the region and human-induced air pollution. AQI is determined based on 8 significant air contaminants in the atmosphere. With rising AQI scores, air pollution levels and the ensuing health risk rise. When the air is clean, there aren't many chemical or material impurities, and it's clear. Poor air quality is often hazy, unhealthy for people, and dangerous for the environment. When the air is clean, there aren't many chemical or material impurities, and it's clear. Poor air quality is often hazy, unhealthy for people, and dangerous for the environment.

2. Air Quality Index (AQI)

In many nations, the Air Quality Index (AQI) is a tool used for decision-making that effectively informs the public about the air quality status of a region in simple words. It converts complicated air quality data from various pollutants into a single number (index value), nomenclature, and colour that falls into one of the six AQI categories, which are shown in Table 1 in an easily recognizable colour scheme which also represents the health impacts.

Table 1. AQI Categories and associated Health Impacts (Source – AQI Dashboard)

AQI	REMARK	COLOUR	POSSIBLE HEALTH EFFECTS

		CODE	
0-50	Good		limited impact
51-100	Satisfactory		minor discomfort with breathing for sensitive individuals
101-200	Moderate		People with lung, asthma, and heart disorders may experience breathing problems
201-300	Poor		On prolonged exposure, most people experience breathing difficulty
301-400	Very Poor		respiratory disease with long-term exposure.
401-500	Severe		Affects both healthy people and persons who already have ailments.

Each of these classifications for air quality is determined using weighted ambient concentration values for eight air pollutants, comprising particulate matter 10 (PM_{10} and $PM_{2.5}$), NO_2, SO_2, CO, and ozone, as well as the potential impacts on human health (which are occasionally referred to as health breakpoints). The sub-indices for specific pollutants at a monitoring site are derived using the range of the health breakpoint concentration and the pollutant's recorded average concentration over the previous 24 hours (except for CO and O_3, which have data collected every 8 hours). A specific pollutant's concentration has a linear relationship with the sub-index. These eight pollutants have led to the development of an air quality sub-index and health breakpoints, for which yearly and short-term (up to 24 hour) National Ambient Air Quality Standards are set. The highest air quality index value for each pollutant being measured at a particular site is what is known as the air quality index (AQI) for that location. The sensor reports the concentration Cp for each pollutant P. This reading is an average over a period of time. The following equation (1) provides the pollutant index. From the collected data, the level of contaminants has been calculated.

$$\mathbf{I_p = [I_{high} - I_{low} / C_{high} - C_{low}] * (C_p - C_{low}) + I_{low}} \qquad \text{(eqn.1)}$$

These variables are the following from the eqn.1

I_p = index of pollutant P
C_p = concentration of pollutant P
C_{high}, C_{low} = the low/high concentration breakpoints that contain C_p.
I_{high}, I_{low} = the low/high index range associated with concentration breakpoint associated with C_p.
Where **C_{high}, C_{low}**, **I_{high}**, and **I_{low}** are taken from the AQI breakpoint table for the C_p value.

3. Study Area

In Chennai, TamilNadu there are nine pollution monitoring stations available out of which six stations belong to TamilNadu Pollution Control Board (TNPCB) and three stations belong to Central Pollution Control Board (CPCB). The study areas are Koyambedu, Kodungaiyur, Royapuram, and Perungudi located at Chennai, TamilNadu, India where all these stations belong to TNPCB. The study focuses on the four AQI stations which are chosen based on pollution, traffic, and industrial conditions are focussed in Figure 1.

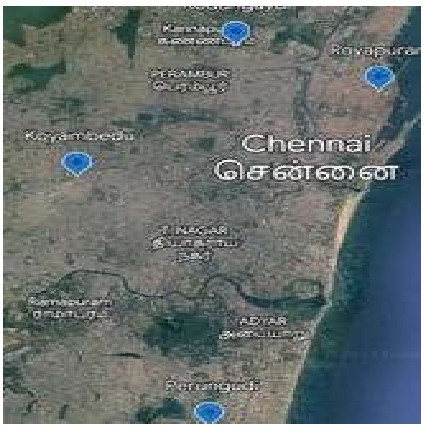

Figure1. Selected Air Quality Monitoring stations in Chennai

4. Results and discussion

4.1 Analysis of AQI data

Pollutants concentration data has been collected from Tamil Nadu Pollution Control Board (TNPCB) and with the help of the collected data AQI was calculated for the stations Koyambedu, Kodungaiyur, Royapuram, and Perungudi. The yearly AQI average data for the year 2019-2022 for the stations were analyzed and represented in Figure.2. Analysis of AQI data for the years 2019–2022 was done and the bar chart is obtained from the. The bar chart is created based on the yearly average values in Table 2 of the four Air Quality Monitoring stations.

