RESEARCH ARTICLE

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Analytical Study of Effects of Lockdown on Air Pollution and Comparison of Air Quality of Pune (Maharashtra, India) before and During the Lockdown

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Abstract

Significant reduction in air pollution has occurred during the period of lockdown due to COVID-19 pandemic situation. It has given a wonderful opportunity to compare the air pollution as Industries and the maximum traffic of the city had been stopped during the lockdown, which otherwise could not be possible, to stop all the traffic and observe the impact. The study aims to compare the air pollution levels before and during the lockdown period in different areas of Pune city (MS, India). The daily data of Air Quality Index (AQI), Sulphur di oxide (SO_2) and Oxides of Nitrogen (NOx) is collected, compared, and analyzed. Analysis shows the fall in AQI in large extent which can be directly corelated with the traffic reduction in the city. The other factors like winter inversion, seasonal and festival effects are also considered for analysis. The data is also compared with previous year data for fair conclusions. The result shows the influence of anthropogenic sources of air pollution on AQI.

Keywords: Air Pollution, Air Quality Index, AQI, SO_2, NOx, COVID-19, lockdown effect.

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Introduction

To prevent the increasing infection of covid-19 disease the forced lockdown was implemented in India, due to which prominent reduction in air pollution of many major cities in India is measured and positive impact on ambient air quality is noted.[1-5] The considerable reduction in air pollution of Pune (MS, India), major city in Maharashtra state, has also observed during this period of lockdown. The radical change in the air-pollution of the city is marked[6] as the maximum activities in the Pune city were restricted excluding medical and few life-essential activities. This lockdown was initially planned for 15 days from 25 March 2020 but eventually the restrictions were continued till June 2020, until the unlock process ends. The new minimum levels of the decades are observed as the maximum anthropogenic sources, like traffic and Indus- tries, of air pollution was not functional. Considering the main cause of air pollution of the area is vehicular emission.[7] This situation has given a good chance to do experiment on the effect of the vehicular pollution and industry emission on air pollution which otherwise cannot be possible to observe the results with and without these anthropogenic sources. To find the actual effects, the data for the pollutants SO2, NOx and AQI of air pollution are collected and analyzed.[8,9] The data from ambient air quality monitoring stations of the areas like Karve-Nagar, Nal-Stop, Bhosari and Swargate are used. Further the historic data of the same time frame from preceding year is compared to make final conclusions. At the end, the other effects like winter inversion and any festivals influence (like Holi) are verified to give the fare judgement to conclusions.

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Methodology and Data collection

Lockdown imposed by Indian government has stopped the maximum extent on non-essential traffic of the Pune city. The study aims to find the effect of traffic halt on AirQuality Index (AQI) of the city. For the same, the daily data of AQI, SO_2 And NOx has been collected from the Ambient Air Quality Monitoring stations of Karve-Road, Nal-Stop, Bhosari and Swargate areas.

The data are collected from the website of Maharashtra pollution control board (MPCB) with the help from Central Pollution Control Board (CPCB) for the desired period before and during the lockdown for desired areas.[8,9]

As per given in the Table 1, strict lockdown was imposed from 24 March 2020 for 15 day and then eventually extended till end of May 2020 after that unlock process started allowing gradual resumption of essential services. But still, till the end of June most of the services like schools, malls and markets were shut. Pune being IT city, maximum offices have implemented work from home policies. Considering the abovescenarios, the period of three months i.e., April, May and June of year 2020 were selected for the study.

And for assessment, previous three months data are considered for analysis and comparison when all the activities were normal. Also, to come to fair conclusions and to avoid the winter inversion effect, previous years data for the months of April, May and June 2019 are also collected and compared with lockdown-period data.

The data of AQI, SO_2 And NOx is collected from 1st Jan 2020 to 30th June 2020 which include previous three months period from 1st Jan 2020 to 31st March 2020 and the actual lockdown period 1st April 2020 to 30th June 2020. To compare with previous year data, daily concentration data with the same dates of the lockdown period, i.e., 1st April 2019 to 30th June 2019, are collected.

Collected data is rearranged as per requirement and then cleaned to avoid unwanteddata, null or missing values. Monthly average values are calculated and converted into graphical representations and these average values and graphs are then studied and compared with previous months and previous year data to arrive the findings.

Air pollution averages

Standard Values of the Pollutants

Before discussion about comparisons and analysis the standard values of the pollutants SO2, NOx and AQI as per considered in MPCB should be understood to make any comparisons. The standard values as per government gazettes, CPCB and MPCB are given in the following tables, Tables 2 and 3.

