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## Impact of COVID-19 Lockdown on Air Pollution and Air Quality Index (AQI) in India

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### ABSTRACT

*From the start of industrialization, air pollution in India and around the globe started increasing with new pollutants coming into existence. The extent of air pollution has also increased in the last few decades, very rapidly affecting human health and the earth's ecosystem badly. During pandemic like it happened in other countries, the same way, in India also government-imposed lockdown that resulted in the termination of all economic activities. The pandemic and imposed lockdown provided improved air quality as a gift to mankind. This duration also shows insight into the relationship between the economy and good air quality. We also get some insight into how to improve air quality without affecting the basic needs of society. This paper aims to examine the variation of the concentration of 5 main contaminants (PM2.5, PM10, NO2, CO and Ozone) before and after the lockdown imposed in 5 major Indian cities. After reading this paper, we get an insight into to what extent we can reduce air pollution by imposing lockdown and how the socio-economic, geographical variance across cities decides the extent of reduction in air pollution. We also get direction for future management strategies and policies to regain economic strength with sustainable improvements. So at the moment, we have to focus on both air pollution management and economic recovery. This study provides insight into the air quality index across the geographical variation of India.*

**Keywords**— Impact of COVID-19, Lockdown, Air Pollution, Aqi, India, Cities

### 1. INTRODUCTION

To understand Air pollution and its Constituents and AQI, we have presented a few important points.

Air is composed of many gases in different concentrations. Major components are Nitrogen and Oxygen, and some minor components are Carbon Dioxide and Argon. The atmosphere contains a heterogeneous mixture of gases and particles. Some are harmful, and some are useful.

#### So how do we define Air Pollution?

It may be defined as impurities in *excess quantity* and *duration* in the atmosphere to cause adverse effects on the environment(plants, animals, etc. The primary source of air pollutants is Natural resources like volcanic eruptions, forest fire, etc., and Anthropogenic(Man-made) like agricultural activities, industrial activities, domestic waste, etc.

**Types and Sources of Air Pollutants:** Many things are responsible for air pollution. But broadly, it is divided into two parts.

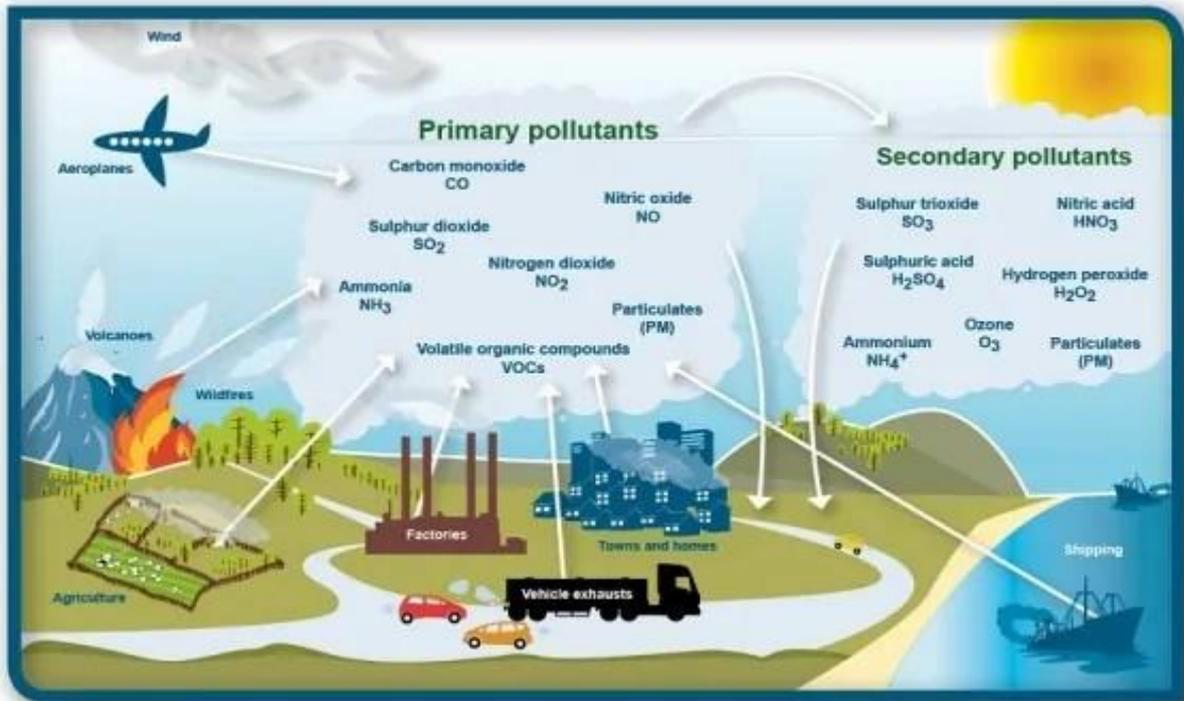
- (a) Particulate Pollutants
- (b) Gaseous Pollutants.

Gaseous pollutants consist of all harmful gases, which cause air pollution when their quantity is more than some safe limit(safe limit depends on geographical condition. We will discuss it later). Some of the Gaseous Pollutants are- CO, Ozone, volatile organic compounds, NO and NO<sub>2</sub>. All atmospheric substances other than gases that are responsible for pollution are known as Particulate Pollutants. Examples of some particulate pollutants are:- Dust, smoke, smog, etc.

**Primary and Secondary Pollutants:** Pollutants that are directly emitted from a source are known as primary pollutants. While secondary pollutants are not directly emitted but formed by reaction between primary pollutants. Examples of secondary pollutants are:

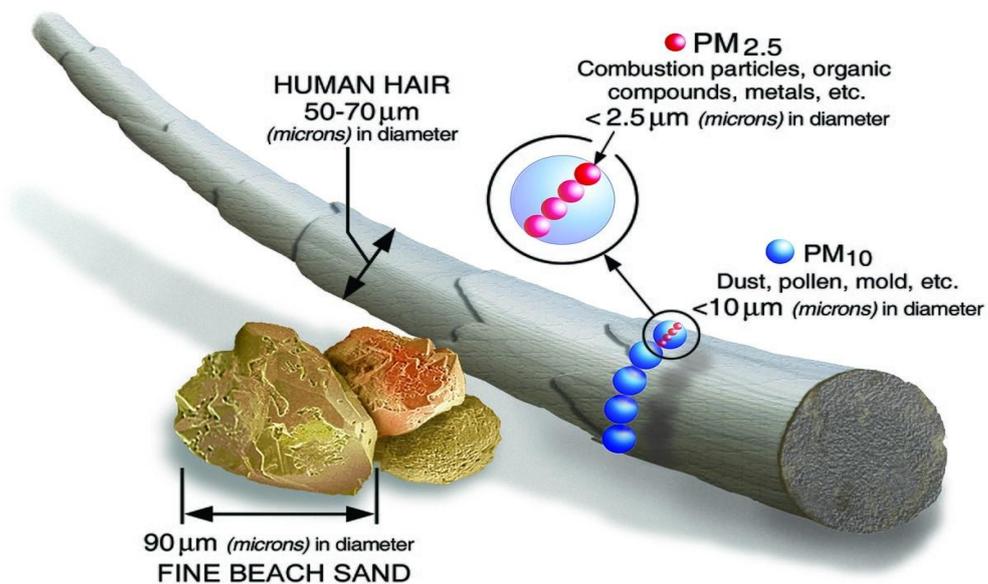
- Ozone(O<sub>3</sub>)= formed by hydrocarbon and nitrogen oxides (in the presence of sunlight.)

- Photochemical smog:- When nitrogen oxides and volatile organic compounds react in the presence of sunlight (creating brown haze)
- PAN(peroxyAcetyl Nitrate) etc.



**What are PM2.5 and PM10?**

PM stands for particulate matters. It is a general term used for microscopic particles and liquid droplets present in the atmosphere. PM2.5:-fine particle, defined as a particle that has a diameter of fewer than 2.5 micrometres. PM10:- coarse particles, the diameter of 10 micrometres or less.



Source:-Wikipedia

**Why does the size of particles matter?**

The main factor determining whether the particles would settle in the respiratory tract when inhaled is the particle size. A nose filters larger particles. But particles with dia smaller than 10 micrometres can relax in the lungs and cause serious health issues.

**Health Effects of PM2.5 and PM10:-**

- As the size of particle decreases, toxicity increases.
- Due to its small size (especially PM2.5), this particle penetrates deep into the lungs and causes inflammation, leading to cough and asthma attacks, strokes, high blood pressure, etc.
- If the concentration of PM2.5 is higher in the air, it can also affect visibility by forming mist or fog.
- Irritation in the eyes, nose, breathing problems, severe respiratory diseases is caused by excess conc. PM2.5 and PM10.

**NATIONAL AMBIENT AIR QUALITY STANDARDS (2009)**

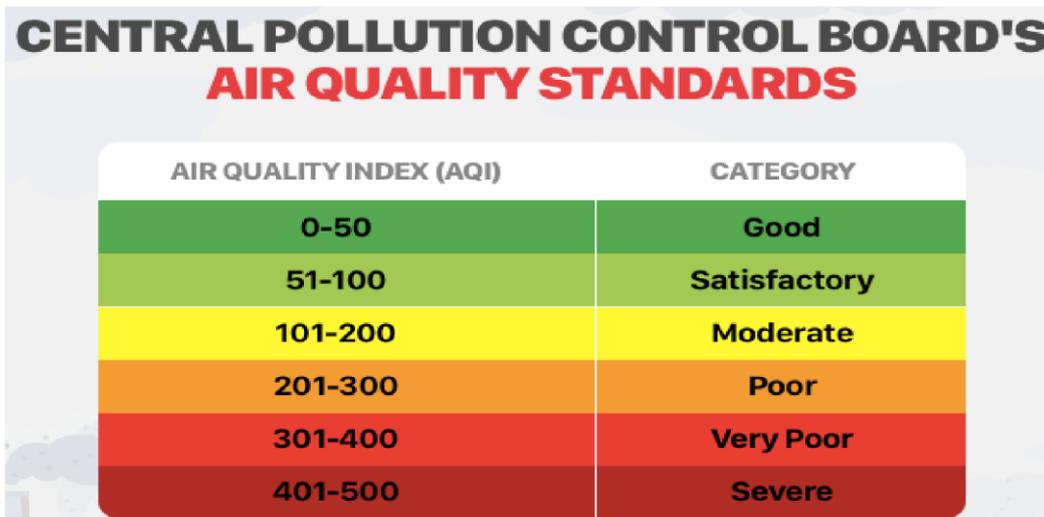
Pollutants (µg/m <sup>3</sup> )	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by GOI)
Sulphur Dioxide (SO <sub>2</sub> )	Annual *	50	20
	24 Hours **	80	80
Nitrogen Dioxide (NO <sub>2</sub> )	Annual *	40	30
	24 Hours **	80	80
Particulate Matter, Size less than 10 µm (PM <sub>10</sub> )	Annual *	60	60
	24 Hours **	100	100
Particulate Matter, Size less than 2.5µm (PM <sub>2.5</sub> )	Annual *	40	40
	24 Hours **	60	60
Ozone (O <sub>3</sub> )	8 Hours *	100	100
	1 Hour **	180	180

source:-CPCB

**How is Air Quality Measured?**

Air quality is measured by how clean or polluted air is. So to prevent air pollution, it is necessary to monitor Air Quality.

