



SPATIO-TEMPORAL VARIATION STUDY OF AMBIENT AIR QUALITY IN NASHIK CITY AMID COVID 19 LOCKDOWN: A GIS APPROACH

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Abstract— India placed countrywide limitations on individuals' freedom of travel during the final week of March 2020 to track the spread of the new coronavirus (COVID-19) (lockdown). India had a substantial drop in particulate matter (PM) concentrations despite its economy being shut down by regulations. In India, the concentration of air pollution and its consequent health impacts are quickly rising. This study was designed to analyse the spatial and temporal variations of particulate matter (PM_{2.5}, PM₁₀) concentrations in Nashik city, Maharashtra. The daily PM_{2.5} and PM₁₀ concentrations monitored by the sensors at the different locations distributed in the study region were used for the analysis. The descriptive statistics indicate that the spatial mean of average PM_{2.5} concentrations ranged from 59.4524 µg/m³ to 9.9034 µg/m³ and average PM₁₀ concentration ranged from 69.66 to 11.4906 µg/m³. The maximum and minimum spatial variousness were observed in March 2021 (no lockdown) and June 2021 (fifth lockdown period). The study also analysed the PM_{2.5} and PM₁₀ air quality index. The AQI value was determined according to the Government of India, Ministry of Environment, Forest and Climate Change. The result suggests that most of the area had the moderate to unhealthy category of PM_{2.5}-AQI & PM₁₀-AQI, which leads to severe breathing discomfort for people in the area. It was observed that the air quality level was worst during March 2021, when there was no lockdown and sound in June with the highly restricted lockdown. For the spatial analysis done with the help of QGIS, an Inverse Distance Weighted (IDW) interpolation technique is used. Furthermore, the overall result shows a decrement in the air quality index AQI during the lockdown compared to pre-lockdown.

Keywords— lockdown, PM_{2.5}, PM₁₀, AQI, interpolation, IDW

I. INTRODUCTION

Most of the world's population lives in cities hubs of economic development and innovation. However, cities are particularly susceptible to stresses like natural and artificial disasters due to the great concentration of people and activity there. With this in mind, a large amount of research on the effects of various calamities on cities, as well as the essential preparation, recovery, and adaptation steps that need to be done to deal with such disasters, has been published during the past several decades. Even though pandemics had impacted cities previously throughout human history, there was little written about them before the appearance of the COVID-19 pandemic (Matthew and McDonald, 2006). According to Bayram (2008), Neck (1994), Colls (2002), and Fenger (2002), particulate matter (PM₁₀ and PM_{2.5}), sulphur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO), and ozone (O₃) are the primary air pollutants in metropolitan environments. Harikesh Singh, Gowhar Meraj, Sachchidanand Singh, Vaibhav Shrivastava, Vishal Sharma, Majid Farooq, Shruti Kanga, Suraj Kumar Singh, and Pankaj Kumar performed research on air pollution during COVID-19-induced lockdown in Delhi, the relationship between the air quality and the SARS-CoV-2-related national lockdown for the city of Delhi using GIS technology. Data were collected from about 37 CAQM sites both before and after the lockdown. The air quality index for the city dropped by over 37%. They were owing to the shutdown, 46% in terms of PM_{2.5} and PM₁₀, respectively. Another study was carried out by Amit Kumar Mishra, Prashant Rajput, Amit Singh, Chander Kumar Singh, and Rajesh Kumar Mall on lockdown effects in 16 Indian cities. They concluded that When compared to their concentrations during the last time in the years 2017-2019, air contaminants examined herein show a striking drop in their abundance throughout the lockdown period (termed reference period). A study by Watts and Kommenda (2020) revealed a sharp decrease in air pollutants during industrial stoppage. Cadotte (2020) also noted a decline in air pollution in the world's largest cities, where the COVID-19 epidemic is at its strongest. Ogen (2020) discovered a significant correlation between NO₂ concentration and COVID-19-related death outcomes. According to Coccia's (2020) research, PM₁₀ and ozone pollution, in particular, significantly impact the acceleration and widespread dissemination of COVID-19 in the provincial capitals of northern Italy. The methods used in GIS technology made tracking changes in the Air Quality Index easier.

Additionally, geo-visualisation with GIS has shown to be a more effective way to track air pollution. Hence in this study, it has been decided to conduct an AQI analysis of the study area Nashik City using GIS.