Table 1. Lockdown in year 2020

Lockdown phases	*From date*	*To date*
Phase 1	24-Mar	14-Apr
Phase 2	15-Apr	3-May
Phase 3	4-May	17-May
Phase 4	18-May	31-May
Unlock 1.0	1-Jun	30-Jun

Table 2. Standards for value of SO_2 And NOx

Pollutant	SO_2 (µg/m^3)	NOx (µg/m^3)
Standards	80.00	80.00

By considering the above standard values of SO_2, NOx & AQI, the pre-lockdown, lockdown and previous year data is analyzed to make following findings.

Comparison with Pre-lockdown Months Data

As stated above, The AQI, SO_2 and NOx values of the daily concentration data from the areas Karve Road, Nal-Stop, Bhosari and Swargate from 1st Jan 2020 to 30th June2020 is compared. Where January to March period is considered as pre-lockdown and April to June period is considered as lockdown broadly.

In Table 4 AQI avg values are displayed, the AQI is clearly seen decreasing in all the areas, at Karve Road it has been dropped from 118.6129 to 17.03846, at Nal-Stop from 127.2222 to 79.2, at Bhosari 158 to 62.53 and at Swargate AQI has dropped from 109 to 60.16667 and Figure 1 shows the graphical representation of the Table 4

In Table 5, SO_2 avg values are displayed the SO_2 values is clearly seen reducing at Karve Road and Swargate whereas it's been seen increased at Nal-Stop and Bhosari area, In Karve Road it has been dropped from 21.09677 to 5.24, at Swargate from 19 to 15.83333, at Nal Stop SO_2 has seen increasing from 14.22222 to 19.2 and at Bhosarifrom 15.66667 to 19.07143. Figure 2 shows the graphical representation of the Table 5.

In Table 6, NOx average values are displayed the NOx is clearly seen decreasing inall the areas, at Karve Road it has been dropped from 66.09677 to 12.6087, at Nal-Stop

Table 3. Standards for value of AQI

AQI	*Quality classification*	*Remarks*
0–50	Minimal Impact	Good
51–100	Minor breathing discomfort to sensitive people	Satisfactory
101–200	Breathing discomfort to the people with lung, heart disease, children and older adults	Moderate
201–300	Breathing discomfort to people on prolonged exposure	Poor
301–400	Respiratory illness to the people on prolonged exposure	Very Poor
>401	Respiratory effects even on healthy people	Severe

Table 4. AQI of pre-lockdown and Lockdown period.

Months	*KarveRoad*	*Nalstop*	*Bhosari*	*Swargate*
Jan	118.6129	127.2222	158	109
Feb	104.25	138.125	130.75	127
Mar	73.38462	120.6667	82.16667	159.8
Apr	35.88889	87.36364	N. A.	71
May	34.17241	81.18182	66	55.25
Jun	17.03846	79.2	62.53846	60.16667

from 71.55556 to 57.8, at Bhosari 55.22222 to 46.21429, NOx average has reached 39.4 in the month of May. The data for the month of April is not available with MPCBso it is not considered in the comparison. and at Swargate NOx has dropped from 65 to28 and Figure 3 shows the graphical representation of the Table 6.

In Table 6, NOx average values are displayed the NOx is clearly seen decreasing inall the areas, at Karve Road it has been dropped from 66.09677 to 12.6087, at Nal-Stop from 71.55556 to 57.8, at Bhosari 55.22222 to 46.21429, NOx average has reached 39.4 in the month of May. The data for the month of April is not available with MPCBso it is not considered in the comparison. and at Swargate NOx has dropped from 65 to28 and Figure 3 shows the graphical representation of the Table 6.

Comparison with Previous Year Data

Additionally, the lockdown period data of AQI, SO2 and NOx is compared with theprevious year data of matching period from the same Ambient Air Quality Monitoring stations of Karve-Road, Nal-Stop, Bhosari and Swargate areas. Precisely the dataof the period from 1 April 2020 to 30th June 2020 is compared with the data from 1st April 2019 to 30th June 2019. The data is collected from the publicly available data from the MPCB's website for Ambient Air Quality Monitoring Network in Maharash-tra. The data that was not available is taken from the authentical document "Air QualityStatus of Maharashtra, 2019-20" published by MPCB.[10]

In Table 7, AQI avg values are displayed. The AQI is clearly seen decreasing in allthe areas, in the months of April May as well as in June, Figure 4 shows the graphical representation of Table 7.

In Table 8, SO_2 avg values are displayed. The SO2 is clearly seen decreasing in allthe areas, in the months of April May as well as in June, Figure 5 shows the graphical representation of Table 8

In Table 9, NOx avg values are displayed. The NOx is clearly seen decreasing in allthe areas, in the months of April May as well as in June, Figure 6 shows the graphical representation of the Table 9.