Table 2. Yearly AQI average data

Station/Year	2019	2020	2021	2022
Kodungaiyur	69.53	51.19	65.07	64.16
Royapuram	64.92	50.51	51.00	70.48
Perungudi	67.20	43.64	62.42	65.72
Koyembedu	75.33	53.28	58.66	66.81

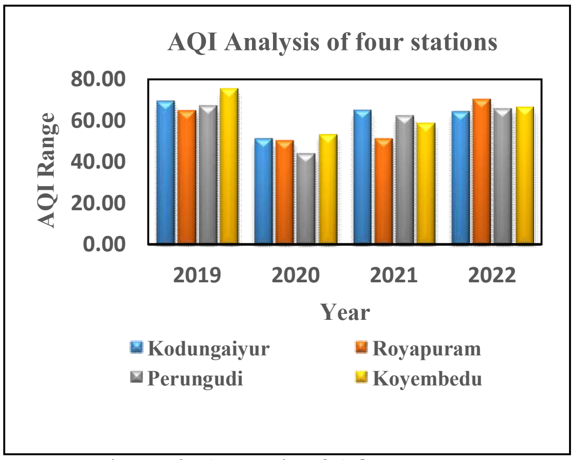

Figure 2. Analysis of AQI data

During the year 2019, the AQI ranges were between 50-100 under satisfactory conditions for all four areas and it is evident that during this year the air quality was poor in Koyambedu compared to other stations because of vehicular emissions as various classes of people from students to office goers rely on Koyambedu for being the main hub for transportation to various places in and around the city. Whereas during the year 2020, the air quality got improved by around 25% compared to 2019 and the main reason behind that was the COVID-19 pandemic situation. Due to the pandemic, there were strict lockdowns imposed all over the country and people were allowed to get essentials only during a certain allotted time, all industrial activities got paused and schools and colleges were closed, education system turned to a new dimension as the online education and work from home was practiced among office goers which greatly helped in decreasing the vehicular and industrial emissions thereby increasing the quality of air. During the year 2021 the pandemic situation was almost brought under control but not completely so there were partial lockdowns and night curfews imposed and as certain activities got resumed the air quality subsequently started to deteriorate and got decreased by around 20%.

For the year 2022, the situation was brought back to a state before COVID and therefore there were neither any curfews nor restrictions imposed. As a result, the air quality got further decreased by around 10% when compared to the previous year. During this year the AQI was maximum at Royapuram as it is a commercial area and the AQI of Perungudi and Kodungaiyur were almost the same compared to the year 2021 indicating that there was not much difference in the activity that took place during the years as both places were dump yard sites.

4.2 AQI analysis during the lockdown period of the year 2020

AQI analysis was calculated for the year 2020 during the Covid -19 lockdown period which are shown in the Table 3 and in Figure 3.

Table 3. AQI average during the lockdown period of the year 2020

Lockdown status	Period for the year 2020	Duration (days)	Remarks	AQI average for all the stations
Pre-lockdown	1st to 23rd March	23	Normal activities; Janata curfew on 22nd March 2020 was not separately considered	49.54
Lockdown 1.0	24th March to 14th April	22	Complete lockdown	33.92
Lockdown 2.0	15th April to 3rd May	19		21.82
Lockdown 3.0	4th to 17th May	14	Lockdown with certain relaxations	22.71