- Air quality is measured with **Air Quality Index(AQI)**.
- AQI can be defined as a single number that consists of weighted values of individual parameters(pollutant concentration)
- Eight parameters (PM10, PM2.5, NO2, SO2, CO, O3, NH3, and Pb)
- In India, Air quality is monitored by measurements at 573 locations under the National Air Monitoring Programme(NAMP).most of the stations only measure three pollutants, i.e., PM10, sulfur dioxide, and Nitrogen Dioxide.



Source: CPCB

Breakpoints for AQI Scale 0-500 (units: µg/m<sup>3</sup> unless mentioned otherwise)

AQI Category (Range)	PM <sub>10</sub> 24-hr	PM <sub>2.5</sub> 24-hr	NO <sub>2</sub> 24-hr	O <sub>3</sub> 8-hr	CO 8-hr (mg/m <sup>3</sup> )	SO <sub>2</sub> 24-hr	NH <sub>3</sub> 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.6-1.0
Moderate (101-200)	101-250	61-90	81-180	101-168	2.1-10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10.1-17	381-800	801-1200	2.1-3.0
Very poor (301-400)	351-430	121-250	281-400	209-748*	17.1-34	801-1600	1201-1800	3.1-3.5
Severe (401-500)	430+	250+	400+	748+*	34+	1600+	1800+	3.5+

\*One hourly monitoring (for mathematical calculation only)

In India, we measure impurities as air pollution in 12 different pollutants, PM 2.5, PM 10, O<sub>2</sub>, and many others. We have various government or private organizations that provide reliable and Excel data about the air pollution index in different cities and parts of the country. We will refer to CPCB data, analyze it, and get the results of how the data was changed and the reason for those changes. Analyzing this problem and findings will help us know how human history's rare conditions have changed the air quality parameters and how we can learn from them and interpret artificial changes from ourselves.

**2. BACKGROUND**

**(A) Approach:** The report should provide insight into the air pollution changes during lockdown across different cities. The approach is straightforward: we compare the previous year's data and the 2020 year for the 30 days. Many factors affect pollutant concentration in any City. Some of them could be like the biophysical, metrological, economic condition of the city. We provide a study for the five pollutants concentrations **PM 2.5, PM 10, NO<sub>2</sub>, O<sub>3</sub>, and CO**. Meteorological factors are considered in particular cities and data collected from various stations. There are many other factors, and the combined effect of all these factors decides the pollutant concentration in any specific measurement station. To get the secondary data, we visit the CPCB website and get air quality index data for the various cities for the 30-day duration, taking care of all the stations and their average. For each city, the findings are correlated with social-economic factors that decide the emissions of this city. And the results are discussed below related to the literature review, and then the discussion is written down.

**(B) Selection of cities:** The selection of cities is made based on two considerations. The first one is how easily the data is available for the city, and the second is how well our information covers the Geographical variations across the country. Also, there is a constraint on the number of measurement stations a particular city has, and the city varies in terms of the extent of pollution. By taking care of all the above points and the social-economic, the source of pollution, we have considered five cities as part of the research. All these cities are from various parts of the country and have a significant extent of pollution. The cities are **Delhi, Mumbai, Jaipur, Bangalore, and Hyderabad**. Delhi is the most polluted and has a large geographical area, so we have divided it into three parts. We have also divided Mumbai into three parts. The data for the socio-economical and environmental management policies are analyzed to measure the pollutants concentrations and provide a sustainable path to remove lockdown for economic recovery.

City	Average Income level	Major Economic Sector	Air Pollution Major Source	Contributed by external boundaries?	Transport Contribution ( Number of regs. Vehicles)
Delhi	High	Tertiary(84 %)	Transport, Industry, Dust	Yes	80 Lakhs
Mumbai	High	Tertiary(79 %)	Transport, construction, Dust	Yes	30 Lakhs
Jaipur	Low	Tertiary(61 %) Secondary (33%)	Transport, Industry, fire	Yes	25 Lakhs
Bangalore	High	Industry, Services	Vehicles emissions 60-70%	No	68 Lakhs
Hyderabad	Low	Services(65 %)	Transport emissions	No	35 akhs

**(C) Socio-Economic conditions of cities:** Air pollution is not caused just because of vehicle emissions; there are various other causes. We get data from MoSPI to get the value of GSDP, which categories average personal income for the city. We also find out the significant economic sectors in the given city to contribute more towards emissions. All the above data is taken from the smart city and budget documents. More critically, all the significant sources of pollutants in a particular town are available on the SPCB website. There are also substantial emissions measured in a city but are caused in the surrounding boundary state. That's why we get data from the SPCB committee for the source of pollutants study in a city. The influence of the number of vehicles and transportation pollution is also measured from government data. Data on various proportions of electricity consumption is also measured like hydro, thermal, renewable, and non-renewable sources. Some other factors are population, land use, industrial activities, and various economic sector pollution.

**(D) Data Collection and Methods:** We get secondary data from the CPCB website and compare the pollutant concentrations for five variables PM 2.5, PM 10, NO<sub>2</sub>, CO, and O<sub>3</sub>, from 25th March 2020 to 24th April 2020. Also, compare the concentration of these pollutants for the year 2019 to 2020. The specified pollutant concentration for PM 2.5 PM, 10 NO<sub>2</sub> in a time average of 24 hours and annual duration and for CO and O<sub>3</sub> in a time average of 8 hours and one hour are also provided in the table above in the introduction part. As we know, the air quality index does not represent all the contributing constituents to the pollution, so that's why we analyzed each constituent separately in each city. We also analyze the difference in the 2019 and 2020 values for individual pollutant concentrations. We plot a Graph and Bar diagram to show the variance with the number of days and compare data from the previous year.

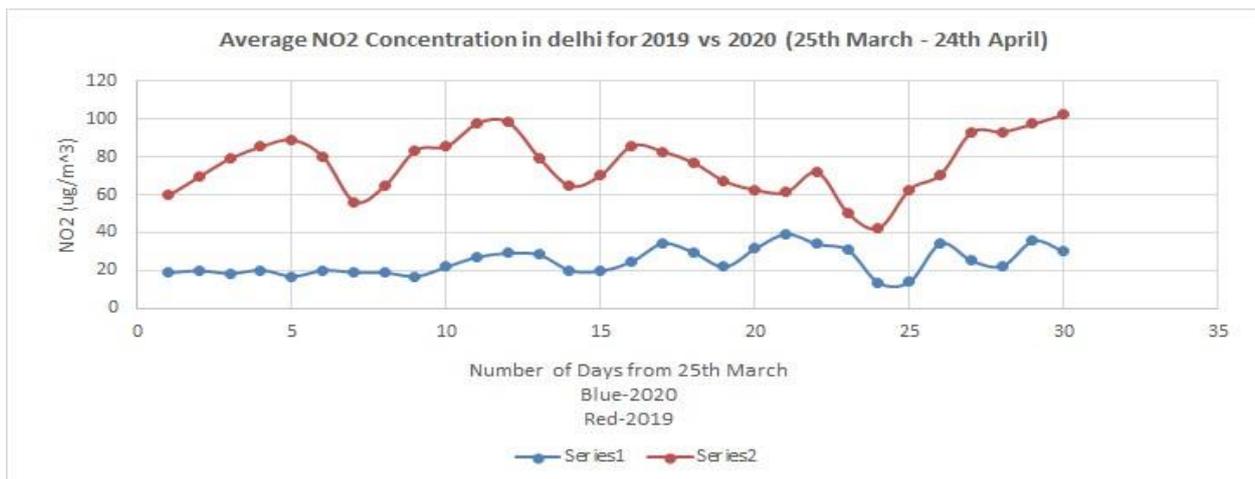
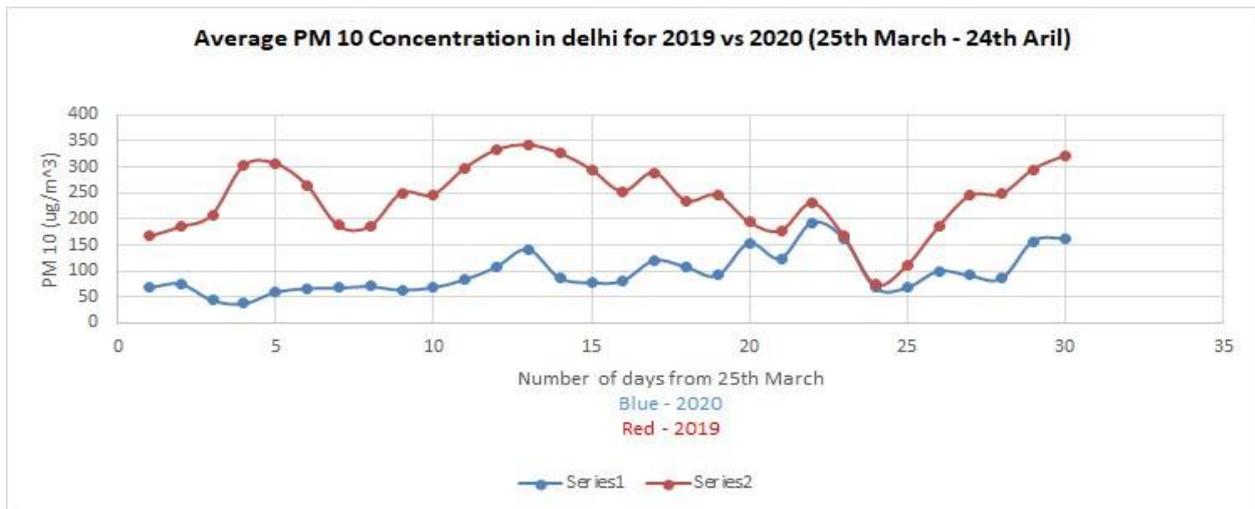
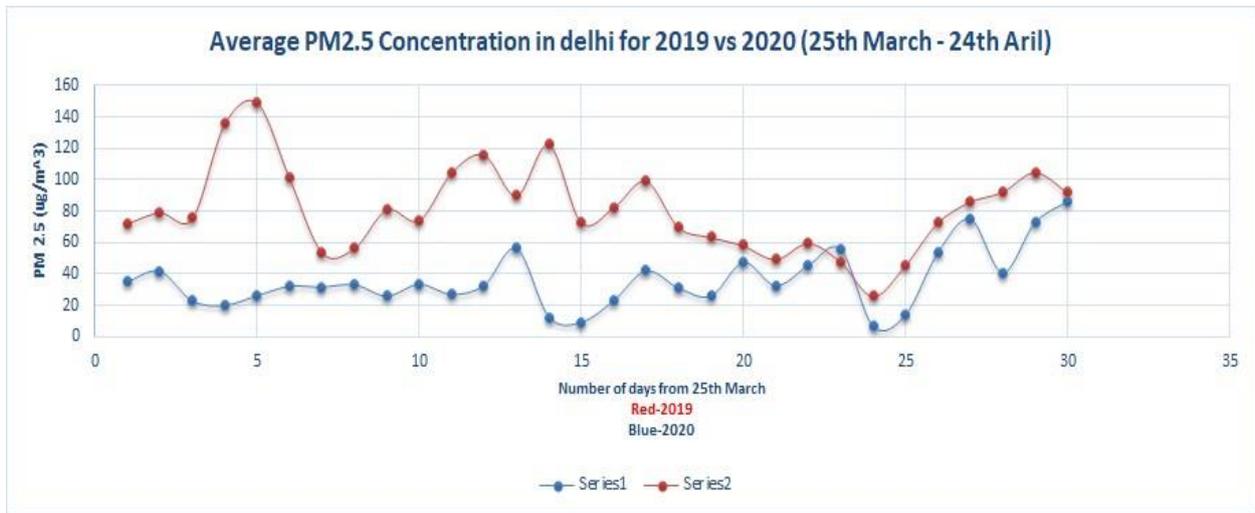
**(E) Limitations of Method:** Methods are based on analysis of secondary data, and it may have an error or mistake in measurement. The pollution in a city is not measured thoroughly and is based on analysis of SPCB, which may have an incorrect