Comparison with Seasonal and Festival Effects

The study period has checked for any seasonal and festival effects like Winter inversion and Holi festival. During the period of pre-lockdown and lockdown the month of Jan and Feb falls under the winter season so winter inversion

Table 5. SO2 of pre-lockdown and Lockdown period

Months	*KarveRoad*	*NalStop*	*Bhosari*	*Swargate*
Jan	21.09677	14.22222	15.66667	19
Feb	20.32143	15.625	15.375	20
Mar	14.30769	11	14	7.6
Apr	8.666667	12.33333	14.33	12
May	8.482759	15.45455	14.6	19.625
Jun	5.24	19.2	19.07143	15.83333

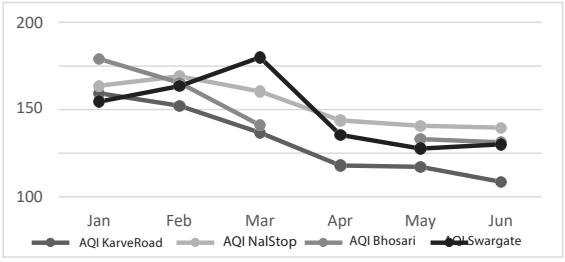

Figure 1. AQI of pre-lockdown and Lockdown period.

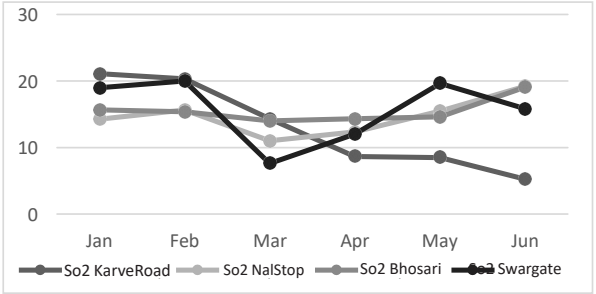

Figure 2. SO2 of pre-lockdown and Lockdown period

Table 6. NOx of pre-lockdown and Lockdown period

Months	*KarveRoad*	*NalStop*	*Bhosari*	*Swargate*
Jan	66.09677	71.55556	55.22222	65
Feb	65.21429	72.125	63.5	105
Mar	39.65385	58	43.66667	75
Apr	23.85185	45.91667	n.a.	38.25
May	22.44828	32.27273	39.4	37.75
Jun	12.6087	57.8	46.21429	28

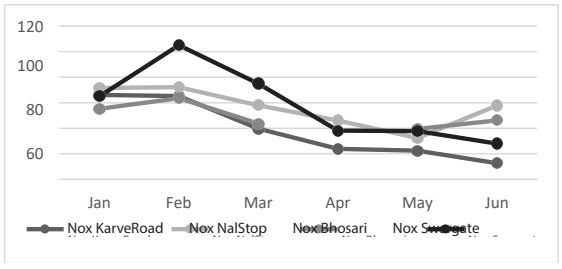

Figure 3. NOx of pre-lockdown and Lockdown period

Table 7. AQI Previous year and lockdown period

Months	*KarveRoad*	*NalStop*	*Bhosari*	*Swargate*
Apr-19	93.33333	130.5714	100.375	114
May-19	83.40909	121.25	98.125	109
Jun-19	63.22222	107	103.5	103
Apr-20	35.88889	87.36364	70.8	71
May-20	34.17241	81.18182	66	55.25
Jun-20	17.03846	79.2	62.53846	60.16667

can increase the air pollution. By considering this scenario the comparison of data from March has been carried out to avoid the winter inversion effect in the month of Januaryand February, still by comparing the averages from Tables 4 to 6 it has been clearly observed that there is continuous drop in AQI, SO_2 and NOx after march when the effectof winter inversion is not present. So, it can be clearly concluded that the lockdown is the main reason behind the drop in air pollution. The values of the AQI shows negligible changes on the Holi festival Day that fall on 9th March 2020 even though it came beforelockdown hence can be neglected also even if there is change in air pollution due Holifestival, it can cause increase in AQI but it cannot be considered as the reason behind drop in AQI.