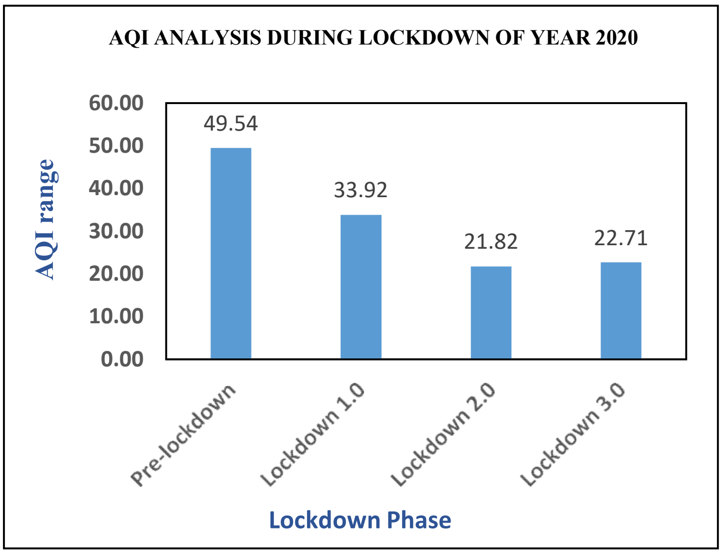

Figure 3. AQI analysis during the lockdown of the year 2020

4.3 Comparison of AQI during Pre and Post Lockdown

From the above AQI analysis of the year 2020, with reference to it the same process was carried out for the specific duration for the following years 2019, 2021, and 2022 of AQI analysis and compared as shown in Figures 4,5 and 6. During all these four years the quality of air was under satisfactory range thereby promising that hardly any cases of health issues were reported because of poor air quality in Chennai. Even though the quality of air is not under poor conditions it is evident that there is a decrease in air quality year after year so certain measures are to be taken to prevent further deterioration in upcoming years.

