A concise air quality study on impact of COVID-19 lockdown for two industrial cities of Chhattisgarh

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Abstract. ‘Good Outcomes from evil situation’ this phrase perfectly fits into the COVID-19 circumstances as several restrictions on anthropogenic activities provided an improvement in the ambient air quality status globally. The study deals with the consequences of COVID-19 lockdown on ambient air quality for 2 major industrial cities (Raipur and Bilaspur) in Central Indian state Chhattisgarh moreover a comparison of air quality data was made with non-lockdown year (2019). The AQI and critical parameters (such as PM_{10}, PM_{2.5}, SO_2 and NO_x) were acquired form online available source and then analysed for the study period (2019 and 2020). Noteworthy reduction in AQI and concentration of pollutants in Raipur was detected whereas there was reduction in Bilaspur but it was less than Raipur. Evident changes in the level of pollutants (NO_x and PM) were observed during the study. Meteorological parameters such as temperature and relative humidity were also examined for Raipur. Statistical analysis between data of meteorological parameters and AQI for capital city Raipur was also carried out.

Key words: COVID-19, AQI, Meteorological parameter and Statistical analysis

1. Introduction

COVID-19 rapid proliferation has turned into global public health emergency. In the end of December 2019, a contagious disease was detected at Wuhan city, China and named Corona virus disease (COVID 19) also known as SARS COV 2[1,2]. The virus began to spread swiftly across the globe in early 2020 infecting nearly many countries. On 30th January 2020 first case was reported in India [3].
The virus eventually expanded to 215 countries throughout the world and the WHO declared it as global pandemic on March 11, 2020 [4].

To avoid the situation from getting more worse, as a prevention from this pandemic period lockdown were imposed at different places in different parts of the world. As a result of the increasing number of cases in various parts of globe because of the virus, the Government of India (GOI) has adopted an early call to eradicate the spread of the COVID by declaring a nationwide lockdown which started on 25th March 2020 to 14th April 2020 further which extended 31st May 2020[5]. The Indian government imposed various restriction on several anthropogenic activities like commercial, industrial, education, transportation sector, tourism and public gathering. During this lockdown time only very essential services like hospital, ATMs, bank, grocery shops, pharmacies and petrol pump were permitted[6,7,8].

The lockdown due to pandemic on the human activities proved as a gift for the environment which gave it much needed time to heal. A great improvement in air quality status was observed around worldwide and a lot of study is going on this[9,10]. As a matter of fact, in India there has been a significant improvement in air quality and reduction in critical pollutant in many metropolitan cities and other part of the country, numerous research papers are present to justify the fact[3,4,11,12,13,14]. Noteworthy reduction in the concentration of pollutants such as NO\textsubscript{2} and particulate matter due to various constraints in lockdown over transportation and industrial sector emission [8,15]. Satellite data and visual maps are also made used in variety of work to get a better understanding of the condition of air quality in the atmosphere [4,5,8,11]. The main objective of the study to analyse consequences of COVID-19 lockdown on ambient air quality for 2 major industrial cities in Chhattisgarh and to compare the air quality data with non-lockdown year (2019).

2. Study Area

Chhattisgarh was granted the status of separate and sovereign state of India in November, 2000. Soon after with the central government aid, the state experienced a boom in all sectors and is now the fastest growing state in the country [16]. The state’s rapid industrialization is due to the abundance of ores and minerals resources such as coal, limestone, granite, iron ore and bauxite [16,17]. In the study major 2 industrial cities Raipur and Bilaspur have been analysed. Raipur is bordered by several industrial areas such as Urla, Siltara, Tilda, Bhanpuri and the district Durg which is also a large industrial city[18,19,20]. Several cement industries, sponge iron units, steel industry, ferro alloy plant, rice mills and power plants are located in the various industrial area near Raipur. The next selected city, Bilaspur is also major industrial city[17,21]. Number of industrial area such as Sigritti, Tifra, Dagori and Silphari are surrounding the city Bilaspur (CSIDC). South Eastern Coalfields Limited (SECL) and National Thermal Power Corporation Limited (NTPC) are also located at the city.
3. Material and Methods

CECB (Chhattisgarh Environment Conservation Board) has been established as an authorised department of Chhattisgarh Government, with its headquarter in Raipur, state capital [17]. The required data for study were obtained from the official site of https://www.enviscecb.org/. For two years (2019 and 2020) the online data for AQI and concentration of pollutant (PM$_{10}$, PM$_{2.5}$, SO$_2$ and NO$_x$) were obtained for the months of March and April. Further the meteorological data were procured from the weather underground services (https://www.wunderground.com/) for Raipur city.