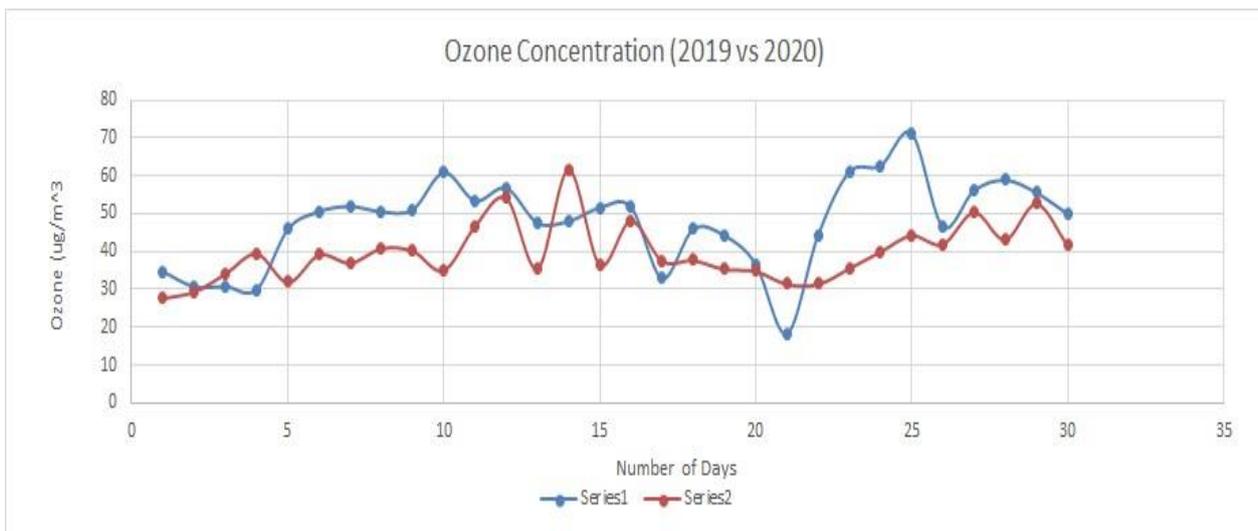
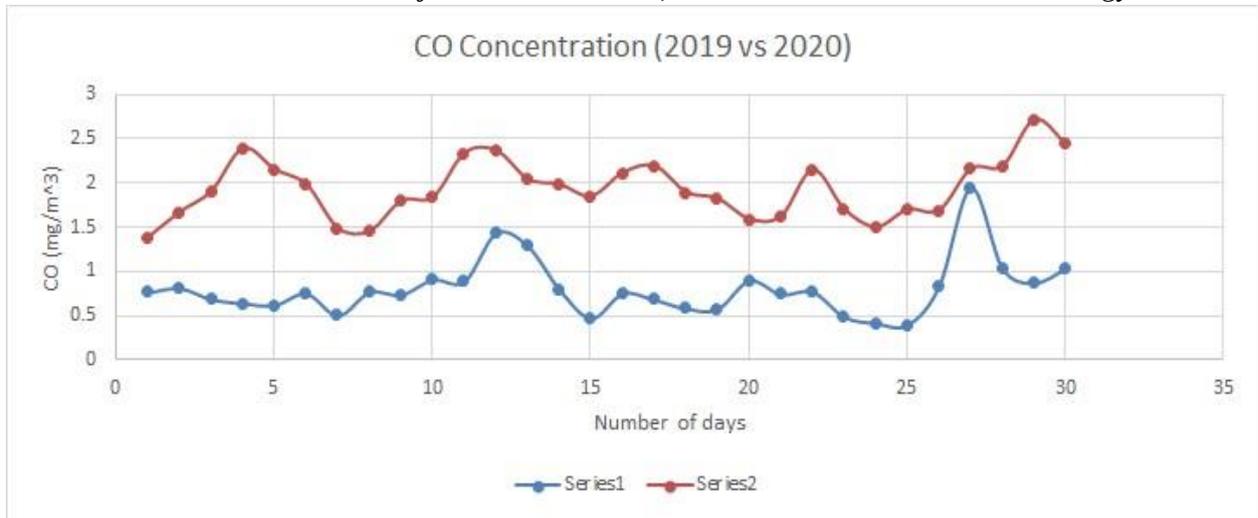
measurement. We did not focus on local geographical or aerial pollution new sources, which may have led to unexpected behaviour in pollutant concentration during the lockdown. We also did not take into account the extent to which lockdown affected the various pollution sources in a city, which may vary from city to city.

#### 4. RESULTS

In most of the cities in the country, the lockdown results in a reduction in pollution levels compared to the year 2019. I can observe that there is an exception in the concentration of Ozone for all the cities. It fluctuates and sometimes increases, but both the concentration of CO and Ozone is well below the national standard average for all the cities. Also, PM2.5 and PM10 concentrations are significantly reduced except for Mumbai data of PM2.5. After a complete analysis of metallurgical data, we observe a similar trend across different countries and Different cities in India And values lie close to each other. This is a correlation between pollutant levels across the globe which is also related to humidity and temperature for that particular city.