Table 8. SO_2 previous year and lockdown period

Months	KarveRoad	NalStop	Bhosari	Swargate
Apr-19	11.75	35.28571	34.75	19
May-19	18.5	26.75	30.66667	19
Jun-19	10	25	25.16667	17.40625
Apr-20	8.666667	12.33333	14.33	12
May-20	8.482759	15.45455	14.6	19.625
Jun-20	5.24	19.2	19.07143	15.83333

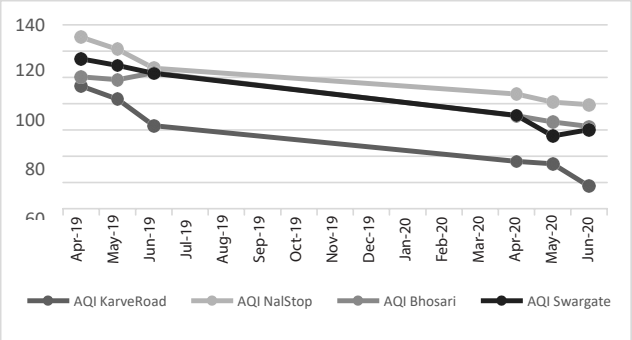

Figure 4. AQI previous year and lockdown period

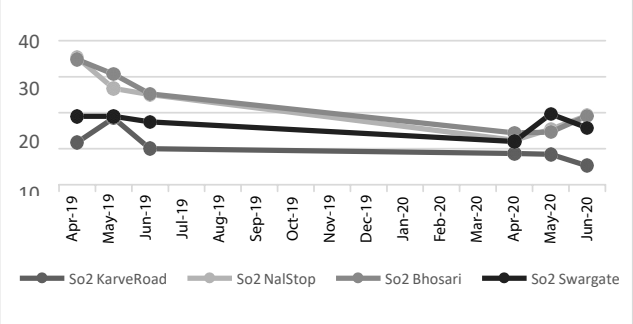

Figure 5. SO_2 previous year and lockdown period

Table 9. NOx previous year and lockdown period

Months	*KarveRoad*	*NalStop*	*Bhosari*	*Swargate*
Apr-19	29.66667	75.42857	76.75	65
May-19	37.45455	71.625	62.55556	65
Jun-19	44.59259	40	39.33333	39.33333
Apr-20	23.85185	45.91667	57	38.25
May-20	22.44828	32.27273	39.4	37.75
Jun-20	12.6087	57.8	46.21429	28

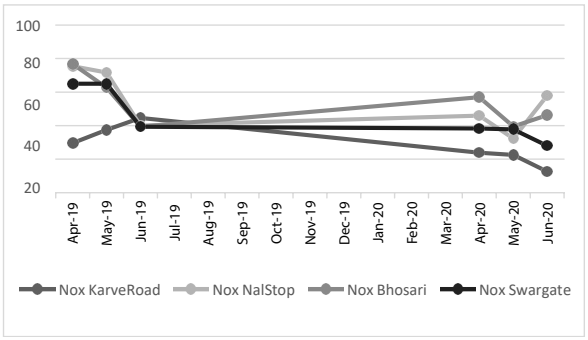

Figure 6. NOx previous year and lockdown period

Solution

From the observations and studies, the Air pollution problem is getting increasingly severe in India. Even the smallest possibilities to reduce pollution should not be neglected as air pollution can be potential health care risk during COVID-19. [11] The detailed area wise analysis done in this study shows the maximum impact of Vehicular and Industrial pollution causes on AQI, which previously been studied by many researchers but this pandemic lockdown situation had given the best experimental chance to study the situation with and without the vehicular and Industrial pollution and proved to be the main causes of Air pollution.

To control the future increase in the air pollution, more strategical[12] and effective solution should be planed as air pollution has potential to increase the human mortality trends.[13] The solutions like use of maximum reusable and sustainable energy in vehicles as well as in industries, more awareness drives for citizens to reduce use of vehicles, even the work from home policies where ever possible can be considered to reduce the traffic in megacities.

Conclusion

The Indian government had imposed the lock down as the mitigation action to prevent spreading of COVID-19 disease. The tremendous reduction in the air pollution is notedduring the lockdown period. From the above analysis, examinations, and observations,it can be indisputably said that the vehicular and Industrial pollution has the maximum impact on the increased air pollution caused in Pune city. All the differentiated areas, Karve Road, Nal Stop, Bhosari and Swargate, in the city have noticed fall in air pollution during the lockdown period when compared with pre-lockdown period, the levelsof AQI, SO_2 and NOx are visibly seen to be

decreased due to impact of lockdown. Theobservations do not show any seasonal and festival impact on this sudden drop in air pollution. For proving that the previous year data is also considered to cross check anypossibilities of winter inversion during pre-lockdown period, and the possibilities of festival impact is also considered and proved to be not substantial.

This period has given a better understanding of air pollution which should lead to bettersolutions, strategies and planning to avoid the future air pollution which will surely getintensified when all the restrictions will get released by the government.

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