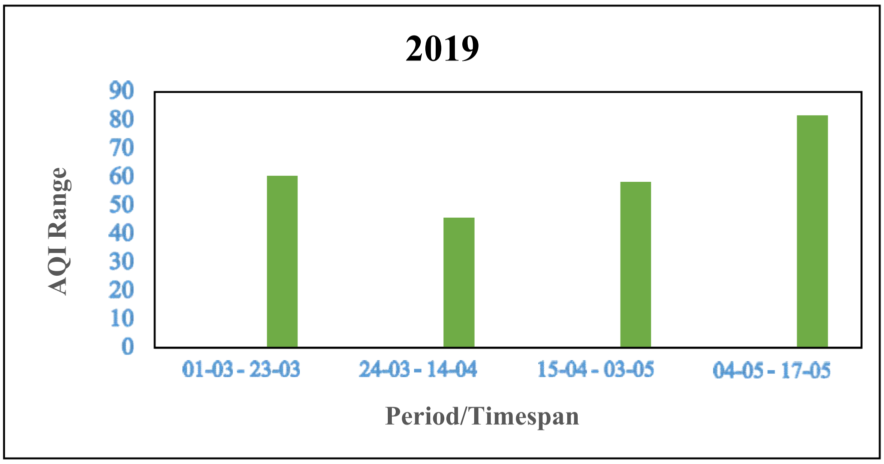

Figure 4. AQI analysis during the year 2019

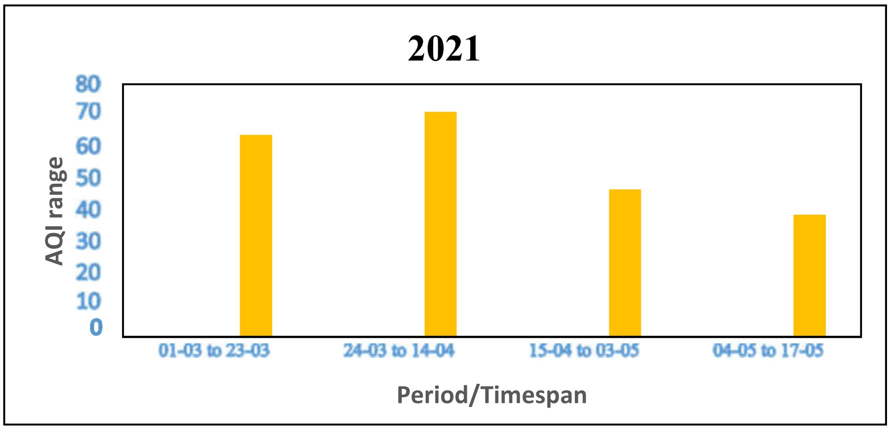

Figure 5. AQI analysis during the year 2021

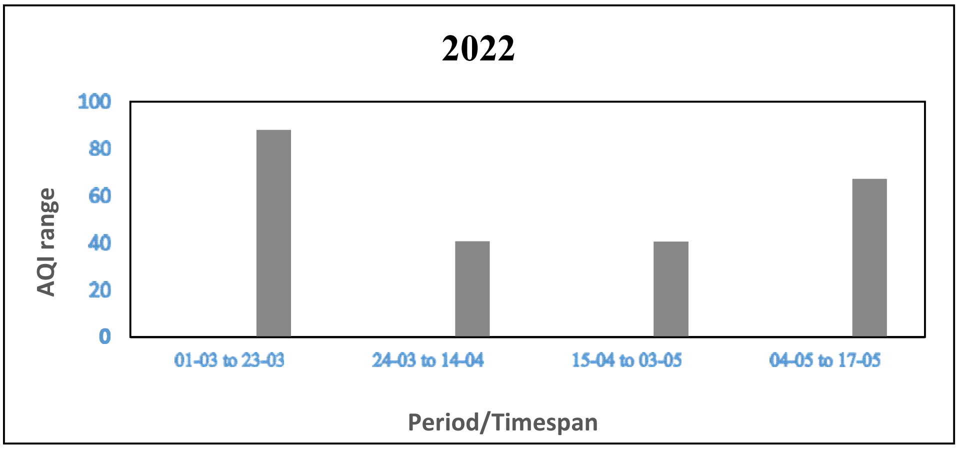

Figure 6. AQI analysis during the year 2022

4.4 Kriging Model

Kriging is one of many techniques that estimate the value of a variable over a continuous spatial field using a small set of sampled data points. A concentration map is created using the Kriging model. The kriging model is used in air pollution modelling to calculate the spatial distribution of contaminants using information from an existing network of air quality monitoring stations. By examining the spatial organisation of the data, a semivariogram was created, from which kriging weights were derived. The semivariogram and the spatial arrangement of nearby measured values are used to make predictions for locations in the study region in order to produce a continuous surface or map of the phenomena.

Figure 7 represents the Kriging model and AQI range for the year 2019. From the model generated the lowest AQI value is found to be 64.93 and the highest is 75.32. As per Central Pollution Control Board (CPCB) AQI standards the AQI values lie between 51 and 100 which seems to be moderate and hence this range value doesn't cause any illness to people. It is observed that the AQI value for Koyambedu station seems to be highest due to high vehicular emission as it is one of the busiest vehicular traffic occurring areas. Hence the AQI value for the stations Royapuram, Perungudi, and Kodungaiyur lies between 64 and 69 which seems to be safe when compared to Koyambedu station. There isn't much difference in AQI value with these three stations. Figure 8 represents the Kriging model and AQI range values for the year 2020. During this year the AQI of Kodungaiyur, Royapuram, and Perungudi is between 0 – 50 which comes under the good AQI category as per Central Pollution Control Board (CPCB) AQI standards. An important reason for this drastic change in AQI is due to the COVID-19 pandemic which led to a complete lockdown from March 23. Compared to the year 2019 the AQI value has reduced by about 25%, which shows how good the air was during the Lockdown period. During this year there were strict restrictions for traveling during the period March 23-May 17 there were very less vehicular emissions and construction activities were also halted which resulted in a major reduction of AQI. The AQI value for Koyambedu is found to be 53.28 which falls under the moderate category as per CPCB AQI standards.