##### (1) Delhi Pollutant Level Analysis



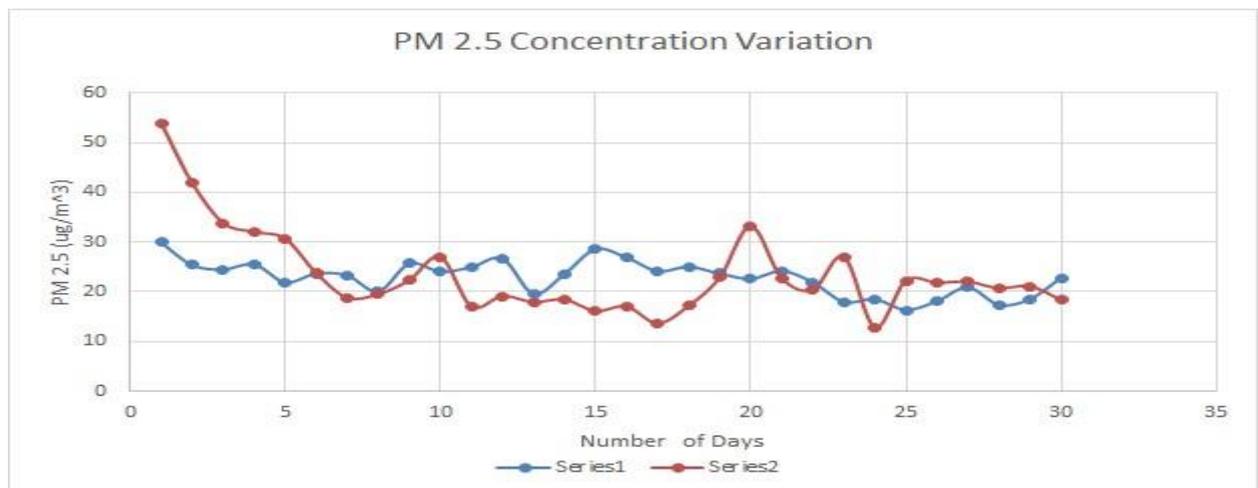


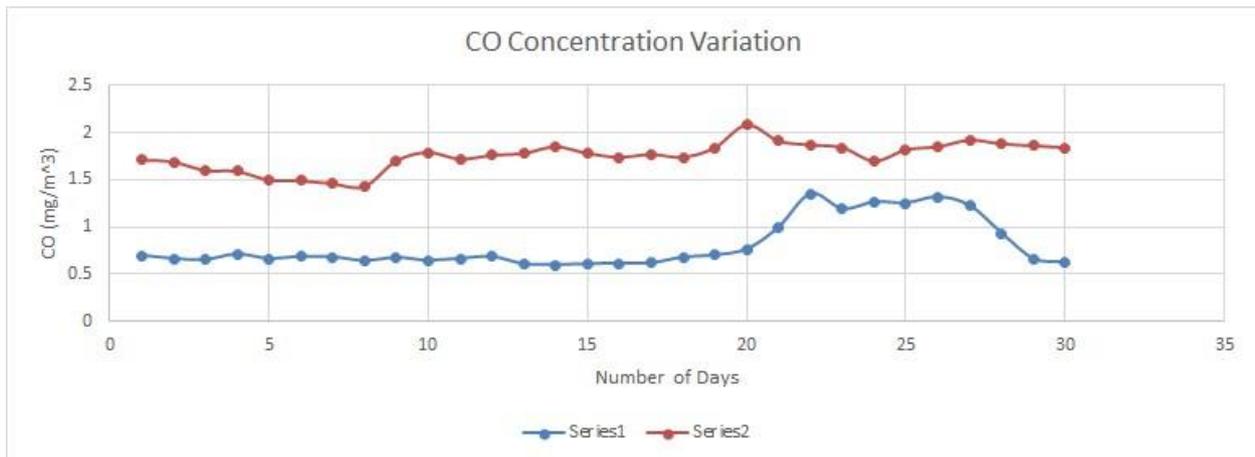
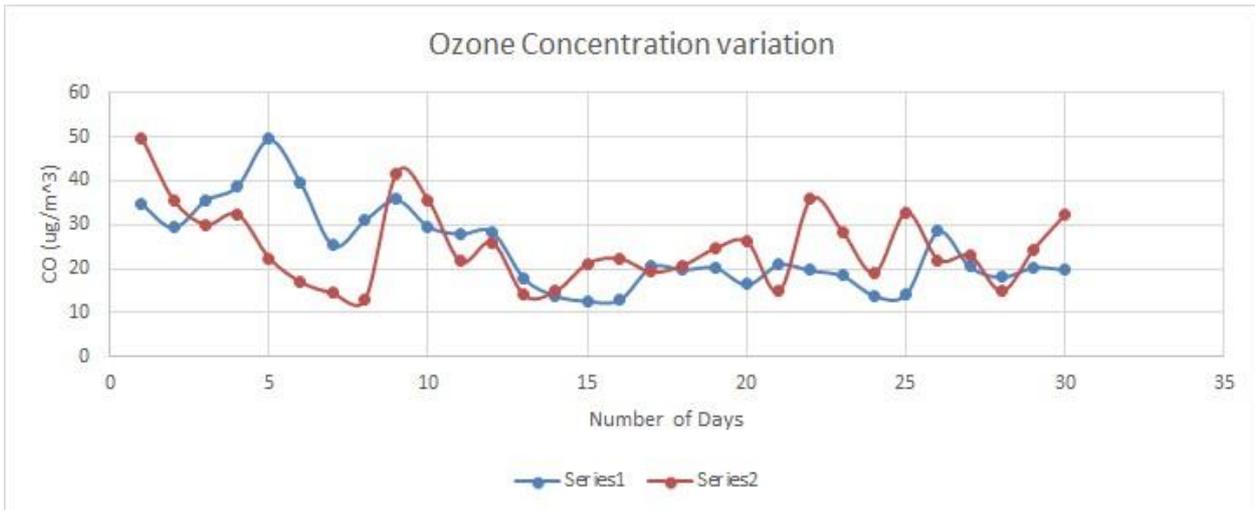
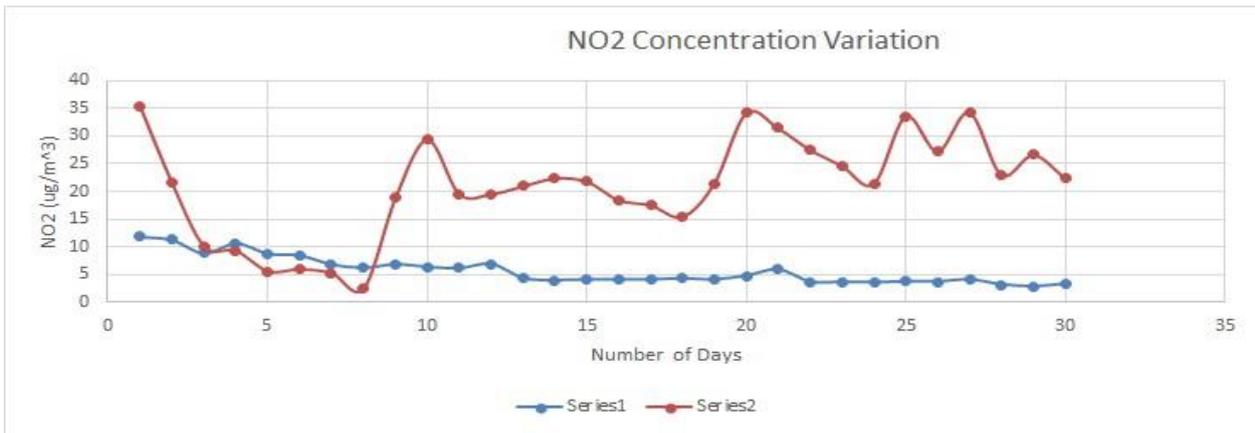
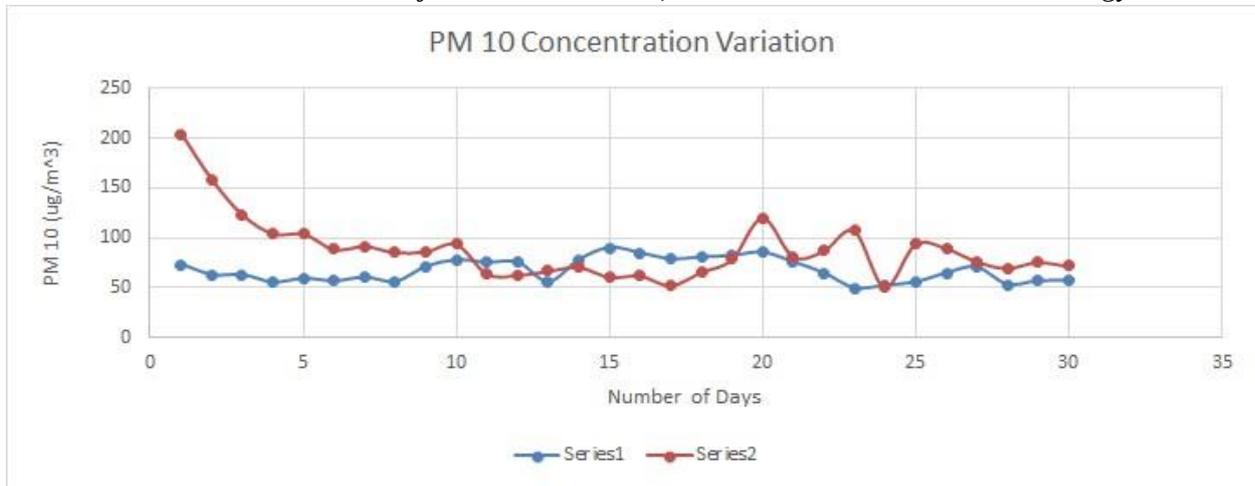
Delhi is one of the most polluted cities in the world and is a highly industrialized area. Besides Ozone, all constituents have a significant reduction in the lockdown period compared to the previous year. Delhi being a high-income city, a major portion of the pollution is contributed by the vehicles, and it is highest compared to any other city. Lockdown, which terminates transport activities, justifies our results. CO and NO<sub>2</sub> levels are above the national average standard, but all other pollutants concentrations are equal to or below the national average.

**(2) Mumbai Pollutant Level Analysis:**

**Blue- 2020**

**Red- 2019**



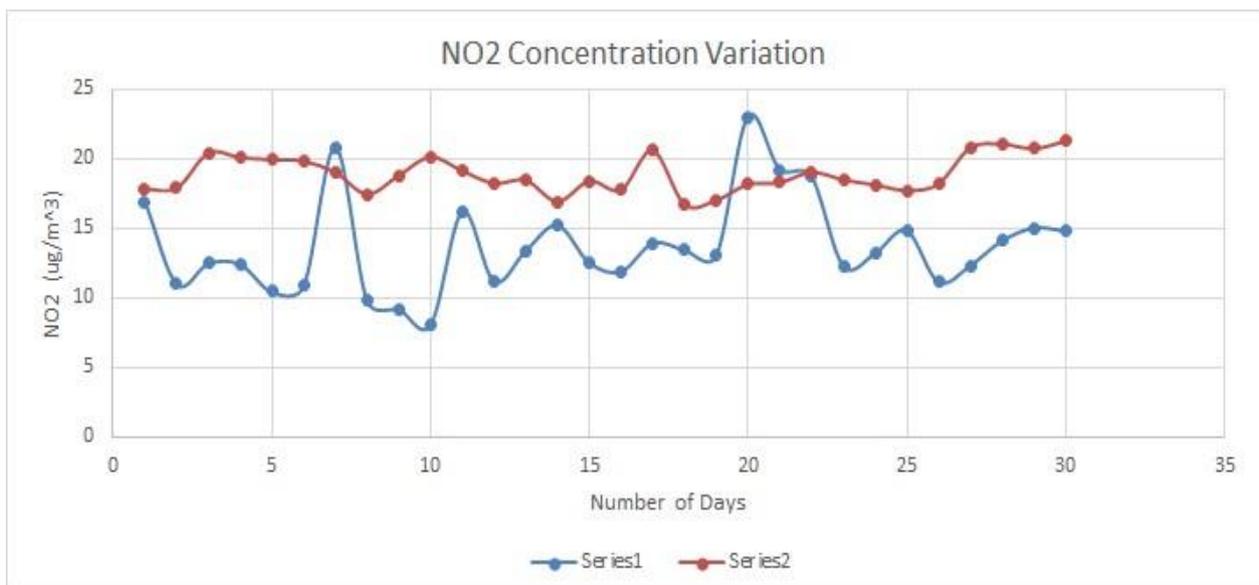
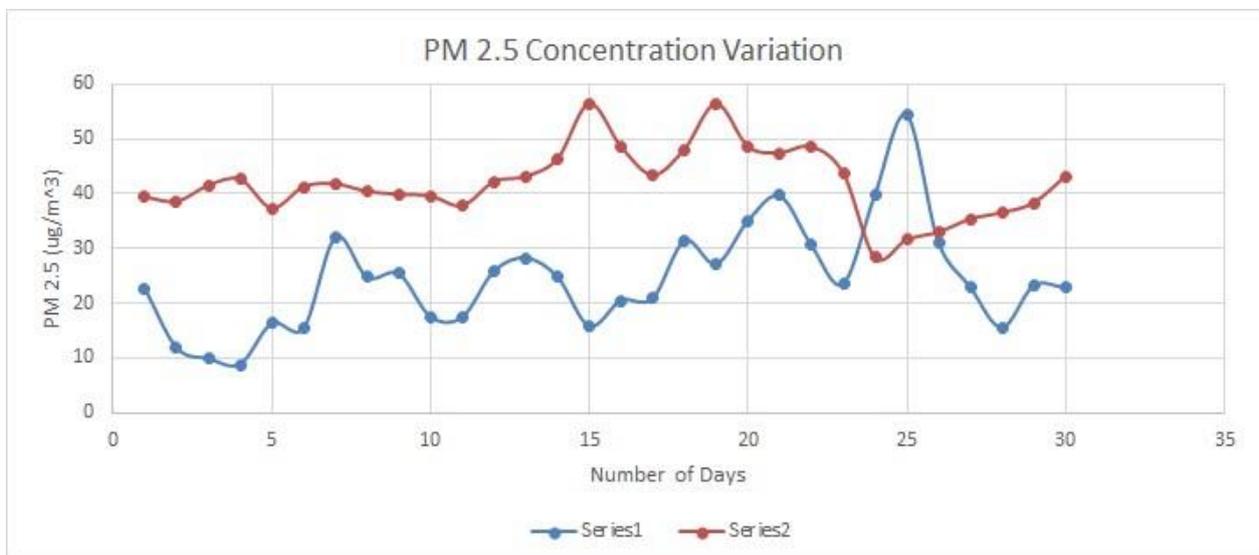
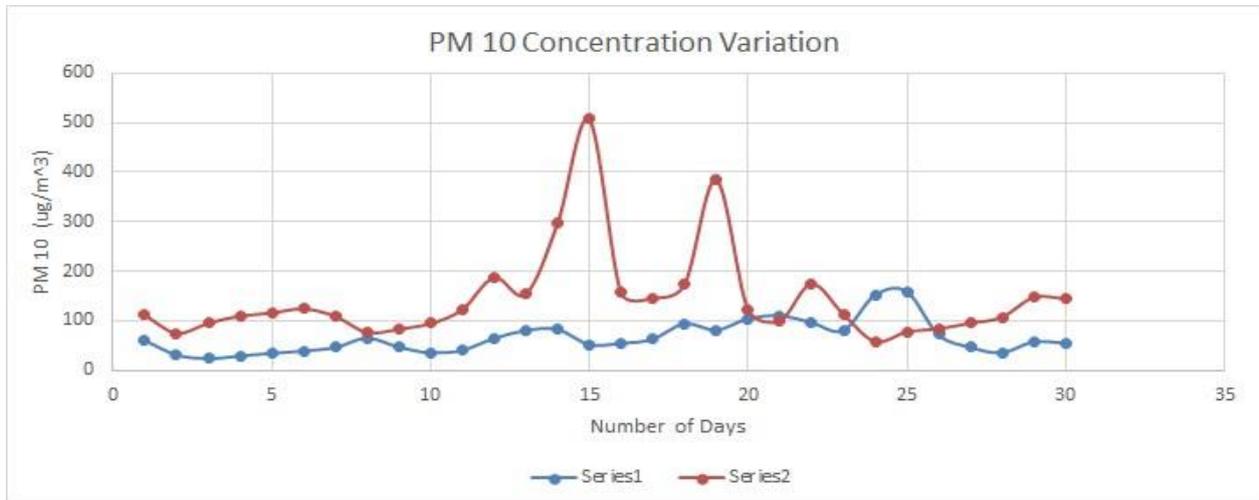