II. STUDY AREA AND DATA

For this research, Nashik City was decided as the study area. Due to its favourable location in the Mumbai-Pune-Nashik Golden Triangle, it is a rapidly rising area with enormous growth potential. Due to this, Nashik City is now a prime site for new industrial and commercial buildings. To collect the air observation samples, 14 locations were chosen. Still, due to some technical issues with the air pollutant sensors at a few locations, it was decided to continue with the functional stations only. So, data was obtained from the following eight stations Indira Nagar, Nandur Naka, Cidco, Jail Road, Datta Mandir, Dwarka Circle Panchyavati Karanjya, Pathardi Gaon. So only that much of the area is considered out of the entire city for easy analysis. The area of the considered station is 146.133 km², which lies between 73.70 and 73.87 North Latitude and 19.90 and 20.03 East Longitude. The selected area for the study is depicted in Fig. 1.

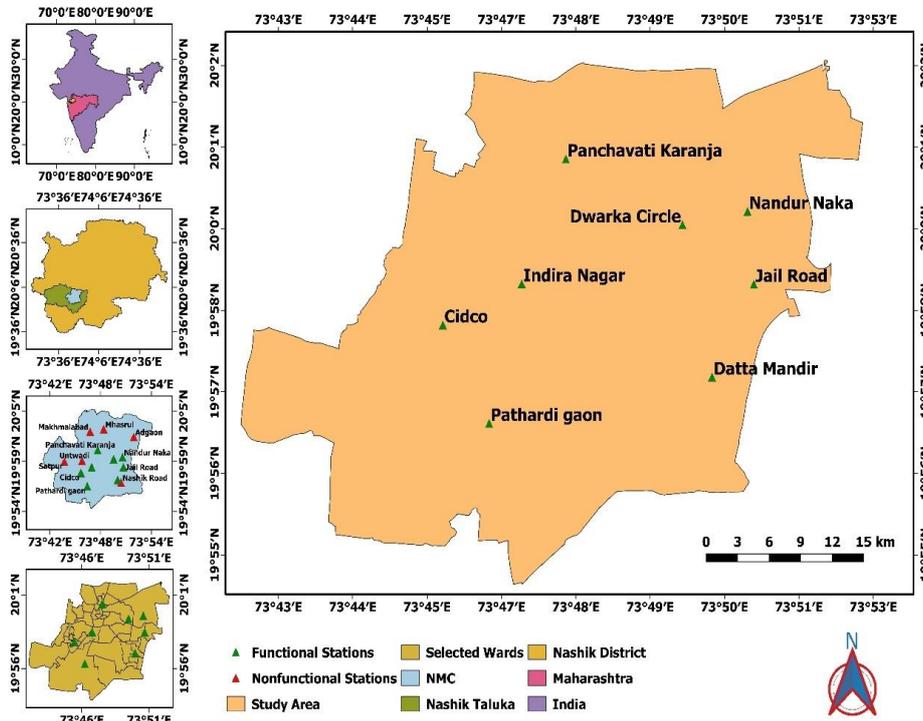


Figure 1: Proposed Study Area Map

Growth Of Population

As per the 2011 census, the total population of the entire area of Nashik Municipal Corporation, was 14,86,053 souls as against the 2001 census population of 10,77,236 souls, indicating a growth rate of 37.95% during the 2001-2011 decade. Similarly, the population for 1991 was 7,33,000 souls indicating decadal growth of 46.96%.

III. Methodology

The data was taken from outdoor monitor sensors placed at various stations by the private agency. The measurement of particulate matter was taken daily with the measurement unit micro gm/ cub m.

The first step includes the processing of data. Data used in this study are from 8 stations, air pollutants, and GIS data. The two pollutants (PM_{2.5} and PM₁₀) were considered in air pollution data between 14 March 2021 to 14 June 2021.

The date range for the study was split into six sections, and the average values were considered. One is the average from 14 March 2021 (before lockdown) to 4 April 2021, the second is the average from 4 April 2021 to 20 April 2021 (1st week of lockdown with low restrictions), the third week of lockdown is the average from 21 April 2021 to 5 May 2021 (2nd week of lockdown with moderate restrictions), forth is the average of 6 May 2021 to 20 May 2021 (3rd week of lockdown with moderate restrictions), the finish is the average from 21 May 2021 to 5 June 2021 (4th week of lockdown with high restrictions), six is the average from 6 June 2021 to 14 June 2021 (5th week of lockdown with high restrictions).

The GIS dataset includes the administrative boundary of Nashik districts and locations of stations in the study area. The adopted methodology flow chart is shown in Figure.

