Temporal Variation of Air Quality Parameters- PM2.5 and PM10 during Lockdown and Post Pandemic in Selected Areas of Delhi, India

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Abstract
Particulate matter is the pollutant generally viewed as most unsafe to human wellbeing. Its minuscule size permits the particles to enter the circulation system by means of respiration, causing asthma and heart disease. COVID-19 has been declared as a Public Health Emergency of International Concern by WHO on 30\textsuperscript{th} January 2020. The objectives of the present study include air quality (with respect to PM2.5 and PM10) monitoring at pre-selected locations during and post COVID-19 phase, comparative assessment of air quality parameters PM2.5 and PM10 concentrations in Delhi during and post COVID-19. To conduct this study the station for air quality monitoring selected is near Hauz Khas metro station, Delhi. Total 4 locations are selected around CPCB Air pollution monitoring station, Hauz Khas. PM sampling has been done for 12 continuous days. The dataset of the time frame (March and April of 2020) of the lockdown phase is collected from CPCB and compared with the dataset of the same time frame (March and April 2021) using excel software. The pollution level drastically increases after the lockdown phase according to present observation and improvement in air quality could not last long after the reopening of industries and vehicular activities.

Keywords: PM2.5, PM10, Monitoring, Lockdown, Temporal variation.

1. Introduction
From the beginning of the 21st century that is industrialization era, the quality of air started to degrade and become toxic to breathe. According to World Health Organisation 2020 report, 90% of people are living in areas which are not matching the standards of healthy air to breathe. The premature deaths of 7 million people are directly or indirectly caused by air pollution.

Air pollution affects the overall ecosystem including humans. The primary sources of air pollution are solid waste burning, coal combustion, industrial emission, biomass burning, vehicular emission, power plants, etc. Indoor pollution is also acting a significant threat these days which are emitted from refrigerators, stove smoke, paints, etc. The poor air quality has adversely affected human health and has
become a global issue. The pandemic COVID-19 has been a blessing for the environment as the air quality drastically improved in India as well as the whole globe. The automobiles, industries, outdoor activities, and pollution-causing activities stopped due to COVID-19 lockdown. It has been demonstrated that the pandemic has improved the air quality worldwide. Many countries such as Spain, Italy, and the UK whereas China and India which remain highly polluted countries have also seen a drop in air pollution during the lockdown. As all the governments strictly maintained the social distancing norms and hence the air quality improvement is said to be influenced by the lockdown imposed. Jasbir Singh Bedi et al., 2020 have observed a major reduction in parameter NO2 of about 29.3% to 74.4%. Shakeel Ahmad Bhat et al., 2021 have investigated reduction in NO2 in China, France, Italy, and Spain. The lockdown has created a positive impact on the environment and has significantly improved the air quality. Pratima Kumari et al., 2020 have recorded that during lockdown the reduction in pollutant emission was PM2.5 (20-34%), PM10 (24-47%), and NO2 (32-64%) respectively. Akvile Feiferyte Škiriene et al., 2021 has recorded the reduction seen during the lockdown period of parameters NO2, PM2.5, PM10 approximately 20-40% in European Countries. Ahmad Hasnain et al., 2021 have done the comparison of PM2.5 and PM10 concentrations during the lockdown period with the past 3 years. Feng Liu et al., 2020 have considered major cities globally to observe a high amount of decrement in a concentration of NO2 of around 23% to 37% as compared to pre lockdown period. Researchers like Shilpi Ghosh et al., 2020; Yogendra Kambalagere (2020) et al., 2020; Ritwik Nigam et al., 2021; Anchal Garg et al., 2021 have discussed the impact of COVID-19 lockdown on improved air quality considering different cities of India. Calvin Jephcote et al., 2021 have investigated that in the urban area i.e. high traffic sites, more improvement in air quality is observed. Iván Y. Hernández-Paniagua et al., 2021 has considered satellite observations to conclude a high amount of reduction in the air pollution in the environment during the lockdown in Mexico City. Meichang Wang et al., 2020 observed that the air quality index (AQI) encounters a 12.2% decrease in the urban communities with the lockdown. Ji Hoon Seo et al., 2020, have recorded Health Benefits due to a reduction in Air pollution during the COVID-19 Pandemic in Korea. Sonal Kumari et al., 2020 have investigated the greatest decrease in PM2.5 and PM10 of about 58% and 57%. In the present study, the variation in the trend of average hourly PM2.5 and PM10 during and post lockdown phase has been observed.