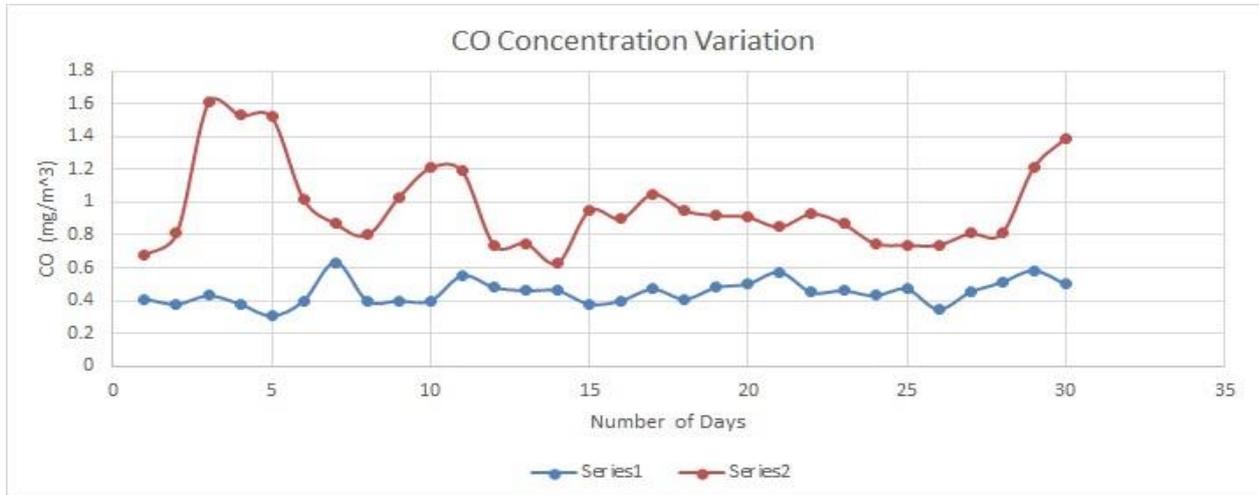
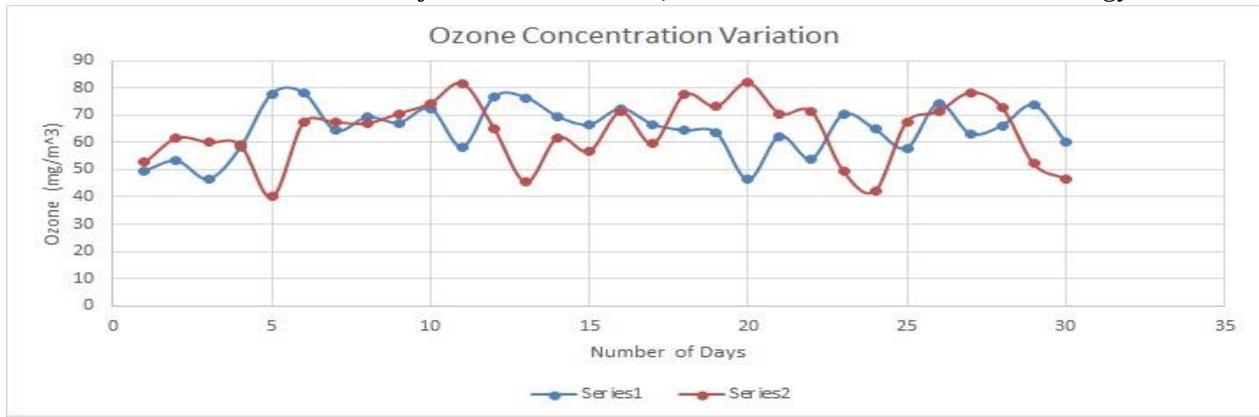
Mumbai, also known as the country's financial capital, is predominant in the economic activities of the tertiary sector. The major contribution to the power supply of the city is thermal and hydroelectric power plants.

There is a sufficient reduction in the concentration of CO and NO<sub>2</sub>, but PM<sub>10</sub> and PM<sub>2.5</sub> observed at the previous year levels. The major contribution for the pollutants could be from the city as vehicle emissions (30 Lakhs) and pollution from the industry at boundaries of the city. Due to the impact on the transport industry, we can observe a reduction in air pollution after lockdown is imposed

**(3)Jaipur Pollutant Level Analysis:**

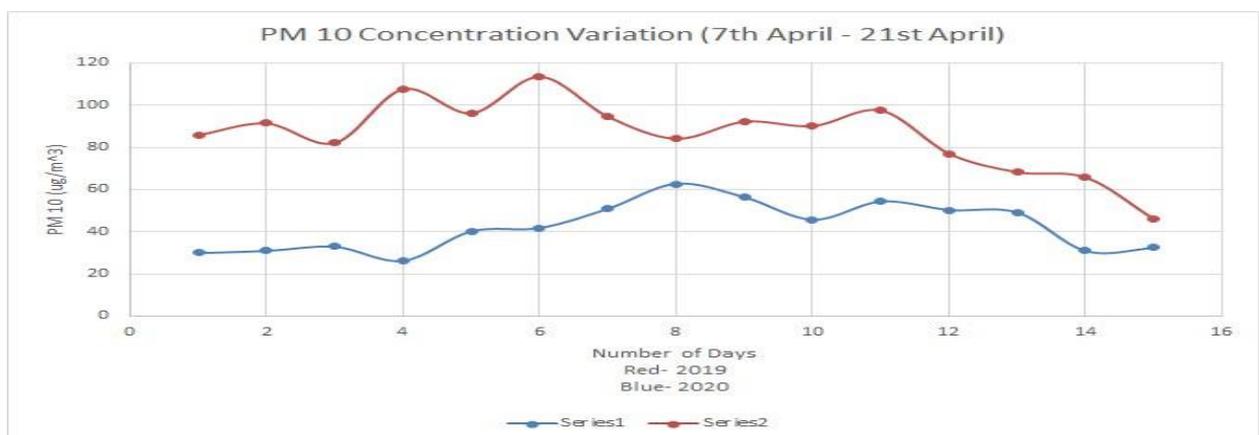
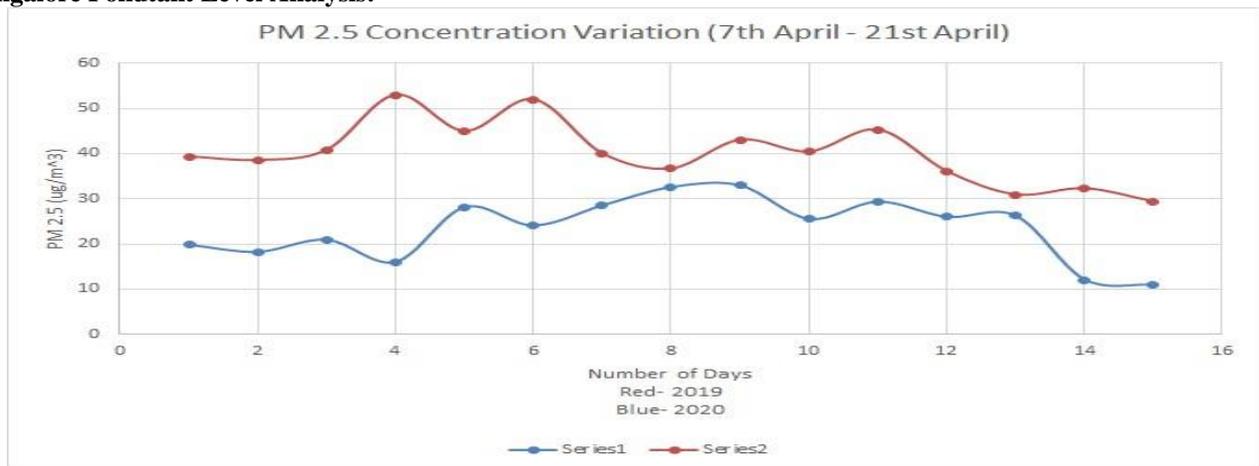
Blue- 2020 Red-2019