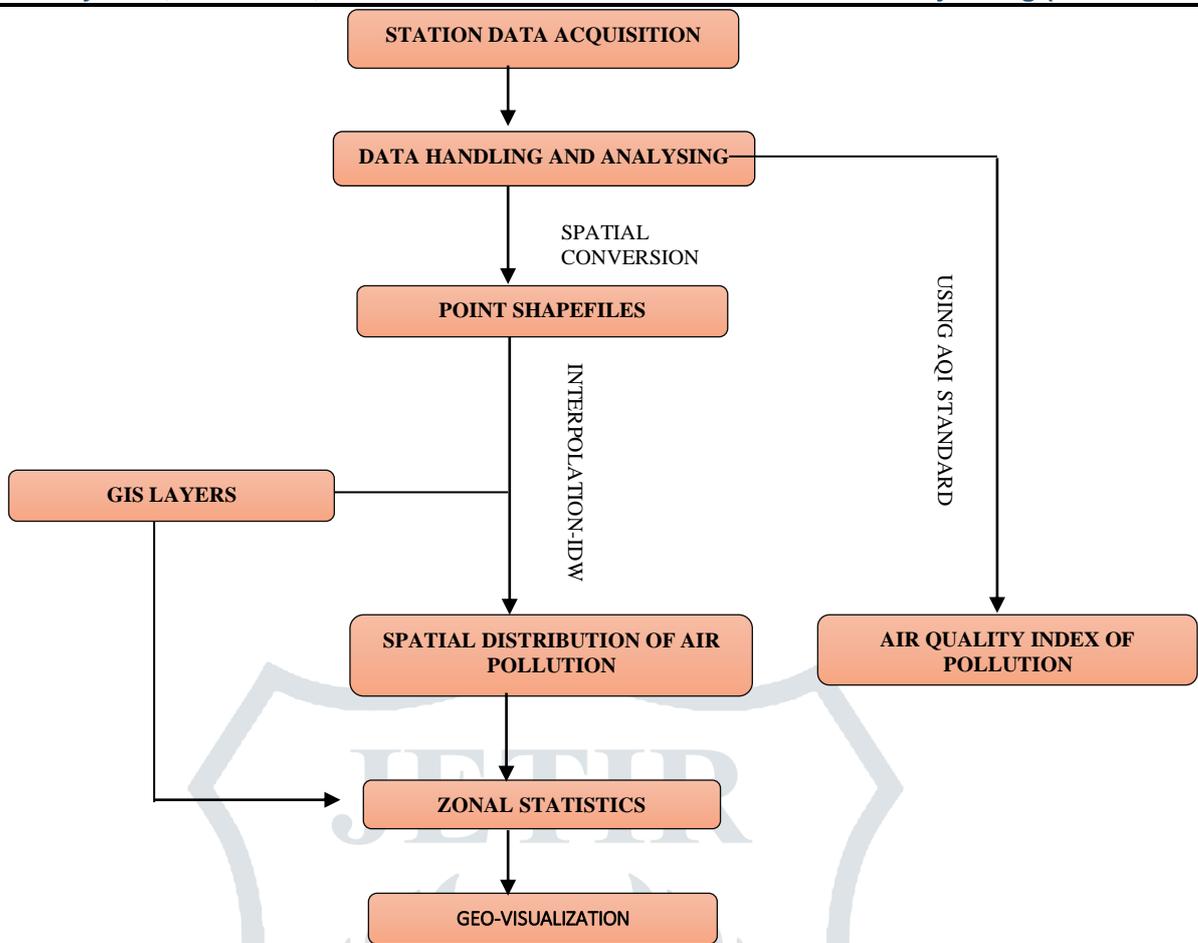


Figure 2: Methodology Steps

IV. OBSERVATIONS AND RESULTS

PARTICULATE MATTER 2.5

The IDW approach was used in this work to predict the PM_{2.5} concentrations at the study area's unsampled sites. The spatial distribution maps were derived using the IDW model for a specific study period. The analysis was done using the Geostatistical Analyst module of QGIS software.

The Figure displays the geographical patterns of PM_{2.5} concentrations for each period. The distribution of PM_{2.5} concentration before lockdown and during the lockdown. It is noted that the pre-lockdown period (A) ranges for PM_{2.5} from 37.3793 µg/m³ to 59.4524 µg/m³. For the first lockdown period (B), values range from 33.9568 µg/m³ to 44.5564 µg/m³. For the second lockdown period, (C) (mild restrictions) values range from 34.6073 µg/m³ to 42.7316 µg/m³. For the third period of lockdown, (D) (moderate restrictions) values range from 18.7948 µg/m³ to 28.8303 µg/m³. For the fourth period of lockdown (E) (high restrictions), values range from 14.101 µg/m³ to 27.5978 µg/m³. For the last period of lockdown (F) (high restrictions), the noted values are 9.90341 µg/m³ to 16.6656 µg/m³.