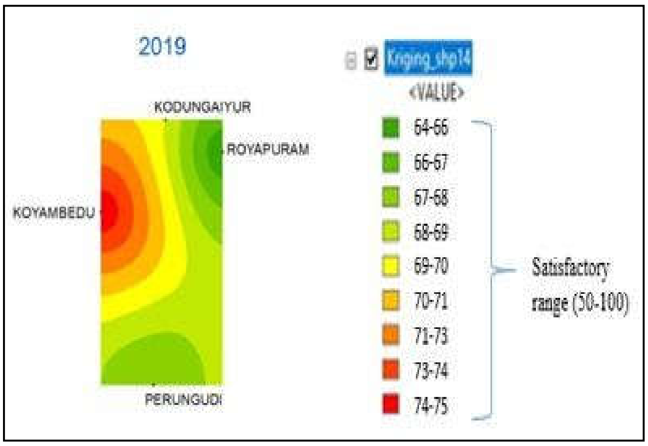

Figure 7. Kriging model for the year 2019

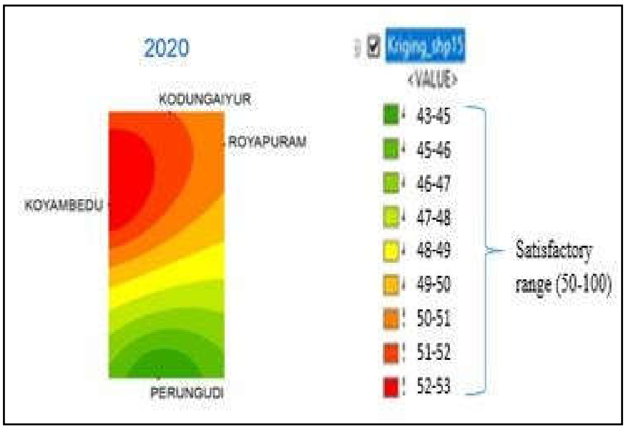

Figure 8. Kriging model for the year 2020

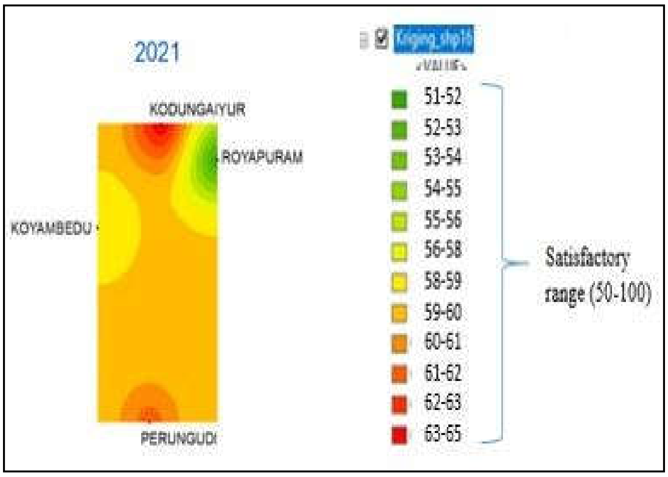

Figure 9. Kriging model for the year 2021

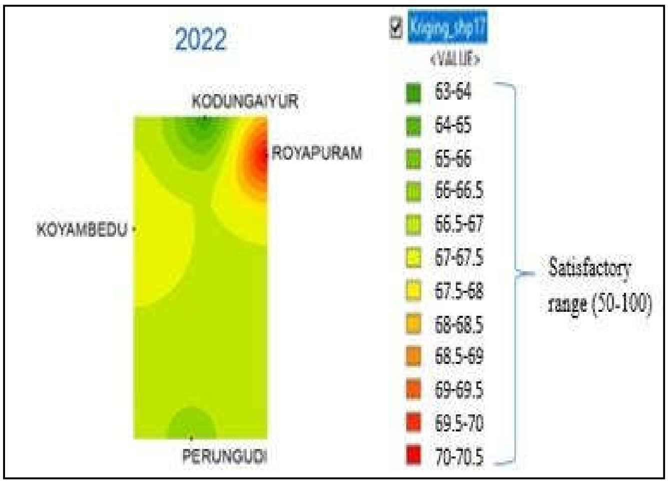

Figure 10. Kriging model for the year 2022

Figure 9 represents the Kriging model and the AQI range values for the year 2021. The AQI range for the year 2021 lies between 51 and 100 which is in moderate condition as per CPCB AQI standards. In Kodungaiyur the AQI is found as 65.07 which is the highest AQI compared to other stations but it also comes under the moderate range. During this year none of the stations fall under the Unhealthy category. When compared to the year 2020 there is a drastic increase in AQI value for Perungudi with 62.42 (43% increase) and Kodungaiyur with 65.07 (27% increase). During this year the AQI did not raise as found in the year 2019. The gradual increase in AQI is due to some relaxation during the year 2021 as construction work was started again and vehicular emission was there. Compared to 2019 there were fewer vehicular emissions as there was a lockdown from May 24 and the public was allowed to move in a certain period.

