Assessment of Air Quality Index in major cities of India – Lessons from Lockdown

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Abstract: An unexpected closure episode of most of the public movement and industrial activities during the initial spreading duration of COVID-19 has significantly resulted in drastic reduction of environmental pollution in the urban areas globally. Being an active bio-aerosol with pandemic effect, COVID-19 presents a never-before scenario for the meteorologists and environmental engineers to look for systematic analysis of the overlap of air quality modelling with modifications in the atmospheric science. The long-term monitoring of pollution records help in defining unique indices for categorizing the severity of the existing pollution and thus helps in developing strategies for improving environmental quality. In this study, we present the observations in major air quality parameters in selected major cities of India using air quality index (AQI) before and after the announcement of a nationwide lockdown that extended nearly for many months. The results indicate a major sustaining type of decline in the average AQI values for major Type-1 and Type-2 cities due to the reduction in public movement and industrial activities, whereas the reduction AQI values for Type-3 and Type-4 cities were observed to be fluctuating due to the continued small-scale industrial activities and low level of awareness about ban on public gathering programmes.

Key words: Air quality index, COVID-19, Air pollution monitoring, Air pollutants

1. Introduction

Several environmental issues are confronting us in today’s society such as global warming, hazardous wastes, water pollution, air pollution, depletion of natural resources [1,2]. Many people die every year due to diseases caused by exposure to harmful air pollutants [3]. Deterioration of air quality is experienced by a majority of 300 million urban Indians, constituting about 30% of the Indian population [4]. Among the top 10 most polluted cities in the world list released by World Health Organization (WHO), nine cities are from India with Delhi at the sixth position [5]. The air quality index (AQI) is an important parameter to evaluate the air quality [6]. The AQI measures the overall quality of the air in a scale of 0 to 500. The range is divided into six levels, i.e. good (0-50), satisfactory (51-100), moderately polluted (101-200), poor (201-300), very poor (301-400) and severe (401-500). A low value indicates good quality air and a higher value indicates poor air quality, which has tremendous impact on the people’s health.

Following the outbreak of novel corona virus disease (COVID-19) several countries across the globe imposed national lockdown to contain the spread [7]. India confirmed its first case on 30th January, 2020 with an exponential increase to 360 cases by 22nd March, 2020, and the Indian government
imposed the curfew on same day for a period of 21 days. Due to this lockdown, 1.3 billion citizens were advised to stay in-doors, transport and industrial activities were suspended and only essential services were allowed. China has reported that the lockdown caused significant reduction in air pollution in three of its cities [8, 9]. A similar effect has been reported by Pathakoti et al. [10]. Therefore, it is important to analyse the direct environmental implications of such large-scale decisions. In this study, we are analysis the air pollution prior to and post outbreak of COVID-19 in terms of AQI for 16 major cities of India to infer the significance of demographic and geographic location in implementing the lockdown system.

2. Data collection
For this study, we have classified the major cities of India into four types according to the variations in the scales of economic development, demographic and geographic considerations. The constitution of the four datasets is as follows: Type-1 consists of Kolkata, Chennai, Delhi and Mumbai; Type-2 consists of Ahmedabad, Chandigarh, Visakhapatnam and Hyderabad; Type-3 consists of Lucknow, Gurugram, Guwahati and Bhopal; and Type-4 consists of Bengaluru, Thiruvananthapuram, Jaipur and Patna. The AQI data was collected from the website [11] for the year 2019 and 2020 for these selected 16 major cities of India. The row AQI data was collected based on the daily calculated values. Based on this, the monthly average values were calculated for a period from January 2019 to July 2020. The variation of daily and monthly averaged AQI values were plotted to get the trends of variation. The starting day of the declared lockdown, 22\textsuperscript{nd} March, 2020 was marked in the graph to differentiate the change in trends before and after the lockdown.