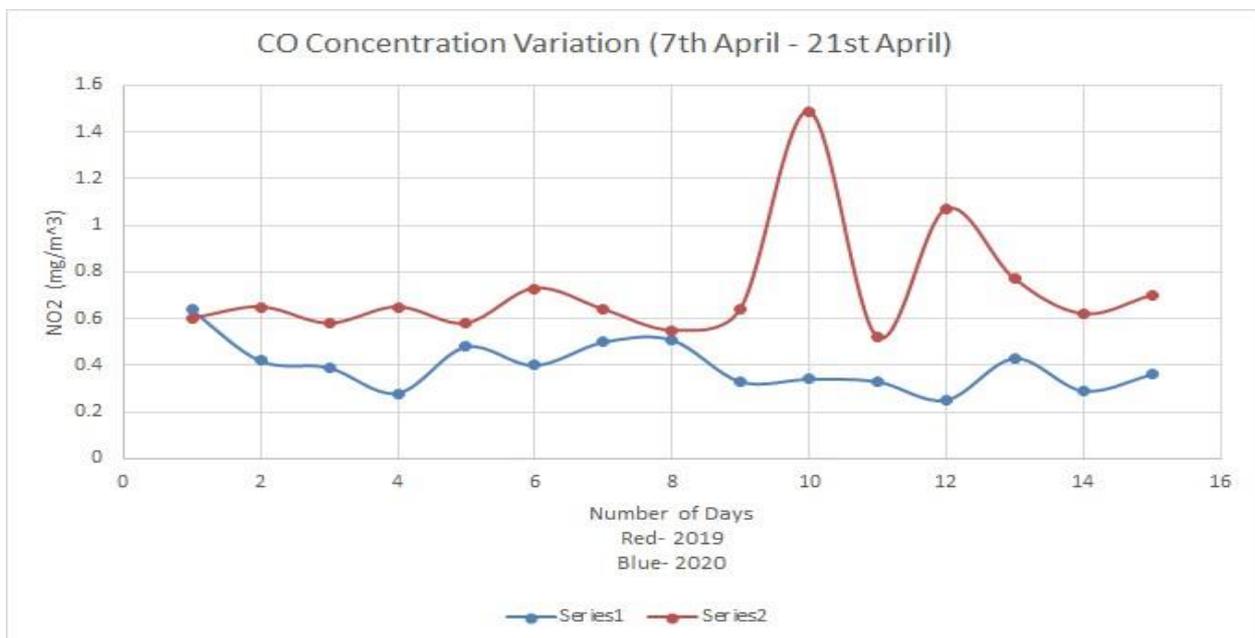
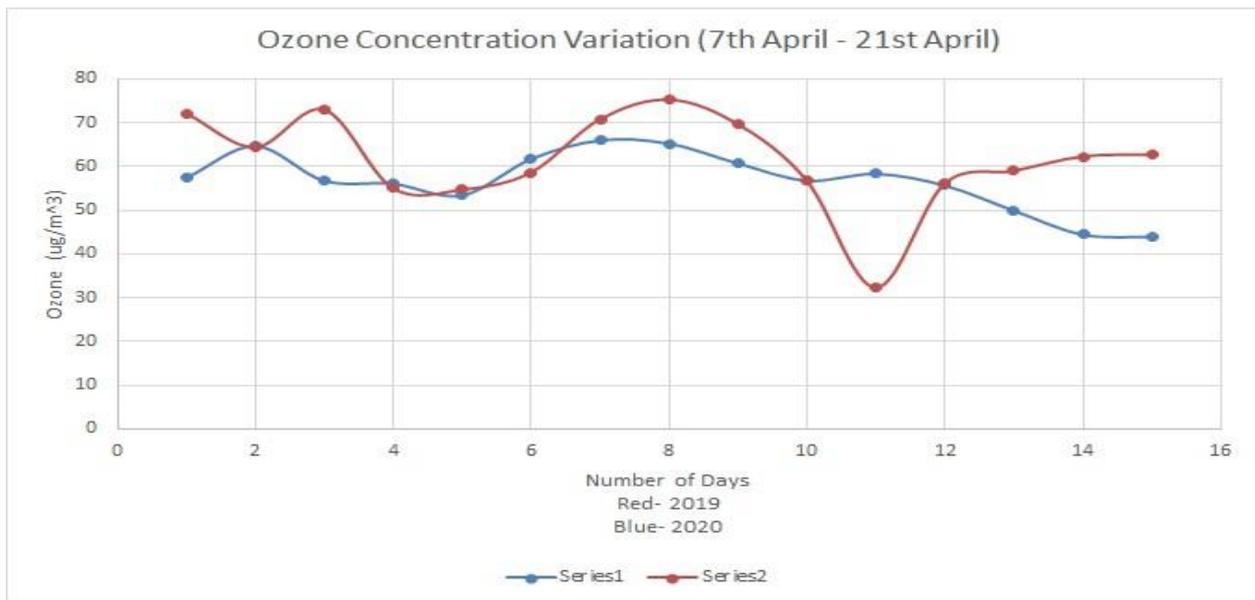




Jaipur has a lower income rate, but predominant in the service sector, and its power supply is majorly contributed by the thermal sector. All types of pollutants that we observe had a significant reduction in concentration except Ozone. Pollutants largely contributed by the construction industry, vehicular exhaust and road dust were completely terminated during the lockdown.

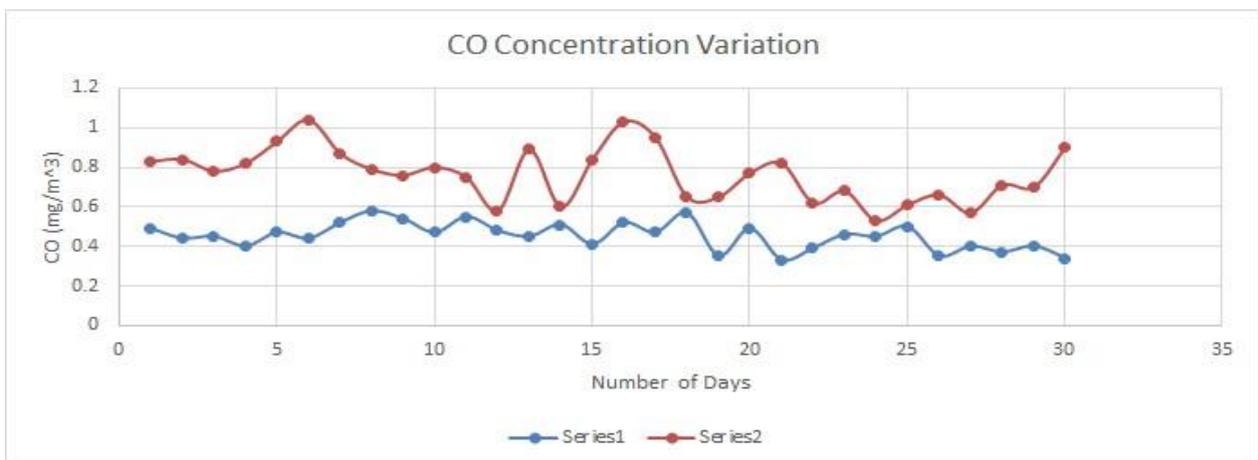
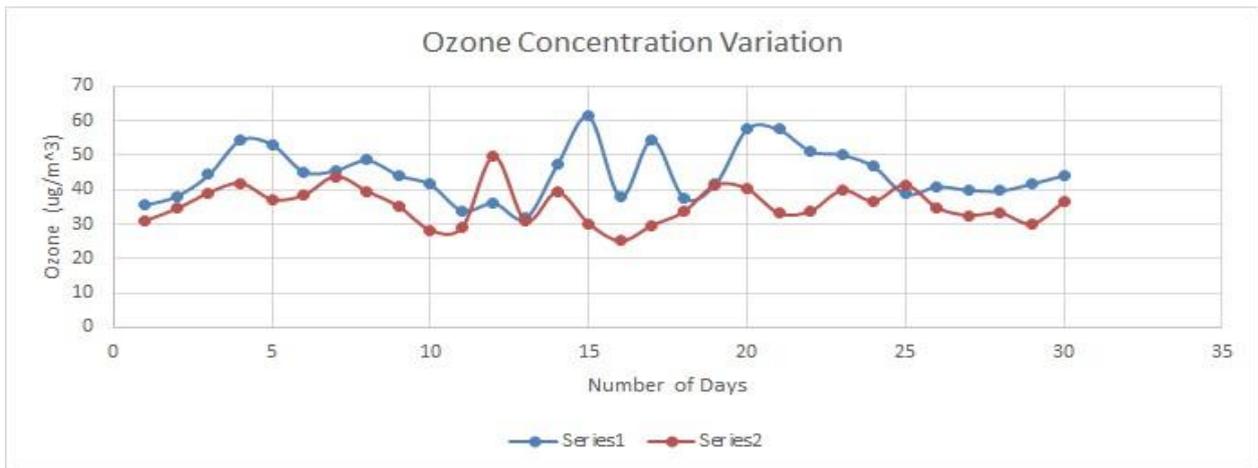
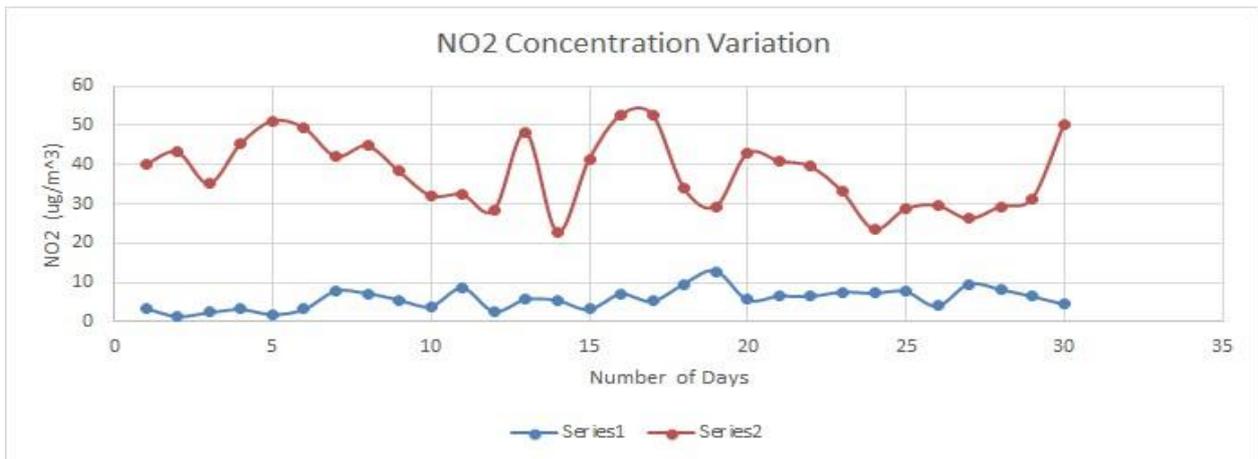
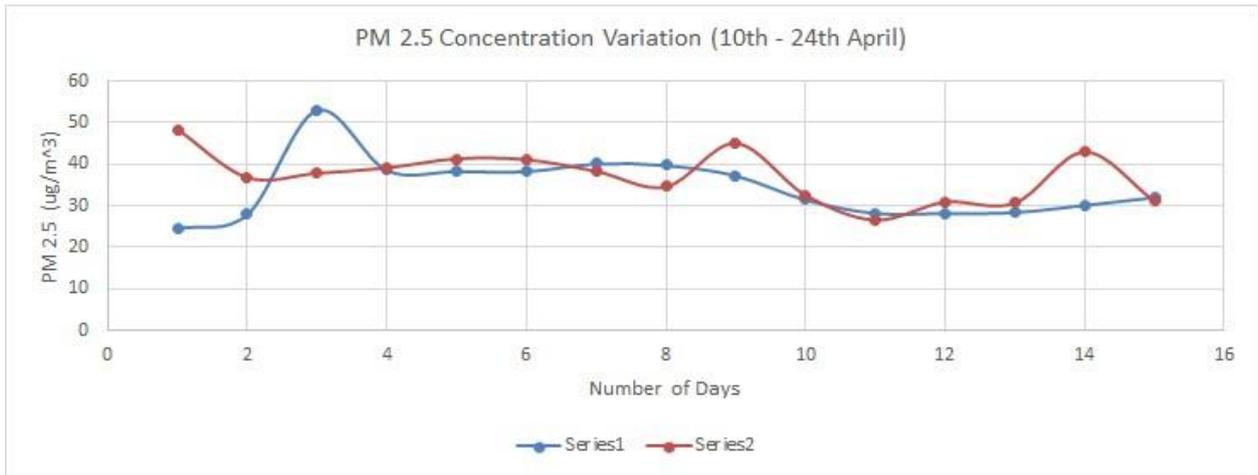
**(4) Bangalore Pollutant Level Analysis:**





