COVID-19 Lockdown induced reduction in air pollutants over Haryana National Capital Region

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Abstract

The current study aims to assess the reduction in the concentration of air pollutants (PM2.5, PM10 and O3) due to COVID-19 driven lockdown, which was imposed over India in four phases during 25 March to 31 May, 2020, to stop the spread of corona virus. Ground-based data (n=15) were downloaded from pollution monitoring stations of Central Pollution Control Board (CPCB) for time ranging from 25 March to 31 May of the year 2019 and 2020, and subjected to the analysis using post-pre subtraction method. Results were analysed both at individual station level as well as spatially over Inverse Distance Weighted (IDW)-based interpolated surfaces. Significant decline in the concentration of PM2.5 (50%) and PM10 (44 %) were observed during lockdown phases as compared to the year 2019 without lockdown. Minor changes were identified in ozone concentration with negative relationship for PM2.5 and PM10. During lockdown all the activities like vehicle movement, industry operations and burning of fossil fuel were stopped and thus pollutants concentration gets reduced.

Key words: COVID-19, Air pollution, PM2, O3, NCR Haryana

1. Introduction

In 2020 world population was facing threat from the Corona Virus know for deadly disease COVID-19. Main symptoms of COVID-19 is fever, dry cough, tiredness and this causes respiratory illness such as severe acute respiratory syndrome (WHO 2020). A worldwide lockdown were seen to control the pandemic. This has reduced the anthropogenic activities across the world in terms of reduced human movement, reduced vehicle emissions and reduction in industrial activities which showed reduced level (ranging from 10 to 50 %) of air pollution/pollutants across the Globe (Lal et al. 2020; Muhammad et al. 2020; Mahato et al. 2020; Sharma et al. 2020; Srivastava et al. 2020; Tobías et al. 2020; Singh et al. 2021a).

India, one of the most polluted regions in the world (231 cities show PM10 level above WHO standard i.e. 50µg/m^3 and causing severe health issues) has also imposed nationwide lockdown which resulted in to clean air over various urban locations including National Capital Region (NCR) (Greenpeace India 2020; Guo et al. 2017). Researcher found decrease in the concentration of PM2.5, PM10 & Ozone (O_3) as compared to the last two years but there were no significant change in the temperature and humidity (Bhawre 2020) showing the reduction is due to COVID-19 driven lockdown. Singh et al. (2021a) reported reduction in PM2.5, PM10, NO_2, over Haryana state due to COVID-19 which were resulted into the improvement in Air Quality Index (AQI) 44%. In Lucknow and New Delhi major impacts of lockdown were observed on the concentration of PM2.5, NO2 & CO and less on the SO_2 (Srivastava et al. 2020). In Delhi and Mumbai NO_2 concentration get declined by 40-50 % due to Lockdown (Shehzad et al. 2020). Sur et al. (2021) reported 20–40% reduction in the concentration of NO_2 over Indo-Gangetic region constitute the part of the current study. Kant et al. (2020) and Singh and Nanda (2020) reported reduction (35- 46%) in AOD over Northern India and Haryana state respectively.

Though several studies have already covered mega cities of India (Mahato et al. 2020; Sharma et al. 2020; Siddiqui et al. 2020; Mishra et al. 2021), Haryana NCR region have still not touched separately and a gap in the knowledge of reasons and magnitude of pollutant reduction exist. The information regarding reduced emission is beneficial in understanding the contribution of pollution from local sources in NCR region of Haryana. It is also important to take decisions and make plans to combat the Delhi air pollution which is a major problem in India especially during winters (Singh et al. 2021b).

Thus, the current study is being done to analyse the variability and magnitude of reduction in Particulate Matter (PM10 & PM2.5) and Ozone (O_3) in four different phases of lockdown viz. Phase I (25 March 2020 to 14 April 2020), Phase II (15 April 2020 to 3 may 2020), Phase III (4 May 2020 to 17 may 2020) & Phase IV (18 May

2020 to 31 May 2020) using ground based data and GIS technologies. The key objective of the study was to understand the spatial variations in the reduction of the PM and O3 concentration during the year 2019 and 2020 corresponding to the time period of COVID-19 driven lockdown phases over NCR region of Haryana.