The levels of the concentrations are differentiated using colour palettes (dark green for low concentration and red for high concentration). In the distribution of PM_{2.5} pollutants map, it is found that before the lockdown period, the maximum level of the concentrations of PM_{2.5} was 59.4524 µg/m³, and the minimum was 37.3793 µg/m³. Moreover, during the lockdown period, the maximum value is 44.5564 µg/m³ and the minimum was 9.90341 µg/m³.

It was also found that in the pre-lockdown period, the Jail Road and the Nandur Naka showed red colour, i.e. high concentration of PM_{2.5}, which is greater than 49.80 µg/m³, and the remaining station (Cidco, Pathardi Gaon, Dwarka, Panchavti Karanja, Datta Mandir, and Indira Nagar) concentration got orange colour which is slightly less than the high concentration, 39.60 µg/m³ to 49.80 µg/m³.

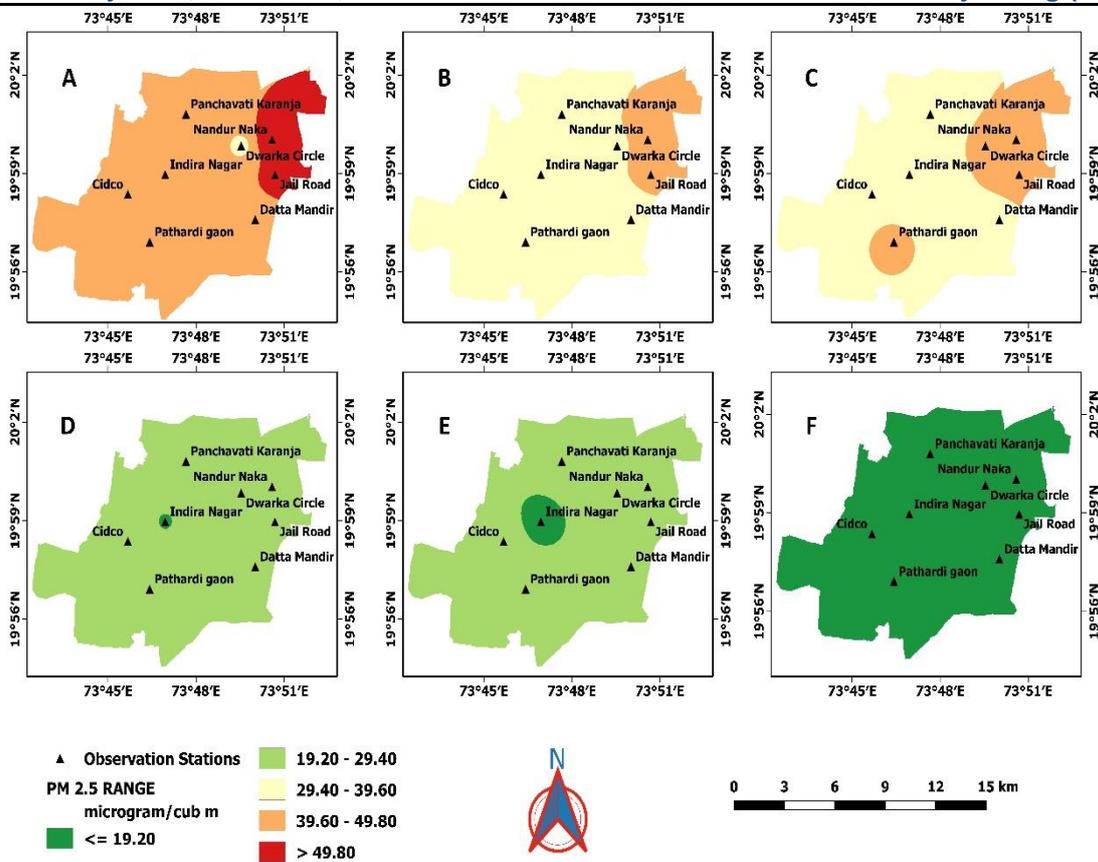


Figure 3: The distribution of PM_{2.5} concentration before lockdown and during the lockdown.

In the first period of lockdown, the quality of air was slightly improved, although, at that time, there were no such restrictions. In the second lockdown period, the quality degrades again for the Nandur Naka and Pathardi Gaon. It may be because the people did not follow lockdown restrictions. Then in the third period of lockdown, significant change is noticed. The quality of all stations is improved. In the fourth lockdown period, the quality improved for all the stations. Furthermore, air quality has become an excellent category for the last lockdown period.

The station Indira Nagar has shown good air quality from the third phase of the lockdown, possibly because of strict rules and regulations. During the lockdown period due to Covid, the concentration of PM_{2.5} was reduced in all stations.

