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Air quality in five major cities of India induced by the COVID-19 pandemic lockdown

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ABSTRACT

This discussion paper looks into the COVID-19 induced lockdown on the air quality of the five most polluted cities in India. There were significant reductions in the concentrations of particulate matter, $\leq 2.5\ \mu\text{m}$ and $\leq 10\ \mu\text{m}$, NO_2 , and CO during lockdown compared to that in 2019. Even then, the levels of particulate matter never reached the target specified by the World Health Organization. There was an increase in the concentrations of O_3 at some cities, which may be attributed to the alterations in the photo-stationary cycle due to change in the concentration of nitrogen oxides and volatile organic carbons.

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COVID-19; $\text{PM}_{2.5}$;
 NO_2 ; India

1. Introduction

With the outbreak of the coronavirus disease, commonly called COVID-19, in Wuhan, China, in December 2019, the pandemic has spread over 210 countries in 4 months. The first COVID-19 case in India was reported in Kerala in January 2020. As the number of confirmed cases touched 400 by 22 March 2020, a complete lockdown was imposed in the country with restrictions on public transport, businesses, and social contacts (MoHFW (Ministry of Health and Family Welfare) 2020) till 14 April 2020, which was further extended to 3 May and 17 May 2020. The lockdown was mainly intended to avoid community spread to cause a decline in infectious cases. The reduction in road transport perhaps has an impact on air quality. Motorized vehicles produce nitrogen oxides (NO_x) due to the combustion reactions at high temperatures in the form of NO. As per 2019 reports, India is ranked 5th among the most polluted countries based on $\text{PM}_{2.5}$ concentrations (World Air Report Region

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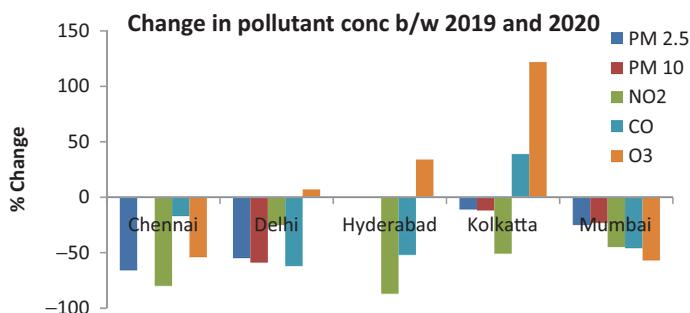


Figure 1. Changes in the concentration of air pollutants during lockdown period in 2020 with respect to 2019; positive values show increase in concentration in 2020 compared to 2019 and negative show decrease in concentration in 2020 compared to 2019.

and City PM 25 ranking 2019). The cities in India having the worst air quality are Delhi, Mumbai, Chennai, Hyderabad, and Kolkata. Ambient air pollution is a major environmental health problem and can lead to cardiovascular and respiratory diseases, especially on exposure to particulate matter (Zanobetti, Schwartz, and Gold 2000). Outdoor air pollution can also elevate the cases of cancer in the lungs and urinary tract/bladder. The World Health Organization (WHO) has put forward guidelines for air quality parameters, namely $PM_{2.5}$, PM_{10} , NO_2 , and O_3 , which apply worldwide (WHO (World Health Organization) 2005). This discussion paper aims to showcase the changes in the air quality of five major cities in India due to the enforcement of the COVID-19 lockdown.

2. Data source

Air quality data of Delhi, Mumbai, Chennai, Hyderabad, and Kolkata have been retrieved from the website of the Central Pollution Control Board (Central Pollution Board, Ministry of Environment, Forests and Climate Change, Government of India https://app.cpcbccr.com/AQI_India/). The hourly data of $PM_{2.5}$, PM_{10} , NO_2 , CO, and O_3 during the lockdown period from 25 March to 14 April 2019 and 2020 have been used. Daily averages were calculated as arithmetic means of the hourly data for each parameter. The changes in the concentrations of $PM_{2.5}$, PM_{10} , NO_2 , CO, and O_3 between 2019 and 2020 were determined. Spatial and time-series maps of Chennai, Mumbai, and Delhi obtained from NASA (NASA Goddard Space Flight Centre Atmospheric Chemistry and Dynamic Laboratory, https://so2.gsfc.nasa.gov/no2/no2_index.html) have been used to assess the change in the NO_2 concentrations in 2020 in comparison with the average concentrations of 2015–2019.