Assessment of the air data (AQI and concentration of pollutant) has been carried out using MS-Excel and various available research works. For the convenient analysis the study has been divided into 2 phase:

1) Before Lockdown Phase (BLP)[1$^{st}$ March -24$^{th}$ March]
2) During Lockdown Phase (DLP)[25$^{th}$ March- 25$^{th}$ April]

for 2 years to monitor the consequences of lockdown on air quality status in 2 industrial cities (Raipur and Bilaspur) of Chhattisgarh. Fixed interval of phase for both the years (2019 and 2020) has been taken so that the comparison and study could become easier.
4. Results and Discussion

4.1 AQI and concentration of pollutants variation for 2 cities

AQI and concentration of pollutants (such as PM\textsubscript{10}, PM\textsubscript{2.5}, SO\textsubscript{2} and NO\textsubscript{x}) data were downloaded from the official site of CECB and after the processing of the data it was divided it into 2 phase further (Table 1) and (Table 2) were prepared.

Table 1 summaries the average AQI and % change over 2 different phases for non-lockdown year (2019) and lockdown year (2020). From Table 1 it was observed that Raipur experienced a greater decrease in AQI which was about 37.3% when the comparison was made between 2020 DLP and 2019 DLP. Moreover, when the comparison was made within the same year (i.e., 2020) between 2 phases (DLP and BLP) the result was also noticeable which about 26% decline in AQI. Presence of numerous of industries around city which were shut down during the lockdown could be one of the reasons for falling off in AQI.

On the other hand, for Bilaspur city the results which were observed were not as good as Raipur. Decrease of 10.9% and 12.5% in AQI were noticed when 2020 DLP was compared with 2019 DLP, and 2020 DLP was compared with 2020 BLP respectively for Bilaspur city. Presence of NTPC near the city could be considered as a factor that there was slight change in AQI. In addition to the fact, the power hub of the state, Korba which has several power stations which were operational during the lockdown also is located near to city [15,17].

(Figure 2) describes graphs for study area with average AQI trend in both phases. Form (Figure 2) it was observed that for Raipur city decreasing trend was noted whereas slight change in AQI for Bilaspur was noticed. Table 2 give details of the average concentration for critical parameter such as (PM\textsubscript{10}, PM\textsubscript{2.5}, SO\textsubscript{2} and NO\textsubscript{x}) and difference % for the lockdown year (2020) which were analysed for Raipur and Bilaspur. Prime source (NO\textsubscript{x} and PM) in Raipur is from several industrial sectors, high intensity vehicular population and re suspension of dust particulate [21,22,23]. As the lockdown was announced in the year 2020 hence due several restrictions on anthropogenic activities such as commercial work, construction activities, industrial and vehicular emission resulted in improvement in the level of concentration of several pollutants. From (Table 2) it was observed that exception decrease of 26.0% and 24.5% in PM\textsubscript{10} and NO\textsubscript{x} respectively for Raipur was found when comparison was made between 2020 DLP and 2020 BLP in the study.

For the second selected city Bilaspur a small decrease% was noticed which was about 11.1% and 8.7% when 2020 DLP was compared to 2020 BLP for PM\textsubscript{10} and NO\textsubscript{x} respectively. From (Table 2) it was observed that for Raipur the concentration level of PM\textsubscript{2.5} and SO\textsubscript{2} were not as remarkable as (NO\textsubscript{x} and PM\textsubscript{10}) but reduction in level of concentrations were found about 15.9% and 13% when BLP was compared to DLP for 2020. Besides for Bilaspur city mere change in the concentration of 4% and 2.4% was recorded for PM\textsubscript{2.5} and SO\textsubscript{2} respectively during the analysis. The reason for this could be operation of various thermal power plant near the study area [15,24].

(Figure 3) depicts the graphical representation of parameters and respective average concentration in both phases of 2020 for selected cities. The result obtained for Raipur and Bilaspur were presented on the graphs.
Table 1. Average AQI and % changes over 2 phase for two major cities of Chhattisgarh state.

| CITIES  | 2019 | 2020 | ΔAQI % in DLP 2020 wrt DLP2019 | ΔAQI % in DLP 2020 wrt BLP 2020 |
|---------|------|------|-------------------------------|---------------------------------|
| RAIPUR  | 71   | 59   | 50                            | 37                             |
| BILASPUR| 54   | 55   | 56                            | 49                             |

BLP-Before Lockdown Phase, DLP-During Lockdown Phase

Figure 2. Average AQI in 2 years for selected cities in 2 phases.

Table 2. Average concentration of parameters and % difference for study areas for year 2020.

| RAIPUR (2020) | PARAMETERS | BLP | DLP | DIFFERENCE | DIFFERENCE % |
|---------------|------------|-----|-----|------------|--------------|
| PM$_{10}$     | 49.8       | 36.8| -13 | -26.0      |
| PM$_{2.5}$    | 27.4       | 23.1| -4.4| -15.9      |
| SO$_2$        | 14.2       | 12.3| -1.8| -13.0      |
| NO$_x$        | 13.7       | 10.4| -3.4| -24.5      |

| BILASPUR (2020) | PARAMETERS | BLP | DLP | Difference | Difference % |
|-----------------|------------|-----|-----|------------|--------------|
| PM$_{10}$       | 55.6       | 49.4| -6.2| -11.1      |
| PM$_{2.5}$      | 16.9       | 16.2| -0.7| -4.0       |
| SO$_2$          | 4.9        | 4.8 | -0.1| -2.4       |
| NO$_x$          | 15.3       | 14.0| -1.3| -8.7       |
Figure 3. Average concentration of parameters in the lockdown year 2020 for 2 cities.