2. Materials and method
The steps involved in PM2.5 and PM10 monitoring include the selection of site, monitoring duration, description of the site, monitoring, and data analysis procedure. All these steps have been discussed in this part.

2.1 Site Selection
The selected air quality monitoring locations are near Hauz Khas metro station, New Delhi, 110016. Total 4 locations are selected around CPCB air quality monitoring station, Siri Fort, Hauz Khas. All these 4 locations are distant at least 100 to 200 meters from each other. The area covered in this monitoring in this study is about 35,410.33 m². The locations have been selected based on distance as well as the angle between them. Siri Fort which is the 4th location of monitoring is considered in the center and all three
locations are 120° from each other. To measure the angle, a Google protractor extension is used. The protractor extension is used on the Google earth computer program.

**Table 1.** Location specifications with monitoring duration.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Location</th>
<th>Latitude and Longitude</th>
<th>Monitoring Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Location 1</td>
<td>Latitude: 28.5490498, Longitude: 77.2163653</td>
<td>26th March to 28th March (2021)</td>
</tr>
<tr>
<td>2.</td>
<td>Location 2</td>
<td>Latitude: 28.5499373, Longitude: 77.2151354</td>
<td>29th March to 31st March (2021)</td>
</tr>
<tr>
<td>3.</td>
<td>Location 3</td>
<td>Latitude: 28.5499373, Longitude: 77.2151354</td>
<td>1st April to 3rd April (2021)</td>
</tr>
</tbody>
</table>

**Fig. 1:** Monitoring locations

2.2 **PM Monitoring Procedure**

A total 4 (four) locations/sites have been selected for monitoring purposes and all of them are nearby Siri Fort, Hauz Khas. At each location/site, PM sampling has been done for 12 continuous days. A sampling of PM2.5 and PM10 has been done every 10 minutes in an 8-hour window (10 am to 6 pm). Then the hourly
average is calculated. All the monitoring is done in March and April. Each site was monitored for continuous 3 days. Hence total of 12 days of monitoring continued for all four locations. The monitoring has started from 26th March 2021 till 6th April 2021.

2.3 Data Analysis Procedure

After the sampling of PM, the data has been inserted in Microsoft Excel to find the temporal variations of the PMs. This is done to get an idea about the trend of emission of PMs on the preselected locations during the lockdown period and post lockdown period. The data of lockdown period i.e. of March and April of the year 2020 is collected from Central Pollution Control Board. The data monitored for this study is of the period March and April of the year 2021. The comparison of air quality data from the lockdown period of the year 2020 and the post lockdown period of the year 2021 of the same time frame is done in this study. The graphs are then plotted to show the variation of PM2.5 and PM10 during and post lockdown period.

3. Results and discussion

The temporal variations of particulate matter during (March-April 2020) and post COVID-19 lockdown phase (March- April 2021) is discussed in this section. The comparison between both these variations on a preselected location is done in this part of study.

3.1 Comparison of Particulate Matters during and Post- Lockdown Period

The comparison of particulate matters i.e. PM2.5 and PM10 is done by calculating average hourly data. The comparison is done of the same time frame of the years 2020 and 2021. The results shown are for 12 days i.e. from 26th of March to 6th of April of the year 2020 as well as 2021. There is a total of 4 locations of monitoring in this study. Monitoring of 3 days is done at each location. The time frame for both years is considered the same so that the variation in weather and climate conditions will not affect the air quality. The comparison in air quality during and post lockdown period is done in the form of graphical representation using an excel tool. The comparison is shown from morning 10 am to evening 5 pm.

Figure 2 is showing the comparison of PM of the day 26th March (1st day) of the year 2021 and 2020 at location 1. The maximum value of PM2.5 observed on this monitoring day i.e. year 2021 is 151 µg/m³ at 11:00 am. And at the same time, the concentration of PM2.5 in the year 2020 observed is 78 µg/m³ which is quite low as compared to the concentration observed in the year 2021. The minimum concentration of PM2.5 observed in the year 2021 on this monitoring day is 78 µg/m³ at 4:00 pm in the evening. The concentration of PM2.5 on the same day at the same time of the year 2020 is observed as 30 µg/m³ which is also very low as compared to the concentration of the year 2021. And likewise, the comparison of PM10 is also conducted. The maximum concentration of PM10 noted on this day of the year 2021 is 239 µg/m³ at 1:00 pm and if the same time frame is considered for the year 2020 the concentration of PM10 is 57 µg/m³. The minimum concentration of PM10 on 26th March 2021 is noted 159 µg/m³ at 5:00 pm. And if the same time and same day are considered for the year 2020 then this concentration is 49 µg/m³ as shown clearly with the help of and graph. Which is quite low as compared to post lockdown phase concentration. This study shows an enormous increase in pollution levels after the lockdown period. The trend is clearly shown in the graphs.
Fig. 2: Comparison of hourly PM concentration of date 26-03-2021 with 26-03-2020