2. Material and Methodology

2.1 Study Area

Study area lies in Northern part of the India and southern part of Haryana between Latitude 27°39' 13.781 to 29°59' 40.877´´N and Longitude 75°27' 39.259 to 77°32' 44.144´´N (Figure 1) . It includes 15 Districts of Haryana which lies in NCR. Total geographical area is 2753355 ha and largely covered by agriculture and built-up/habitation. The elevation ranges from 140 m to 673 m. with annual average rainfall is ~740 mm. Temperature ranges from 0 To 44.5° and relative humidity ranges from 7.78 to 100. The region generally shows high pollution level in all the seasons as compared to the other parts of the state of Haryana due to high anthropogenic activities (Singh et al. 2021b).

2.2. Methodology

2.2.1 Data Source and Analysis

Ground data for air pollutants including PM2.5, PM10, and O3 were downloaded from https://app.cpcbccr.com/ccr/#/caaqm-dashboard-all/caaqm-landing for 15 stations of Central Pollution Control Board (CPCB). Daily average concentration of three criteria pollutants (PM2.5, PM10 & O3) have been collected and processed at individual station level. To assess the spatial variation in the reduction of pollutant concentration over Haryana NCR, a post-pre subtraction method was used on Inverse Distance Weighted (IDW) based interpolated surfaces. IDW was used for the interpolation following Singh et al. (2021a). Various lockdown scenarios including Phase I, Phase II, Phase III, and Phase IV corresponding to the time period from 23 March 2020 to the 31 May 2020 were considered as post-lockdown and similar time frame of the year 2019 were considered as pre-lockdown (Singh et al. 2021a).

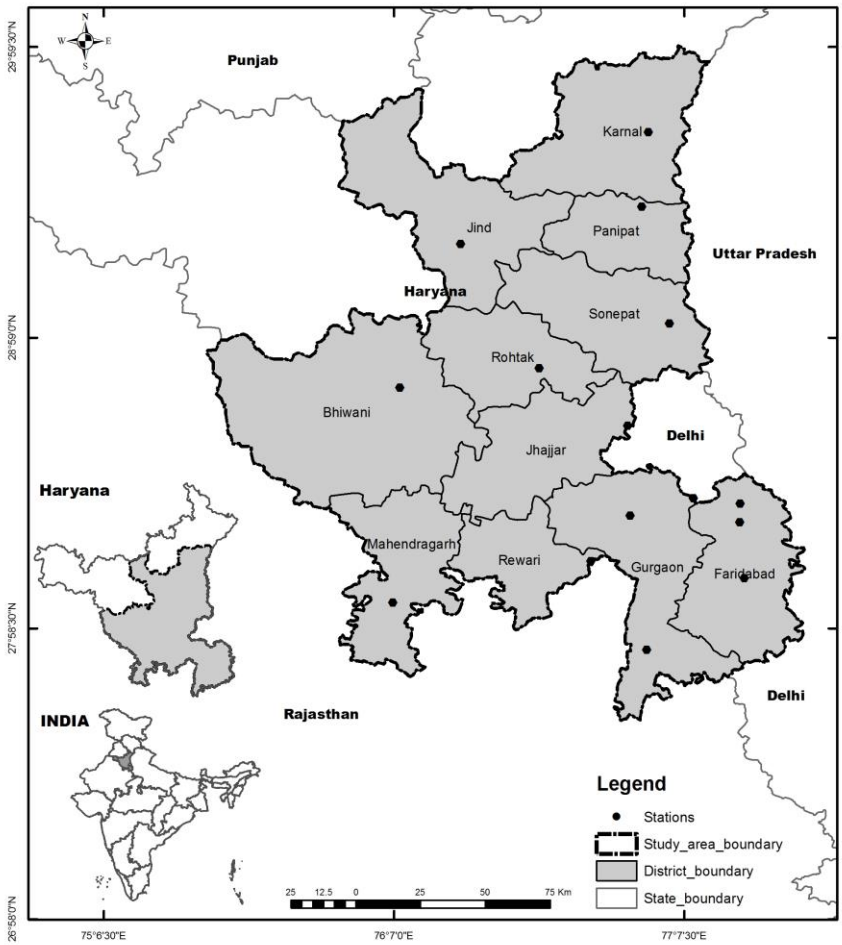

Fig.1 Study area and ground measurement locations

2.2.2 Post-Pre subtraction Method for the Reduction in Pollutants Concentration

Three criteria pollutants (PM2.5, PM10 and O3) were analysed statistically for four phases of lockdown at station level as well as for whole study area. Station level average data were then taken for the generation of spatial surfaces of air pollutants for each phase for the year 2020 (post) and 2019 (pre). The pollutant surfaces were then subjected to the post-pre subtraction method as presented in equation 1. This was further analysed for the assessment of reduction in air pollutants as an effect of COVID-19 driven lockdown.

$$Px_{Reduction} = Px_{post} - Px_{Pre} \qquad \text{(Eq. 1)}$$

Where, $Px_{Reduction}$ is total reduction in pollutant x, Px_{post} is the concentration of x pollutant during the year 2020 (during COVID-19 lockdown) and Px_{Pre} is the concentration of x pollutant during the year 2019 (without lockdown).