PARTICULATE MATTER 10

The same trend was observed in the case of PM₁₀. Before the lockdown period, the concentration of PM₁₀ had a maximum value of 69.6687 µg/m³ and a minimum value of 45.8047 µg/m³. During the lockdown period, the maximum value is 52.543 µg/m³, and the minimum is 11.4906 µg/m³. For the first lockdown period, values range from 43.0371 µg/m³ to 52.543 µg/m³. For the second period of lockdown (mild restrictions), values range from 44.6337 µg/m³ to 50.4078 µg/m³. For the third period of lockdown (moderate restrictions), values range from 28.3693 µg/m³ to 34.2759 µg/m³. For the fourth period of lockdown (high restrictions), values range from 24.625 µg/m³ to 36.4176 µg/m³. For the last period of lockdown (high restrictions), the noted values are 11.4906 µg/m³ to 19.5166 µg/m³.

The levels of the concentrations are differentiated using colour palettes (dark green for low concentration and red for high concentration). In the distribution of PM₁₀ pollutants map, it is found that before the lockdown period, the maximum level of the concentrations of PM₁₀ was 69.6687 µg/m³, and the minimum was 11.4906 µg/m³.

It is found that the concentration of PM₁₀ is more (Red colour shows the high concentration) at the Pathardi Gaon, Indira Nagar, Nandur Naka, Jail Road, and Panchavati Karanja in the pre-lockdown period. Whereas in the same period, Cidco, Datta Mandir, and Dwarka Circle show slightly fewer values (shown by the orange colour on the map) than the stations mentioned above.

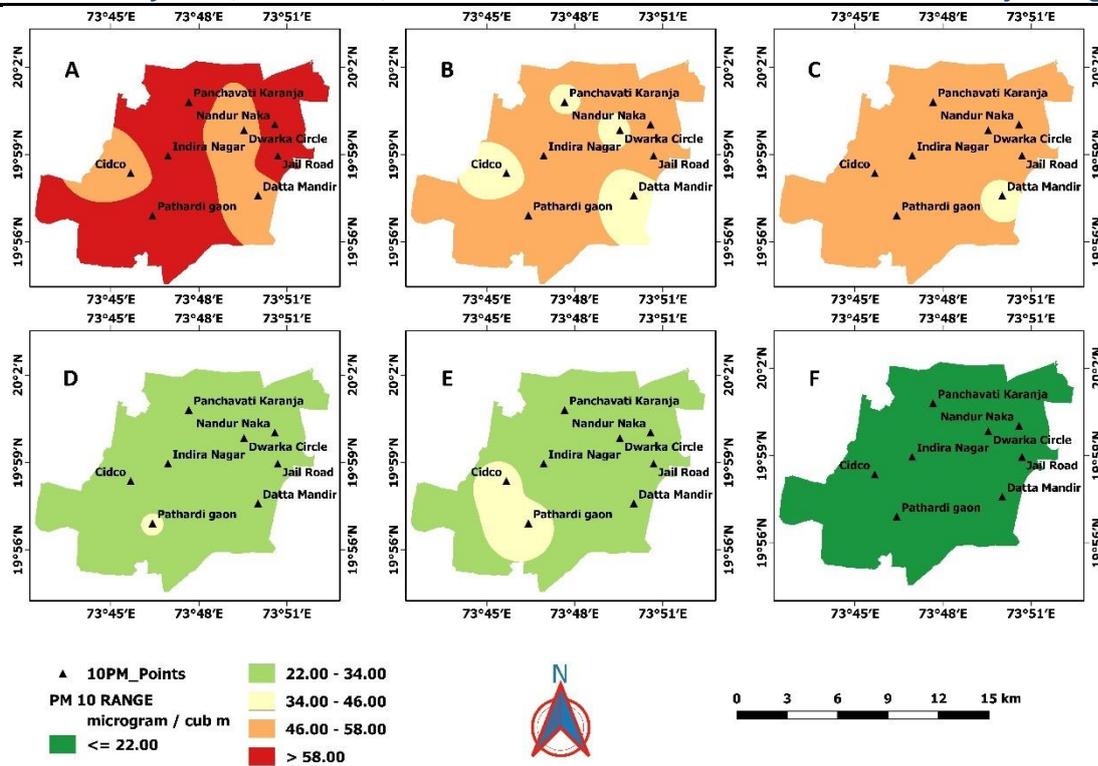


Figure 4: The distribution of PM10 concentration before lockdown and during the lockdown

In the first lockdown period, with fewer restrictions, the air quality was improved at all the stations and significant changes were made at Panchavati Karanja. Again in the second phase of the lockdown, the quality of air deteriorates may be because of fewer restrictions followed by people. In the third period of lockdown, overall quality s again improved except for the station Pathardi Gaon.