Similarly, figure 3 is representing the comparison of PM of the day 27th March (2nd day) of the year 2021 and 2020. The peak of PM2.5 (311 µg/m³) obtained on this day of the year 2021 is at 10:00 am. And at the same time, the concentration of PM2.5 (59 µg/m³) in the year 2020 observed is quite low as compared to the concentration observed in the year 2021. And likewise, the comparison of PM10 is also conducted. The trend shown for the year 2021 is very high as compared to the year 2020.

Fig. 3: Comparison of hourly PM concentration of date 27-03-2021 with 27-03-2020

Likewise, figure 4 is showing the comparison of PM of the day 28th March (3rd day) of the year 2021 and 2020. The maximum value of PM2.5 observed on this monitoring day i.e. year 2021 is 281 µg/m³ at
10:00 am. And at the same time, the concentration of PM2.5 in the year 2020 observed is 59 µg/m³ which is quite low as compared to the concentration observed in the year 2021. And likewise, the comparison of PM10 is also conducted. The maximum concentration of PM10 noted on this day of the year 2021 is 409 µg/m³ at 10:00 am and if the same time frame is considered for the year 2020 the concentration of PM10 is 68 µg/m³. The data collected for the year 2021 is again showing a very high trend.

Fig. 4: Comparison of hourly PM concentration of date 28-03-2021 with 28-03-2020

Fig. 5: Comparison of hourly PM concentration of date 29-03-2021 with 29-03-2020
In figure 5 the comparison of PM2.5 and PM10 of date 29th March (4th day) is representing that almost all the concentrations noted after the lockdown period is above the concentration prescribed by CPCB as well as during lockdown concentrations. The maximum value of PM2.5 observed on this monitoring day i.e. year 2021 is 296 µg/m$^3$ at 10:00 am. If the same time frame of the year 2020 is considered then the concentration noted of PM2.5 is 66 59 µg/m$^3$. And the maximum concentration of PM2.5 in the year 2020 observed is 127 µg/m$^3$. And likewise, the comparison of PM10 is also conducted.

Figure 6 represents the comparison of PM of the day 30th March (5th day) of the year 2021 and 2020. The maximum value of PM2.5 observed on this monitoring day i.e. year 2021 is 406 µg/m$^3$ at 05:00 pm. And at the same time, the concentration of PM2.5 in the year 2020 observed is 69 µg/m$^3$ which is quite low as compared to the concentration observed in the year 2021. And likewise, the comparison of PM10 is also conducted. The trend of 30th March is a little different for PM10 from previous records. Somehow the post lockdown concentration of PM10 is quite less than the lockdown period concentration on this day.

![Fig. 6: Comparison of hourly PM concentration of date 30-03-2021 with 30-03-2020](image)

Figure 7 is showing the comparison of PM of day 31st March (6th day) of the year 2021 and 2020. The maximum value of PM2.5 observed on this monitoring day i.e. year 2021 is 240 µg/m$^3$ at 10:00 am. And the maximum concentration of PM2.5 in the year 2020 observed was 59 µg/m$^3$ which is quite low as compared to the concentration observed in the year 2021. In a similar way, the comparison of PM10 is also conducted. Almost all the values noted during the lockdown period are within the CPCB prescribed limits and low as compared to the post lockdown phase.
Figure 8 is showing the comparison of PM of the day 1st April (7th day) of the year 2021 and 2020. The maximum value of PM2.5 observed on this monitoring day i.e. year 2021 is 151 µg/m³ at 10:00 am. And at the maximum concentration of PM2.5 on this day in the year 2020 observed is 82 µg/m³. Similarly, the comparison of PM10 is also conducted. The maximum concentration of PM10 noted on this day of the year 2021 is 242 µg/m³ and if the maximum concentration is considered for the year 2020 the concentration of PM10 is 68 µg/m³.
Figure 9 is representing the comparison of PM of the day 2nd April (8th day) of the year 2021 and 2020. The maximum value of PM2.5 observed on this monitoring day i.e. year 2021 is 301 µg/m³ at 10:00 am. And at the same time, the concentration of PM2.5 in the year 2020 observed is 47 µg/m³. Similarly, the maximum concentration of PM10 noted on this day of the year 2021 is 198 µg/m³ at 10:00 am and if the same time frame is considered for the year 2020 the concentration of PM10 is 68 µg/m³.