3. Results and discussion
3.1 AQI Variation in Type-1 Cities
The daily variations in reported AQI values between January 2019 and July 2020 were plotted in Figure 1. It shows that there is a common pattern of AQI variation due to the change in climatic conditions in all the four selected cities. The onset of summer and winter seasons are invariably associated with high AQI values owing to the unrestrained release of particulate matter into the atmosphere due to the prevailing surface dryness and humid air. It is also important to notice that Chennai has the minimum variability with a lower range of AQI (80-180) while Delhi also has a lower variability but with a higher range (120-380). The daily variations in the other two coastal cities were apparently same, showing significant variation in AQI between the summer-winter and monsoon periods. The variations in AQI after the lockdown showed that Mumbai and Kolkata experienced larger sustaining reduction while Delhi and Chennai resulted in more or less similar values, although Delhi being at a higher range than Chennai. The variation in mean monthly AQI among these four cities showed that there is a remarkable reduction in atmospheric pollution during the months of lockdown compared with the previous year values (Figure 2). Mumbai and Kolkata showed continuing decrease in the AQI values post lockdown, while Delhi showed an interim rise and a decline during the months of June and July 2020, and Chennai showed slow increase in AQI. The reasons for these variations in trends can be of multiple reasons, and this result serves an important understanding of the variation in air quality compared to the previous year’s data.
3.2 AQI Variation in Type-2 Cities

The variations in Type-2 cities showed significant implications of the industrial activities on ambient air quality over the study period. The variation in daily AQI prior and post lockdown reported insignificant effects in Chandigarh and Visakhapatnam, but the variations were quite significant for Ahmedabad and Hyderabad (Figure 3). Ahmedabad, being the highly industrialized city among the peers in the group, has highest range of AQI (250-1000) annually. However, the impact of lockdown was observed to be highest in Ahmedabad (from 500 to 120) owing to the strict following up of the lockdown by the industries and the public. The next highest impact was observed in Hyderabad where the mean AQI has declined from 120 to 70, bringing better air quality standards in the atmosphere of the city (Figure 4). Visakhapatnam and Chandigarh showed similar trends of low AQI values, though there was a profound drop in AQI in Chandigarh during the period of lockdown, i.e. between March and April, 2020.
Figure 3. Daily variations in reported AQI values of selected four Type-2 cities of India

Figure 4. Variations in monthly averaged AQI values of selected four Type-2 cities of India

3.3 AQI Variation in Type-3 Cities

The daily variations in AQI for the Type-3 cities of India showed cyclic trends over the climatic conditions during 2019-2020 and it is more significant in two economically developed cities of North India namely Lucknow and Gurugram compared to Guwahati and Bhopal. The average air quality is showed to be highest for Guwahati with lowest range of AQI (70-100), followed by Bhopal (100-120) during the period of lockdown (Figure 5). There is a consistent annual reduction in AQI during the onset of summer months in all these cities, but the lockdown has decreased the range of AQI in all the cities. The average monthly variation in AQI also showed similar impact of lockdown where the persisting effect of lockdown is more profound in Gurugram owing to sudden closure of vehicular movement and similar exposed activities (Figure 6). At the same time, the graph also alarms about the increase in air pollution in the minor cities in India especially Guwahati and Gurugram which are prone to increased human and industrial activities due to the drastic increase in the developmental projects.
3.4 AQI Variation in Type-4 Cities

The comparison of AQI in the Type-4 cities of India indicates the relative awareness and rate of pervasiveness of the political notifications to penetrate into the public practices. The best example is shown in the daily variation trend in Thiruvananthapuram which has the lowest AQI (50-75) prior lockdown among the four selected cities which further reduced the AQI to a lowest range of (30-60) post lockdown (Figure 7). This is in consistent with the trend of Bengaluru city (50-70), but is highly contrasted to the city of Patna (80-120). The city of Jaipur shown about 50% reduction in AQI compared to last year’s value, but the trend is towards a higher AQI during the months after the end of lockdown. This is corroborated with the mean monthly variation in AQI which showed closer values for these four apparently incoherent cities during the period of lockdown (Figure 8). It is inevitable to state that this variation in AQI has deep dependencies on social and demographic background, rather than on the climatic conditions.
Figure 7. Daily variations in reported AQI values of selected four Type-4 cities of India

Figure 8. Daily variations in reported AQI values of selected four Type-4 cities of India

4. Conclusion
The impact of a sudden political decision to restrict the mass movement and public activity in India during the onset of COVID-19 pandemic on the general air quality of the major cities is analysed in this study. It is observed that there is a common and significant improvement in the overall air quality after the 21 days of lockdown in all the selected cities, though the variations have to be understood in relation to the specific socio-cultural backgrounds. The impact of climate change is outwardly neglected in the study since the comparison is based on a limited time scale and the cyclic behaviour of AQI is more or less repeated in other seasons as well. Therefore, this study illustrates the significance of a large-scale human intervention to restore the environmental quality which may be less likely to repeat in the history.
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