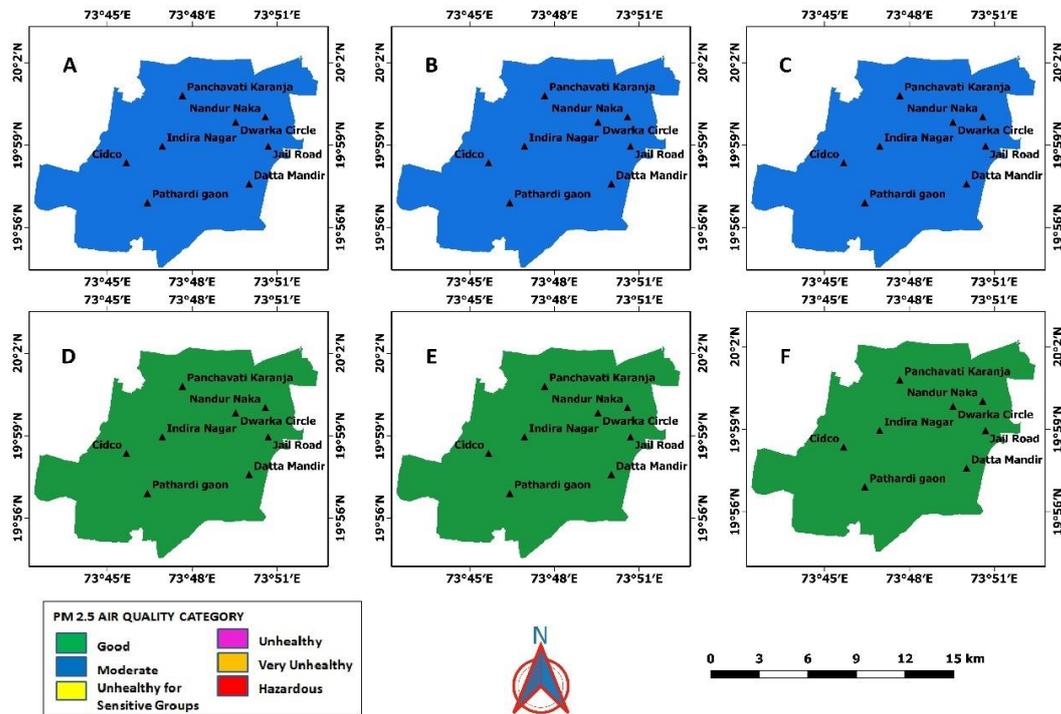
In the fourth period of lockdown the overall quality increased but at the Cidco station quality again deteriorate, again it can be because of no restrictions followed by the people. In the last lockdown period, the overall quality for all stations turns into a suitable category.

The concentration of PM10 level was reduced by more than half of what it was before the lockdown period.

AIR QUALITY INDEX MAPS

Table 1: Air Quality Index Standards

AQI	PM _{2.5}	PM ₁₀	CATEGORY
0 - 50	0 – 30	0 - 50	GOOD
51 - 100	31 – 60	51 – 100	MODERATE
101 - 200	61 – 90	101 – 250	UNHEALTHY FOR SENSITIVE GROUP
201 - 300	91 – 120	251 – 350	UNHEALTHY
301 - 400	120 – 250	351 – 430	VERY UNHEALTHY
401 – 500	>250	>430	HAZARDOUS

AQI FOR PM_{2.5}Figure 5: AQI MAP FOR PM_{2.5}

The significant change took place in the pre-lockdown period (14 March to 4 April with no restriction at all), lockdown third period (6 May to 20 May with moderate restrictions), and the last period of lockdown (6 June to 14 June). Therefore, for analysis purposes, we only consider these three periods.

- **Pre-lockdown condition (no restrictions)**

All stations came under the moderate category of air quality index.

- **Lockdown third period (with moderate restrictions)**

In the third lockdown period, the air quality index of stations increased from moderate to good air quality index.

- **Lockdown last period (with high restrictions)**

In a lockdown, the last period with high restrictions, the air quality index of all stations turned to the excellent category.

The overall air quality index category for PM_{2.5} from the first period (no lockdown) to the last period (lockdown with complete restrictions) is between reasonable and moderate.

AQI FOR PM₁₀

The significant change took place in the pre-lockdown period (14 March to 4 April with no restriction at all), the third lockdown period (6 May to 20 May with moderate restrictions), and the last period of lockdown (6 June to 14 June). Therefore, for analysis purposes, we only consider these three periods.