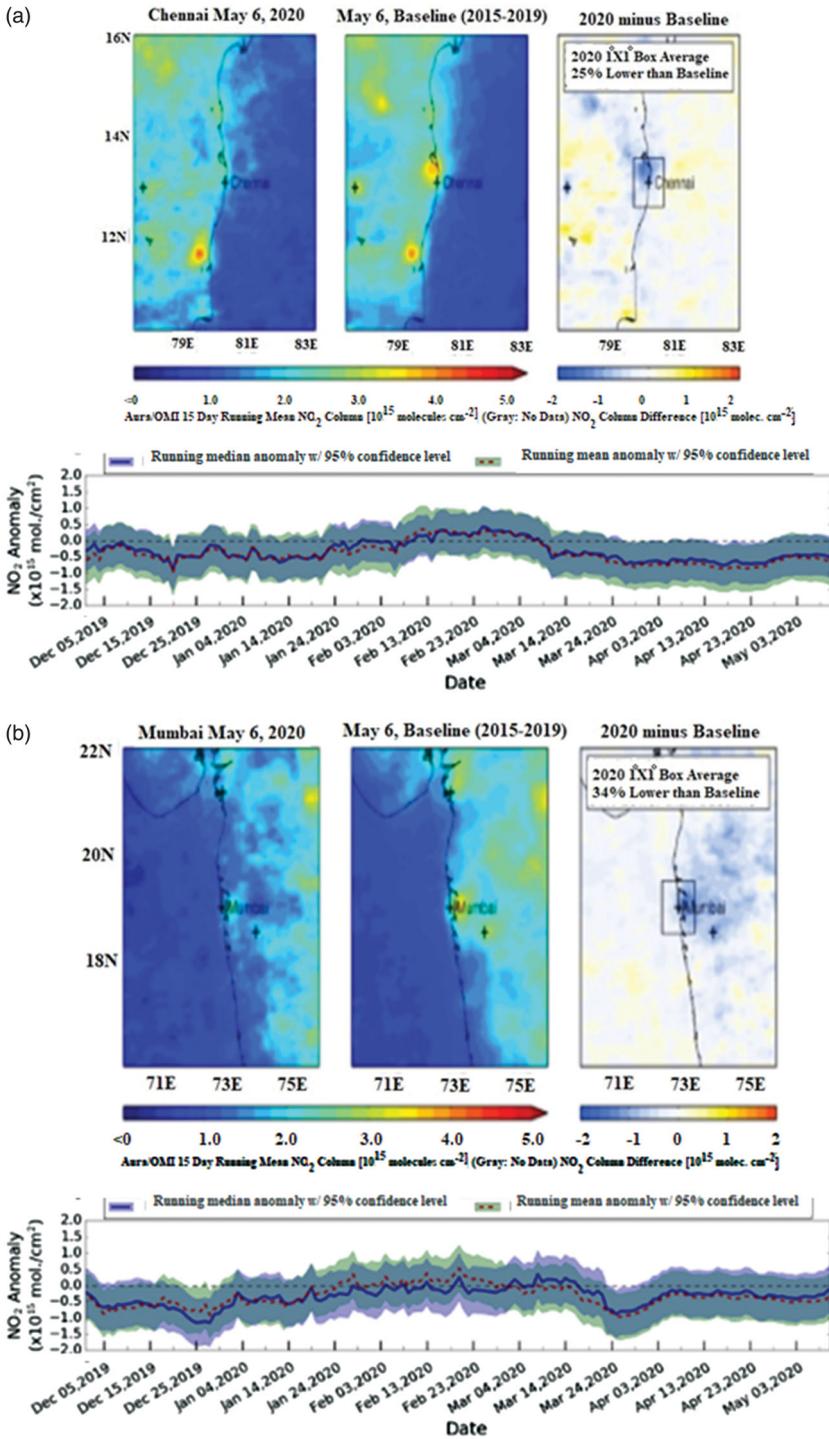


Figure 2. (Continued).