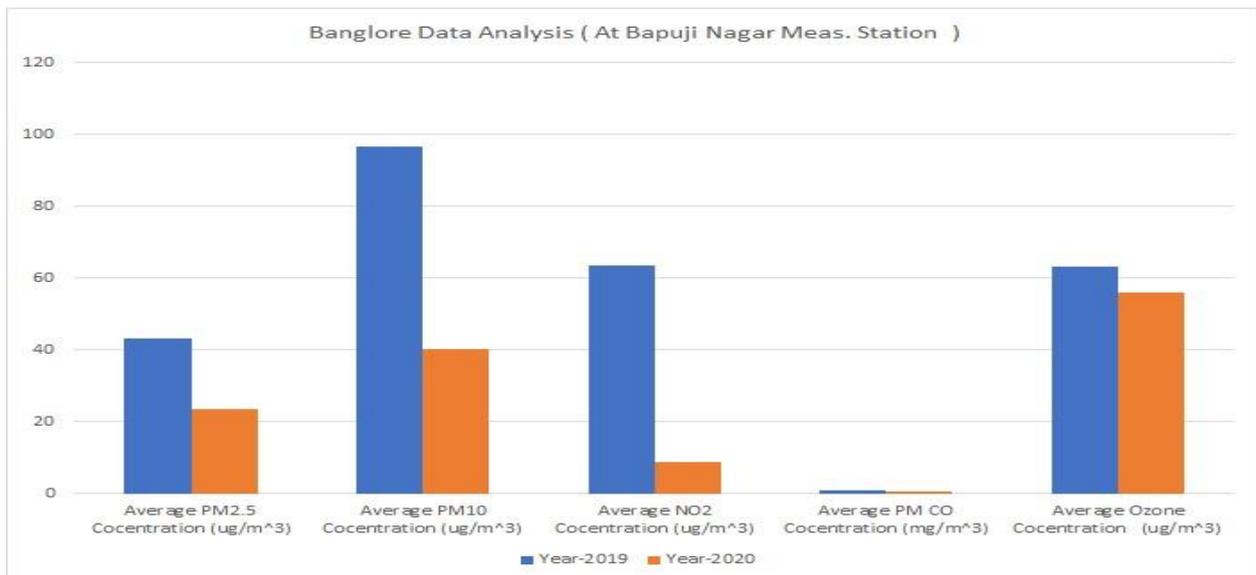
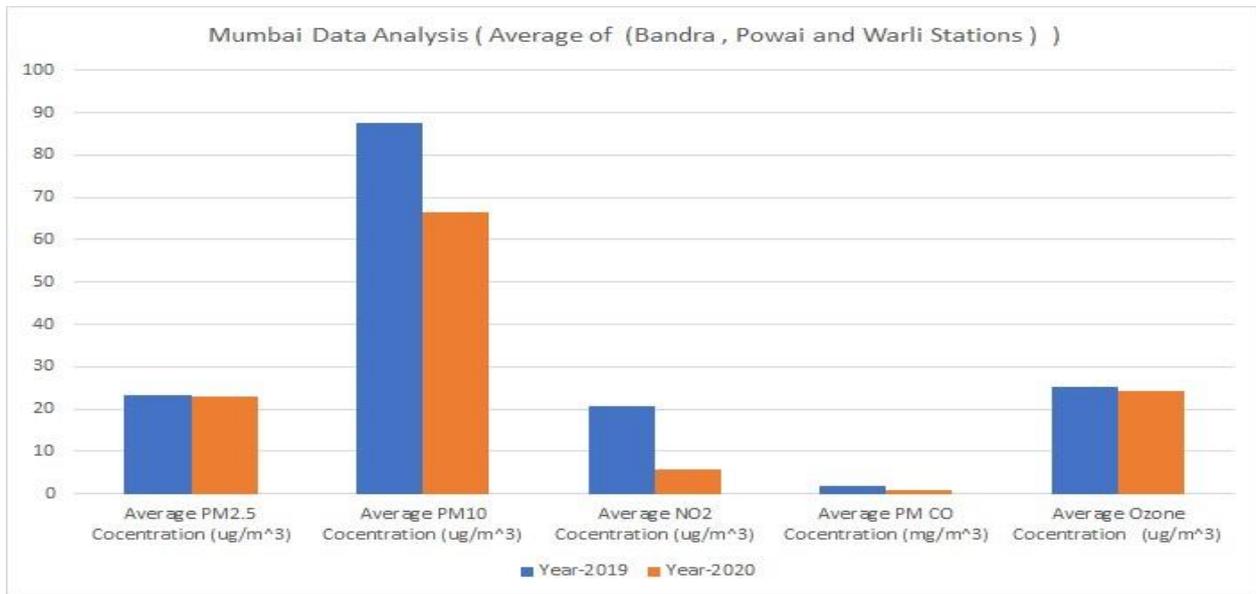
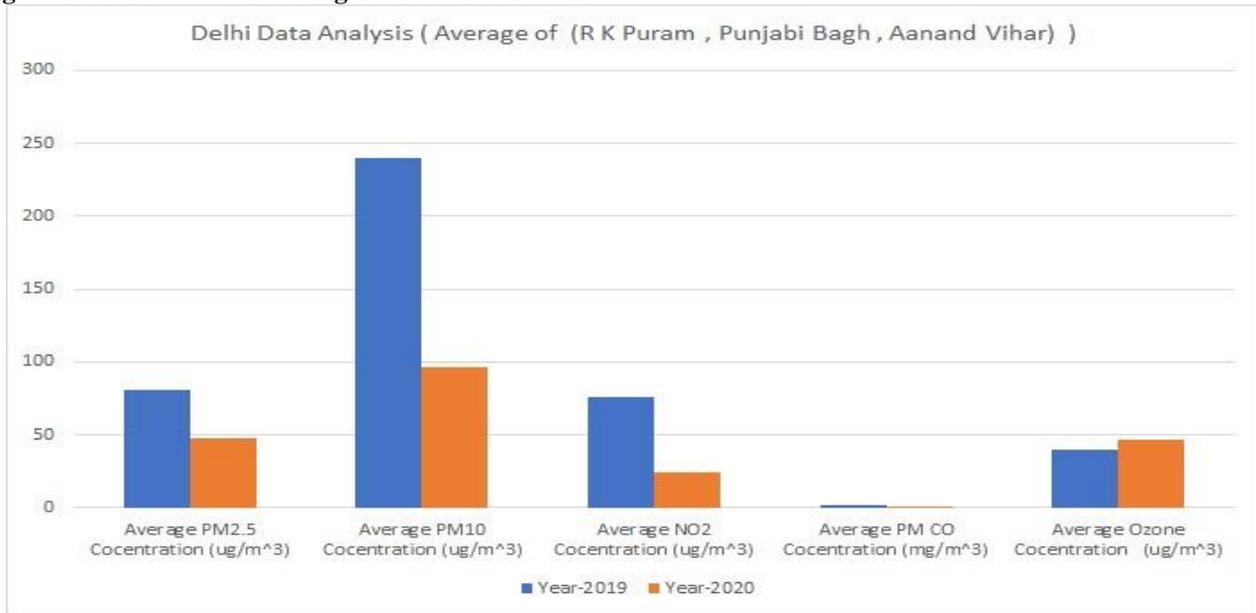
Bangalore also has the same trend in pollution levels during the lockdown as observed in the other city. Except for Ozone, all other pollutants have significant reductions in concentration. Bengaluru has the second largest number of vehicles after Delhi. The pollutant emissions are largely contributed by the transport sector (70%), and this was the sector most affected during the lockdown.