- **Pre-lockdown condition (no restrictions)**

All stations came under a moderate air quality index except station Cidco and Dwarka Circle which came under the category of good. That means the air quality index for PM₁₀ can be also good without restrictions.

- **Lockdown third period (with moderate restrictions)**

In the lockdown third period, the air quality index of stations increased from moderate to good air quality index.

- **Lockdown last period (with high restrictions)**

In a lockdown, the last period with high restrictions, the air quality index of all stations stayed in the excellent category.

The Figure represents the AQI for PM₁₀ before and during the lockdown; it is evident from the graph that the AQI level was reduced by more than half at all of the stations. Moreover, the overall PM₁₀ air quality index is suitable for all the stations from the first to the last period of lockdown. There is not much influence of particulate matter 10 in Nashik Air Pollution.

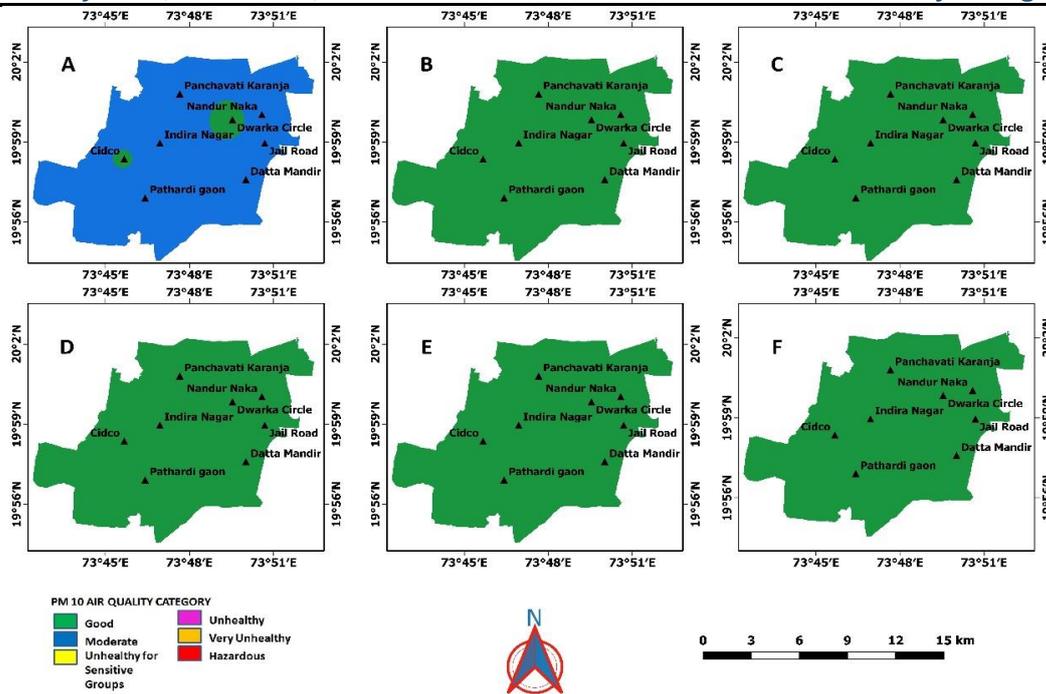


Figure 6: AQI Maps For PM10

Comparative analysis for the selected month

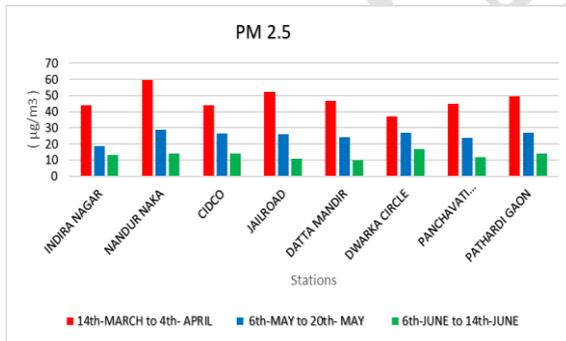


Figure 7: Comparative analysis for PM 2.5

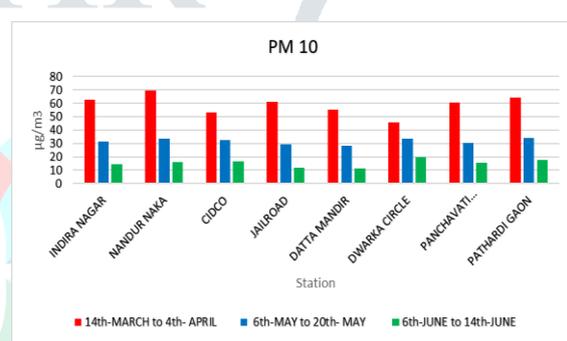


Figure 8: Comparative analysis for PM10

Comparative analysis for PM 2.5

Fig. 7 PM2.5. Furthermore, the average data was calculated previously. Here the data has been analysed for the three selected periods. There was no lockdown in the first span (before lockdown) (14th march to 4 April). Therefore, normal traffic conditions have been there.