Figure 10 represents the Kriging model and the AQI range values for the year 2022. During the year 2022, the AQI of all four stations is between 51 and 100 which comes under the moderate AQI category as per CPCB AQI standards. The lowest and highest AQI during this year is 64.16 and 70.48 respectively. Kodungaiyur's AQI value is found to be 64. Royapuram has the highest AQI value of 70.48 among other stations and has increased by about 38% when compared to the previous year 2021. In Perungudi the AQI is found to be 65.72. Koyambedu has an AQI value of 66.81 which has increased by about 13% to the previous year 2021. This year the AQI range is almost close for the stations Kodungaiyur, Perungudi, and Koyambedu. In the year 2022, the AQI is similar to AQI in the year 2019.

4.6. Suggestive Measures

4.6.1Perungudi

Cause for pollution:

The major cause of pollution in the air is the dump yard located in Perungudi and also vehicular emissions play a vital role. Perungudi a main hub signal is a heavy traffic zone with a regular wait time of 2 to 3 min between each signal this causes heavy traffic and pollution within a single spot to avoid this, bridges and skywalks can be constructed to avoid such congestion.

Suggestion:

The steps mentioned below are more than enough to ensure a clean working area and safety for harmful pollution to the air:

- ❖ Landfill gas extraction
- ❖ Waste segregation
- ❖ Composting
- ❖ Obeying the regulations

4.6.2 Royapuram

Cause for pollution:

Vehicle emissions, industrial processes, and stack emissions from businesses are the main causes of air pollution in Royapuram.

Suggestion:

Fine particle filtration from the high-temperature sources with granular filters can be provided at stacks and sub-microscopic particle filtration with regenerated electret filters. Electret filter media are highly charged synthetic non-woven materials that use electrostatic forces to increase particle capture efficiency well beyond the physical pore structure.

4.6.3 Koyambedu

Cause for pollution:

The main cause of air pollution in Koyambedu is due to vehicular emissions as it is the main hub of transportation.

Suggestion:

Promote people to use public transportation such as metro, bus, auto, etc. so they will avoid individual vehicles to avoid traffic and pollution. During the construction of metro rail projects an alternative route should be provided to travel and to avoid traffic. Metro construction works could be carried over during night hours to avoid traffic congestion in morning peak hours. In the future aspect switching over to electrical vehicles will lead to zero emissions which is one of the greatest ways to reduce air pollution due to vehicular emissions.

5. Conclusion

From the study air quality index estimation method is offered for the four locations of Chennai. Following that, the index is determined for each of the four locations: Royapuram, Kodungaiyur, Koyambedu, and Perungudi. The findings show that from four sites in Chennai, the Air Quality Index was at a moderate level from 2019 to 2022. Due to the COVID-19 pandemic, there were strict lockdowns implemented during the year 2020 as a result of which there were drastic improvements in the Quality of Air throughout the year. The improvement in air quality is due to fewer vehicular emissions, and reduced industrial and construction activities. During the year 2021, there were relaxations due to the reduced number of people affected by COVID when compared to the previous year. As a result, partial lockdowns were implemented to reduce the further spread but due to the relaxations, the Quality of air got decreased by more than 15% when compared to 2020. Whereas during the year 2022, no lockdowns were implemented and daily activities were resumed and people were back to normal, as a result of which the Quality of air returned to its original state as in 2019. Even though there were fluctuations in Air Quality Index over the years 2019-2022 the Quality of Air remained under moderate conditions because of which there is no serious effect on health due to poor Air quality. Despite the moderate conditions it is better to take certain suggestive measures to prevent deterioration of air quality in the upcoming years so that Chennai city doesn't end up like Delhi. One of the best suggestions is to opt for Electrical vehicles and the usage of CNG (Compressed Natural Gas).

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