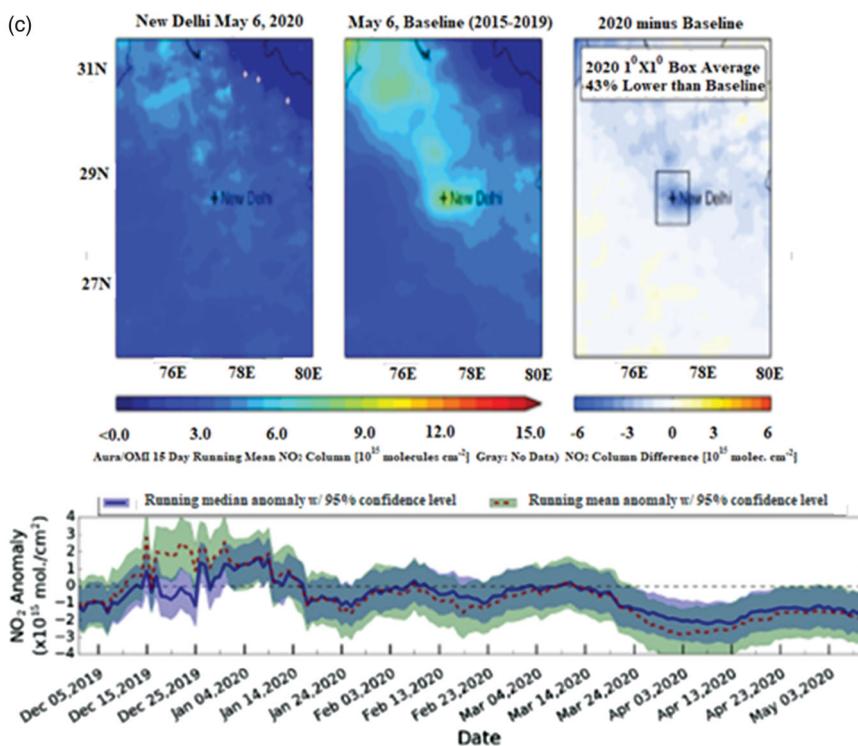


Figure 2. Variations of NO₂ levels in (a) Chennai; (b) Mumbai; and (c) New Delhi (Source: NASA GSFC https://so2.gsfc.nasa.gov/no2/no2_index.html). Note: In each figure, the top left picture represents the spatial variation of NO₂ levels in the city on May 6, 2020, top middle represents the baseline data of 2015–19 and top right represents difference of average NO₂ concentrations with the baseline data of 2015–19. The bottom figure shows the temporal variations of NO₂ concentrations.

3. Results and discussion

There were considerable reductions in PM_{2.5} during the lockdown period compared to 2019 (Figure 1). For instance, the average PM_{2.5} in Chennai during the lockdown was 31 $\mu\text{g}/\text{m}^3$ against 92 $\mu\text{g}/\text{m}^3$ (average values were obtained as described in section 2 using the data from CPCB) in 2019, reporting a reduction by 66%. In Delhi, the decrease of PM_{2.5} was 55%, in Mumbai 25%, while Kolkata exhibited a marginal decrease by 11%. Nevertheless, the 24 h average never reached the WHO target of 10 $\mu\text{g}/\text{m}^3$ in any of these cities. The average concentrations of PM₁₀ were reduced by 59% in Delhi, 23% in Mumbai, and 12% in Kolkata. The average concentrations of PM₁₀ during lockdown were almost similar in these three cities; 64 $\mu\text{g}/\text{m}^3$, 67 $\mu\text{g}/\text{m}^3$, and 56 $\mu\text{g}/\text{m}^3$, while it was 155 $\mu\text{g}/\text{m}^3$, 86 $\mu\text{g}/\text{m}^3$, and 64 $\mu\text{g}/\text{m}^3$ (average values were obtained as described in section 2 using the data from CPCB) in 2019. As the concentration of PM₁₀ in Delhi in 2019 was much