The highest concentration of PM2.5 is found at Nandur Naka, 59.7277 micro gm/cub m., and the lowest concentration is found at Dwarka circle, which is 37.0312 micro gm/cub m. The second selected period is the fourth, from 6 May to 20 May. The in-between periods were skipped (second and third periods) because no noticeable change had been seen because of low restrictions. In this period, the highest concentration was found at Nandur Naka as in the previous period, which is lower to 28.8882 micro gm/cub m. The lowest was found at Indira Nagar, 18.7389 micro gm/cub m.

The third period started selected is the last period from 6 June to 14 June. In this period, the overall air quality has changed to an outstanding category of AQI. All stations came under good quality. The station with the lowest PM2.5 concentration is Datta Mandir which is 9.9034 micro gm/cub m.

Comparative analysis for PM10

Fig. 8 illustrate the analysis for PM10. The average values had been taken. There was no lockdown in the first span (before lockdown) (14th march to 4 April). Therefore normal traffic conditions have been there.

The highest concentration of PM10 found at Nandur Naka, which is 69.6689 micro gm/cub m. as same PM2.5 and the lowest concentration is found at Dwarka circle, which is again the same as PM2.5 is, 45.8041 micro gm/cub m.

The second selected period is the fourth (3rd lockdown period), from 6 May to 22nd May. The in-between periods were skipped (second and third periods) because no noticeable change had been seen because of low restrictions. In this period, the highest concentration was found at Pathardi Gaon, which is 34.2944 micro gm/cub m., and the lowest was found at Datta Mandir, 28.365 micro gm/cub m. The third period started selected is the last period from 6 June to 14 June. In this period, the overall air quality has changed to a perfect category of AQI. All stations came under good quality. The station with the lowest PM2.5 concentration is Datta Mandir which is 11.4859 micro gm/cub m.

V. CONCLUSIONS

This study used GIS to investigate the relationship between Nashik's air quality and the related COVID-19 national lockdown. Data from almost eight stations were observed before and during the lockdown period.

The major conclusion is that the overall AQI (air quality index) of Nashik city decreased during the lockdown and the GIS technology's technique made it possible to effectively track changes in the Air Quality Index. Some of the minor conclusions are as follows.

- The air quality of Nandur Naka and Jail Road was terrible the pre-lockdown which is converted into good quality during the lockdown. The highest concentration (average) of PM_{2.5} is 59.4524 µg/m³, the minimum is 9.9034 µg/m³, and PM₁₀ is 69.6687 µg/m³, and a minimum value is 11.4906 µg/m³.
- The overall air quality index category for PM_{2.5} from the first period (pre-lockdown) to the last period (lockdown with complete restrictions) is between reasonable and moderate.
- Moreover, the overall PM₁₀ air quality index is suitable for all the stations from the first to the last period of lockdown. There is not much influence of particulate matter 10 in Nashik Air Pollution.
- In the comparative analysis for the selected month, the highest concentration of PM_{2.5} is found at Nandur Naka, 59.7277 micro gm/cub m. and the lowest concentration is found at Dwarka circle, which is 37.0312 micro gm/cub m.
- The highest concentration of PM₁₀ found at Nandur Naka which is 69.6689 micro gm/cub m. as the same PM_{2.5} and the lowest concentration is found at Dwarka circle which is again the same as PM_{2.5} is 45.8041 micro gm/cub m.
- Average data comparative analysis of PM_{2.5} and PM₁₀ for each station concludes that the concentration of particulate matter decreased during the lockdown.

Finally, it is possible to conclude that when human activities are abruptly stopped, the natural pace of healing outdoes the disruptions caused, showing that this pandemic has given the environment a small window to breathe and helped the districts NASHIK to recover from bad air quality situations. The findings also suggest that similar lockdown tactics may be used as an emergency solution to tackle severe air pollution, provided they are done without harming the economy and lower echelons of society. Some of the findings are as follows,

- Public transportation facilities with designated zero-mile connections can be used to minimise the number of private vehicles. Furthermore, increase public awareness and promote electric vehicles.
- Water sprinklers, mechanised road sweeping machines, anti-smog guns at construction sites, vehicles mounted anti-smog guns, and sprinkling facilities on high-rise buildings are the measures that can be done.

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