3. Results & Discussion

3.1 Concentration of in-situ Criteria Pollutants during Lockdown Phases

Statistical analysis was done during the lockdown phases in 2020 and during pre-lockdown in 2019 for comparing the pollutant concentration and significant reduction was clearly seen (Table 1). PM10 concentration was lowest (73±32 µg/m^3) during phase-I of lockdown and consecutively increased till Phase IV (Table 1). Similarly, PM2.5 concentration was 32 ± 12 µg/m^3 in phase I of lockdown and then increased consecutively. Minor changes in the concentration of O3 were observed (Table 1). Interestingly the standard deviation (SD) of Phase-I was least for all the parameters in all the phases due to the strict lockdown norms and uniform reduction in the pollutants concentration. The concentration of PM2.5 in 2020 was well within the permissible limit (60 µg/m^3) of Indian standard while for the year 2019 it was beyond this limit. Similar results were found for PM10 (Table 1).

Table 1 Variation in Pollutant concentration during lockdown phases

Parameters (unit of measurement)	Phase-I (25Mar.-14Apr.)		Phase-II (15Apr.-3May)		Phase-III (4-17May)		Phase-IV (18-31May)	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
PM2.5 (µg/m^3)	75 ± 32	32 ± 12	79 ± 36	43 ± 18	104 ± 44	43 ± 16	63 ± 22	43 ± 21
PM10 (µg/m^3)	184 ± 72	73 ± 32	198 ± 89	108 ± 55	236 ± 100	115 ± 57	140 ± 61	130 ± 63
O3 (µg/m^3)	41 ± 18	38 ± 22	42 ± 21	40 ± 24	40 ± 23	48 ± 28	47 ± 28	45 ± 23

3.2 Reduction in Pollutant Concentration

Significant reduction (50 % and 44% respectively) were observed in the concentration of PM2.5 and PM10 due to lockdown over Haryana NCR regions (Figure 2 a to c, Table 1). However, there was no significant reduction in the concentration of O3 (Table 1) despite the variation during the year 2019 and 2020 (Figure 2 c). Nevertheless, the O3 concentration was higher during 3rd phase of lockdown which is obvious as there is the clear sky condition for photochemical reduction of O2 required for O3 generation, followed by the reduction in NO2 concentration (Sur et al. 2021, Singh et al. 2021a). Similar reductions (55-61%) in PM were reported by Singh et al. (2021a) for Haryana state due to COVID-19 using satellite derived products.

High pollutants concentration during the year 2019 may be due to the combined effect of anthropogenic emissions like transportation, industrial activity, burning of Fossil Fuel, construction activity etc. as well as natural emissions from desert dust (Singh et al. 2021a). The reduction obtained in the year 2020 may be due to the reduced anthropogenic activities amid COVID-19 lockdown (Siddiqui et al. 2020; Srivastava et al. 2020; Singh et al. 2021a).

Spatial variations in the average reduction of PM2.5, PM10 and O3 concentration in different lockdown phases are represented in Figure 3. Map showed significant reduction in pollutant concentration with relatively high reduction during Phase-I of lockdown. Spatially, the reductions were high on the regions near to Delhi due to reduced anthropogenic activities which are otherwise very intense over these regions in normal, like in 2019.

Similar reductions in pollutants concentration were observed by Mahato et al. (2020), Singh et al. (2021a), Siddiqui et al. (2020), and Srivastava et al. (2020) among others. It has been also observed that the O3 were negatively correlated with both the PM2.5 and PM10. An increase in O3 concentration was also seen during III phase of the lockdown due to the reduction in NO2 provides free radicals (O) for O3 formation in clear sky conditions. Availability of free oxygen radicals (O) may also have increased due to the O2 reduction in high

solar radiation reaching to the earth in clear sky conditions. The increase in O3 concentration during lockdown phases also indicates the possible hazard to human health in taking similar measures to combat air pollution especially in sub-urban and rural areas. Thus the lockdown is suggested to the urban and dense urban areas as a measure to combat air pollution.