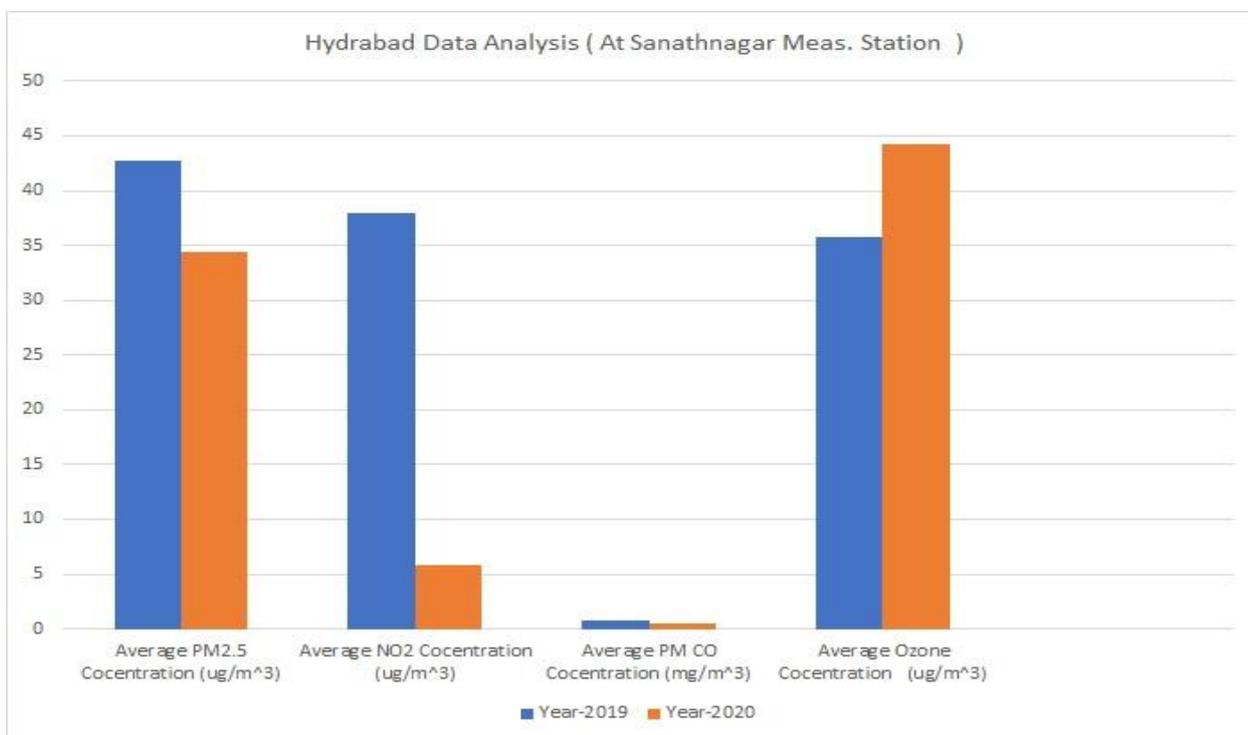
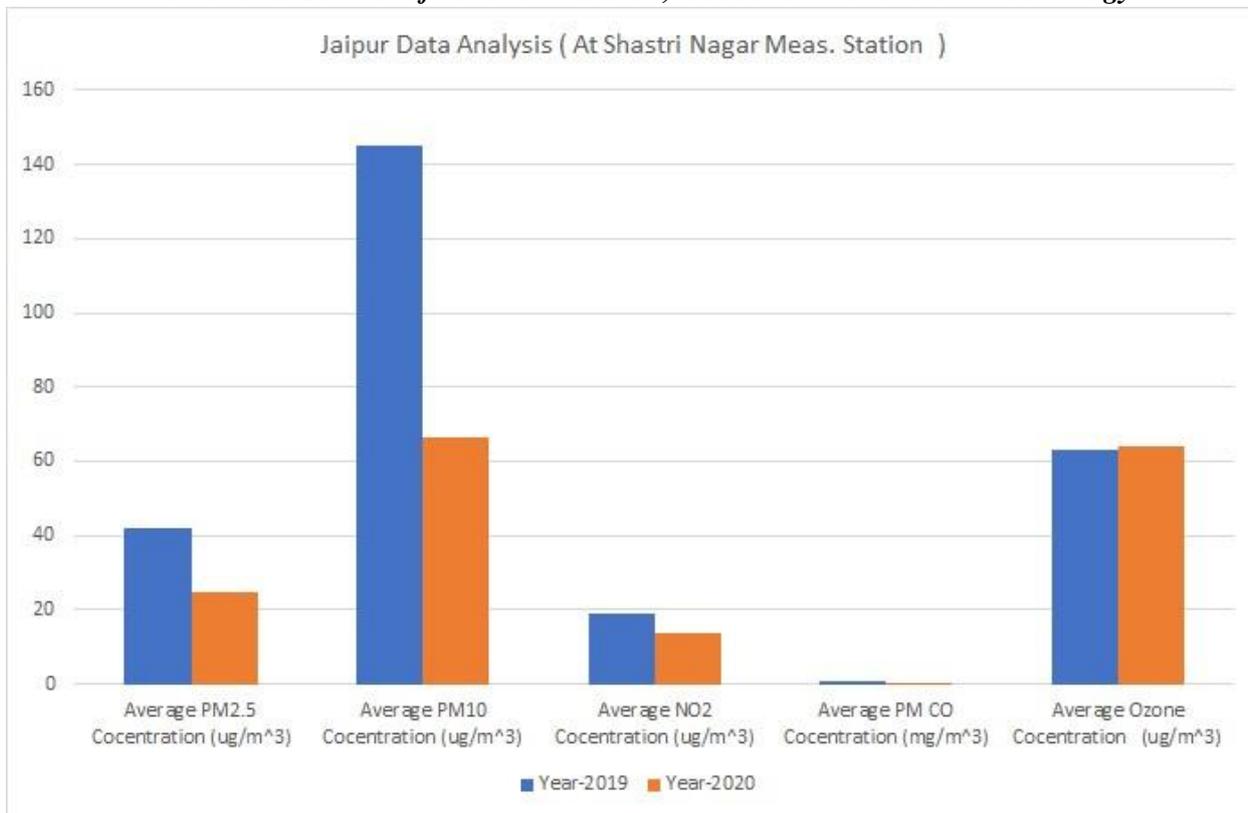
(5) Hyderabad Pollutant Level Analysis  
 Blue-2020 Red-2019



Hyderabad has a large number of industries and vehicles. It is the next developing Bengaluru, so as a developing city, new industries are emerging, and pollutant levels are increasing for years. We observed a significant reduction in the concentration of all the pollutants. All the values during the lockdown are below the national standard average.

**Average Pollution Reduction during Lockdown Across India:-**





Note: The data for PM 10 pollutants for the city of Hyderabad is not available.

### 5. ASSESSMENT AND TAKE-AWAY SOLUTION

**Assessment:** After observing different pollutants for different cities, we found out that though there was a significant reduction in concentration for most pollutants, there are still some cities for which ozone and CO pollutants concentration shows unexpected results. These unexpected results are due to the variability of the source of the pollutants. I want to say that the source of pollutants largely affects its variance through time. Even if the lockdown was imposed still some pollutants show increase in their concentration. This analysis of the source of pollutants for a particular city would be the key point to counter the air pollution of that city and adjust the air quality index accordingly.

**Solutions:** These are solutions provided based on the results and assessment discovered:

- (a) Every city has its major source of pollutants, even they also vary in % source of pollutants. We should be more focused on reducing the emissions for each city to the major source of pollutants. For example, Delhi's major focus should be on

the pollution caused by surrounding areas "Farmers Pulao" burning emissions and transport and road dust pollutions. Still, for Bangalore, the focus should be on cutting pollutions caused by transport emissions.

- (b) As we know, there are two major sources of air pollution in all cities. One is the combustion of fossil fuels, and the other is emissions from factories. The most effective solution is replacing all fossil fuel-based vehicles with electric or renewable energy vehicles, maybe CNG gas used as a fuel. But, in India, this is very low, which is not very effective, so the best way is to prompt the use of electric vehicles in India and provide a large subsidy to incentivize people to use them.
- (c) The next most effective solution would be to reduce the number of vehicles used. More emphasis should be given to the use of public transport and vehicle sharing.
- (d) We should do more research on building green structures and dust-free roads. People should be motivated to research these topics for sustainable development and the betterment of society.
- (e) Vehicles should be replaced by bicycles, and burning of solid waste should be avoided. They should be properly treated with composting in an engineered manner to avoid carbon emissions.

## 6. DISCUSSION

The pandemic and the resultant lockdown have led to a reduction in the concentration of major pollutants. Still, for the Ozone, there was an increase in concentration comparative to last year. As the lockdown was imposed after harvesting Rabi crops like wheat, so large Ozone concentration may be due to the burning of this agricultural residue "Pulao". Due to lockdown, there was a large reduction in NO<sub>x</sub> emissions (like NO), and these pollutants are precursors of the Ozone that results in a high concentration of Ozone. This analysis above provides us with a new challenge to understand the chemistry of a mix of pollutants.

According to NCAP, there is a large prolonged bad effect on the air quality of the cities due to boundaries and regional areas around the city. As per NCAP, In northern India, crop burning is the major source of pollution, contributing more than 50%, which happens after harvesting the crops. Keeping in mind the above facts, a policy (NPMCR) was made in 2014 to control crops residue burning. After that, in 2015, the NGT had implemented the NPMCR in the four states of India. Subsequently, the cabinet formed a law in 2018 to ban or prohibit the burning of crops residue.

Afterwards, keeping in mind the extent of air pollution and its critical condition, the government made a policy called NCAP, which aims to cut the average concentration of PM<sub>2.5</sub> and PM<sub>10</sub> to 20-30% by 2024. In the last few decades, due to all the above changes, the environment department, ministers and concerns with the pollution control board has become an important part of development and prevention.

It is very important to have a good link between human health and high renewable energy efficiency. Some pollutants have more harmful effects than others, but we should still try our best to regain economic recovery, keeping in mind the sustainability and air quality index.

## 7. CONCLUSION

The study done by us considering different cities in India, provides insight into the extent of air pollution reduction and various factors that govern to decide the extent of reduction. There is a great need to provide clean air and water keeping sustainable development in mind. We have to keep in mind that air pollution reduction will also result in better health for our society. There are many diseases (Respiratory disease) that just become severe only due to air pollution.

There we need to think about and invest in research of green energy, technology and infrastructure. For most cities in India, economic growth and pollution levels are increasing together as a unit. It seems as if we can not reduce the relationship in a unit. In the future, we have to think about new types of city plans where new technology with renewable energy is implemented to have a better future for humankind. The covid-19 lockdown provided us with a great insight into it that could not be received or thought otherwise. Now, this insight can be used in the future to have a bright future for humanity. This lockdown provides a great message to humanity that the life of human civilization can not go this way, we are exploiting mother earth from the last many centuries, and it can not go on. Either we have to change the way of development or we will be finished on this planet. The countdown has started, we have to start working now towards a better society and civilization with being together.

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