higher, the reduction was also higher. In the case of PM_{10} also, the WHO guidelines of $20 \mu\text{g}/\text{m}^3$ were not achieved.

Hyderabad and Chennai exhibited substantial reductions in average NO_2 concentrations by 86 and 79%, while the decrease was marginal in Delhi. The CO concentrations in Delhi, Hyderabad, Mumbai, and Chennai have reduced during the lockdown period. An increase in average concentrations from 36 to $49 \mu\text{g}/\text{m}^3$ (average values were obtained as described in section 2 using the data from CPCB) was observed in Kolkata. There was a significant increase in the average concentrations of O_3 in Kolkata by 122%, while the increase in Hyderabad and Delhi were minimal. On the other hand, a decrease was observed in Mumbai and Chennai. The precursors contributing to the formation of O_3 in the atmosphere are NO_2 and non-methane hydrocarbons, the volatile organic carbons (VOC) (Dang and Liao 2019; Li et al. 2019). The VOC to nitrogen oxide ratio is one among the several factors affecting the concentration of O_3 ; a VOC to nitrogen oxide ratio of 4:1 to 10:1 is most favorable for the formation of ozone (Finlayson-Pitts and Pitts 1986). A detailed analysis of these aspects can help in proposing the pathways for the increase in O_3 concentration and need further studies.

Figure 2(a–c) depict the variations in NO_2 level in Chennai, Mumbai, and New Delhi, wherein the spatial maps and time series graphs are represented. The maps on the top of each figure show average of 15 days tropospheric NO_2 gridded at 1° latitude by 1° longitude resolution (NASA website: https://so2.gsfc.nasa.gov/no2/no2_index.html). These maps are prepared using a contouring algorithm applied for a region around a given city. In each map, the left panels show the variations during 2020, the middle maps show the data averaged over the years 2015–2019 (the reference line), and the plots on the right show the absolute difference between the first two maps. The red color in the image represents the highest level, and blue represents the lowest level. The maps show the reduction in average NO_2 levels in 2020 compared to the average values of 2015–2019 for Chennai, Mumbai, and Delhi.

The time-series maps of NO_2 during the periods 5 December 2019 to 3 May 2020 for Chennai, Mumbai, and New Delhi are represented in Figure 2(a–c). The blue dotted line represents the baseline for each day within the range 2015–2019. The graph shows a so-called "anomaly" defined as the difference between the 15 days running median and mean for the past several months and the baseline from 2015 to 2019. A negative value means that the recent values are below the baseline. The NO_2 level is well below the baseline from the starting of the lockdown period (Figure 2(a–c)). The observations depict the occurrence of a rare event that cause the concentrations to fall continuously for a long period.

Thus, it is evident that the COVID-induced lockdown has caused a significant reduction in NO₂.

4. Conclusions

The lockdown measures adopted in India have resulted in improvements in the air quality of the five major cities. Except for O₃, all the studied parameters showed a reduction in the concentration with reference to 2019 and the averages of 201–2019. However, after the withdrawal of lockdown, the concentration of pollutants can again spike up, and hence, the short-term improvement in air quality may not help out. Strict implementation of air quality policies in the country is required improve the quality of air. The contaminants have to be monitored regularly and proper implementation of management practices are called for to achieve the target set by the World Health Organization.

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