![Fig. 9: Comparison of hourly PM concentration of date 02-04-2021 with 02-04-2020](image)

Figure 10 is showing the comparison of PM of day 3rd April (9th day) of the year 2021 and 2020. The maximum value of PM2.5 observed on this monitoring day i.e. year 2021 is 120 µg/m³ at 10:00 am. And at the same time, the concentration of PM2.5 in the year 2020 observed is 113 µg/m³ which is quite low as compared to the concentration observed in the year 2021. And likewise, the comparison of PM10 is also conducted. The maximum concentration of PM10 noted on this day of the year 2021 is 251 µg/m³ at 10:00 am and if the same time frame is considered for the year 2020 the concentration of PM10 is 111 µg/m³.

![Fig. 10: Comparison of hourly PM concentration of date 03-04-2021 with 03-04-2020](image)
Similarly, figure 11 is showing the comparison of PM of the day 4th April (10th day) of the year 2021 and 2020. The maximum value of PM2.5 observed on this monitoring day i.e. year 2021 is 253 µg/m³ at 11:00 am. And at the same time, the concentration of PM2.5 in the year 2020 observed was 56 µg/m³ which is quite low as compared to the concentration observed in the year 2021. And likewise, the comparison of PM10 is also conducted. The maximum concentration of PM10 noted on this day of the year 2021 is 188 µg/m³ at 10:00 am and if the same time frame is considered for the year 2020 the concentration of PM10 is 110 µg/m³.

Figure 12 is showing the comparison of PM of the day 5th April (11th day) of the year 2021 and 2020. The maximum value of PM2.5 observed on this monitoring day i.e. year 2021 is 237 µg/m³ at 12:00 pm. And at the same time, the concentration of PM2.5 in the year 2020 observed was 81 µg/m³ which is quite low as compared to the concentration observed in the year 2021. And likewise, the comparison of PM10 is also conducted. The maximum concentration of PM10 noted on this day of the year 2021 is 237 µg/m³ at 12:00 pm and if the same time frame is considered for the year 2020 the concentration of PM10 is 89 µg/m³. This day of monitoring is also showing a similar trend as before. The concentration of PM after the lockdown phase is high as compared to during the lockdown period.
Figure 13 is showing the comparison of PM of the day 6th April (12th day) of the year 2021 and 2020. The maximum value of PM2.5 observed on this monitoring day i.e. year 2021 is 327 µg/m³ at 10:00 am. And at the same time, the concentration of PM2.5 in the year 2020 observed was 203 µg/m³ which is less as compared to the concentration observed in the year 2021. And likewise, the comparison of PM10 is also conducted. The maximum concentration of PM10 noted on this day of the year 2021 is 407 µg/m³ at 5:00 pm and if the same time frame is considered for the year 2020 the concentration of PM10 is 67 µg/m³. The highest trend of PM is observed on 6th April (post lockdown) as compared to the trend noted in previous monitoring days.
4. Conclusions

The comparison done in this investigation clearly shows variation in particulate matters i.e. PM2.5 and PM10 concentration. The same time frame of the years 2020 and 2021 has been considered to conduct this study. March and April months of the year 2020 when the lockdown was imposed and hence vehicular as well as industrial activities were stopped. That is the reason for the sudden reduction in the pollution level of air in lockdown. This is obvious from this study that lockdown improved the quality of air enormously. The graphs are showing a surprisingly low trend of particulate matter in the lockdown period. This is evident from the results that the major reason for elevated concentrations of air pollutants is due to vehicular emission which is also the chief cause of PM emissions. As the vehicular movement was less during lockdown hence the data obtained after the lockdown period is higher than the prescribed limit. Other factors that have affected the increased particulate matter in the environment after lifting the lockdown are industrial emissions and construction activities etc. The unsealed roads cause a lot of dust around and that is also a major issue to deal with and participate in adding particulate matter to the environment.

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References