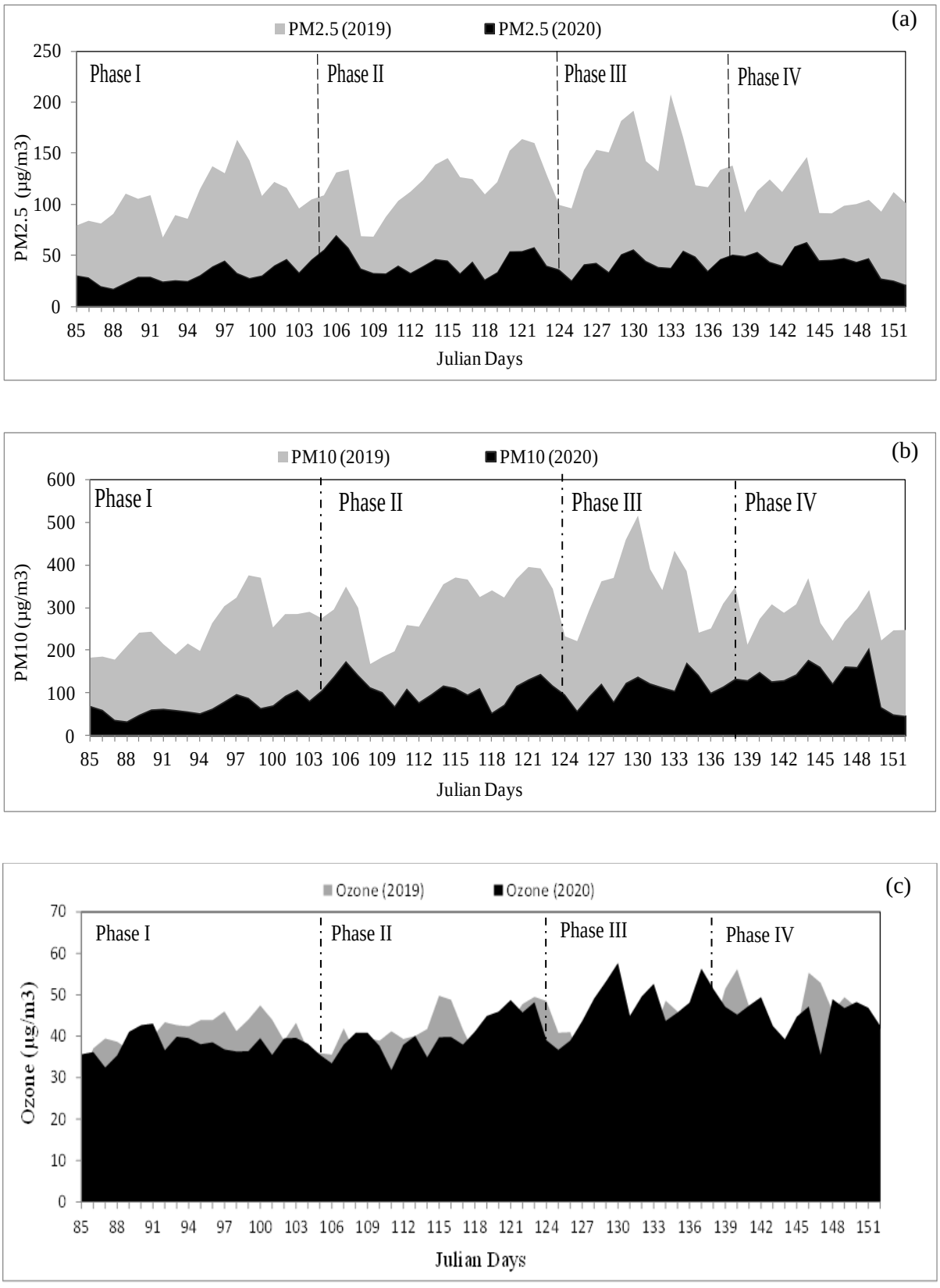

Fig.2 Variations in concentration of PM2.5 (a), PM10 (b), and O3 (c) during various lockdowm phases

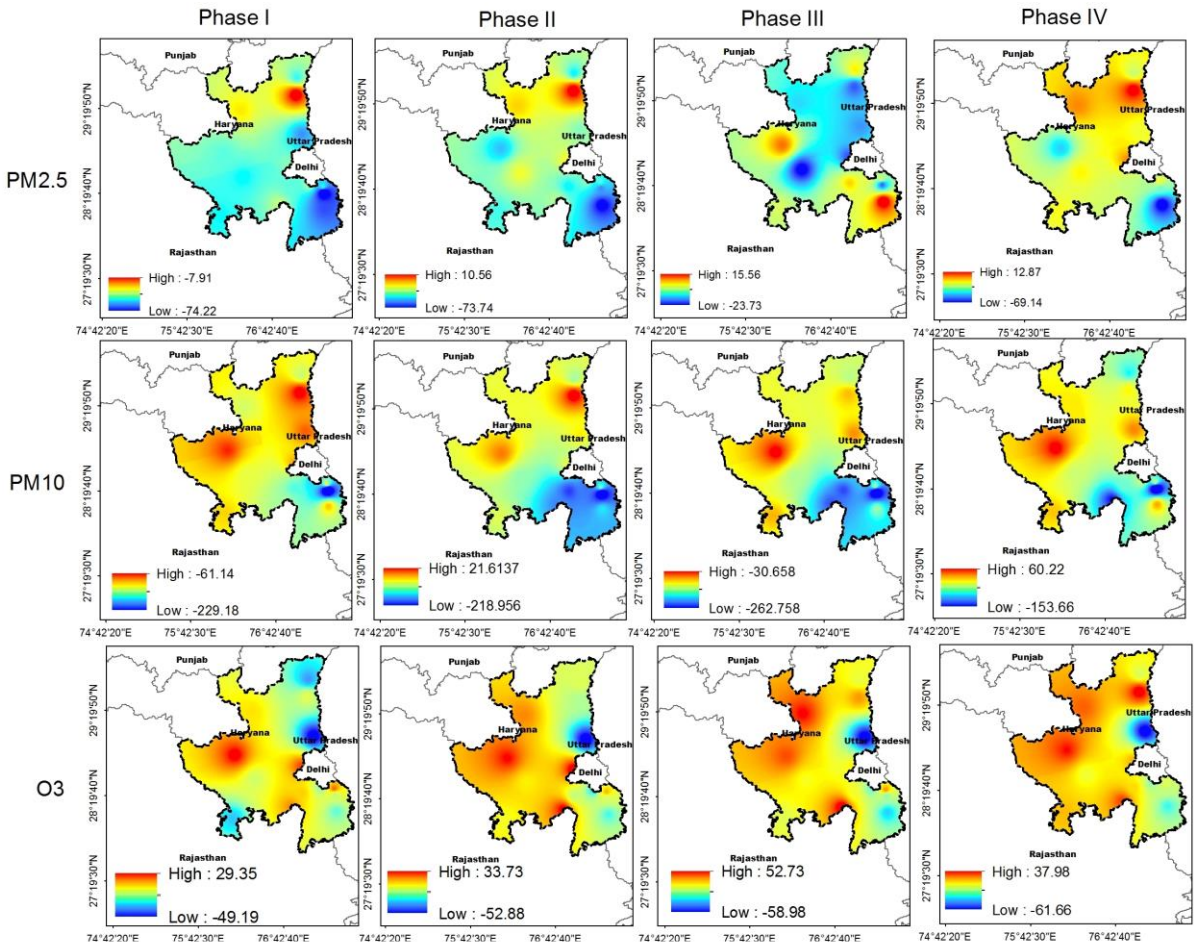

Fig.3: Spatial variation in the reduction of PM2.5, PM10, and O3 in various phases in COVOD-19 lockdown. Negative values show that the concentrations of pollutants were less during lockdown while positive values show high concentration during lockdown.

4. Conclusions

Based on analysis of three pollutants namely PM2.5, PM10 and O3 over the most polluted regions of India i.e. NCR region of Haryana, improvement in the air quality parameters were observed. A significant reduction of 50% and 44% were observed in the concentration of PM2.5 and PM10 respectively over Haryana NCR region during lockdown phases (year 2020) as compared to the same time frame of the year 2019. The reduction was minor in the O3 concentration with no significant difference. O3 were increased during III phase of lockdown due to clear sky condition and less NO2 concentration. O3 were negatively related with PM2.5 and PM10. High reductions were observed over the regions near to Delhi is mainly due to high baseline concentration over Delhi and nearby regions (resulted from high anthropogenic activities) and uniform reduction (resulted from uniform lockdown implementation). The current work will be a baseline for further studies on air pollution over Haryana NCR which is a data deficient region especially in the case of COVID-19 related pollution reduction as per our best knowledge. Since the Haryana NCR is strategically very important area for the developmental activities of India the pollution level will surely increase in future, which will further increase the pollution related problems in Delhi. Information regarding lockdown driven pollution reduction as presented in the current study may be taken to manage air pollution taking lockdown as a strategic option.

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