4.2 Change in Meteorological parameters for Raipur city

Parameters such as temperature, relative humidity, wind speed, direction and precipitation greatly influence the air quality for any region. Pollutants in the environment can be easily dispersed, diluted and washed away with the help of meteorological parameters [25,26].

As the 2 phases which are selected for the study period lies in 2 different seasons. The BLP which lies at end of winter season and DLP come under the summer season. In winter due to prevailing meteorological conditions and low mixing height the pollutants are not easily dispersed whereas for summer the dispersion is better than winter season. Level of concentration is greatly influenced meteorological parameters [27].

Table 3 depicts the average temperature and relative humidity for year 2019 and 2020 for Raipur. The meteorological parameters such as temperature and relative humidity were obtained from the weather underground site for Raipur city and then these were analysed for 2 phases for year 2019 and 2020.

In the analysis of meteorological parameter (temperature and relative humidity) for the Raipur city it was observed that temperature variation for BLP in year 2019 and 2020 ranged between 24.7-34.8˚C and 23.1-28.7˚C respectively. Further for DLP of both the year it found to be 30.4-36.0˚C and 26.5-32.9˚C respectively. On the other hand, relative humidity variation was seen 26 - 69.4% and 55.87-82.3% in BLP period of 2019 and 2020, and for DLP it was found 24-53.6% and 38.2-63.3%.

Rise in the temperature and drop in humidity when comparison was made between the 2 phases (BLP and DLP) of same year this was remarked from analysis and also from the Table 3. This result was observed for both the years. From various other studies it was justified that high temperature and low humidity were helpful in improving the air quality status [5,14,26]. Hence it was concluded that there was improvement in AQI during this period of pandemic and meteorological parameter also supported it.
Table 3. Meteorological parameters over 2 phases for Raipur.

| Year  | Temperature(˚C) | Relative Humidity (%) |
|-------|-----------------|-----------------------|
|       | BLP    | DLP    | BLP    | DLP    |
| 2019  | 29.5   | 33.0   | 43.2   | 33.6   |
| 2020  | 25.9   | 30.7   | 69.0   | 47.1   |

4.2.1 Correlation between the meteorological parameters and AQI.

The correlation analysis was performed to get relation between meteorological parameter and AQI with the accessible data of the year 2021 for Raipur city. In the atmosphere, meteorological parameters play a vital role in carriage, dispersal and natural purification [25,26]. So, for the study statistical analysis to determine the influence of meteorological parameters on AQI for Raipur the analysis was carried out using MS Excel. Several correlation analyses for different parameters had been performed earlier for the study area in different works [27,28]. The meteorological parameters such that temperature and relative humidity were worked out for this study. The parameters were procured form the Weather Underground site for the month March-April 2021. Figure 4(a),(b),(c) and (d) show the graphs representing the correlation between parameters(temperature and relative humidity) and AQI. After carrying out the analysis for March 2021 it was observed that positive correlation of (0.188) between temperature and AQI Figure 4(a), and correlation between relative humidity and AQI was (0.109) Figure 4(b). Moreover, when the analysis was done for April 2021 a poor positive correlation of (0.001) between temperature and AQI Figure 4(c) and a correlation of (0.006) were acquired between relative humidity and AQI Figure 4(d).
March 2021

\[ y = -0.2596x + 57.816 \]

\[ R^2 = 0.1095 \]

(b)

APRIL 2021

\[ y = 0.1551x + 38.142 \]

\[ R^2 = 0.0013 \]

(c)
5. Conclusion

The study analysed the impact of COVID 19 on the Air Quality Index and concentration of pollutants (PM$_{10}$, PM$_{2.5}$, SO$_2$ and NO$_x$) for 2 selected cities of Chhattisgarh state, further the results were compared with the non-lockdown year 2019 with the available CECB data. A part of the study also comprised of correlation of meteorological parameter with air quality index which was found to be poorly correlated with the available data of year 2021 for Raipur city.

After analysis of air quality data during the study it was observed Raipur showed an appreciably result in improvement of AQI, about decrease of 37.99% when the comparison was made between 2020 DLP and 2019 DLP. Whereas for Bilaspur results of AQI reduction were not as good as Raipur only 10.04% of decrease when 2020 DLP was compared with 2019 DLP. For both the parameter (PM$_{10}$ and NO$_x$) remarkable decline in level of concentration was observed, little less in Bilaspur. Meteorological parameters also supported in enhancing air quality. All these obtained results were possible due to the lockdown which was imposed and several limitations which were put on pollution producing activities. The pandemic turned out to be gift for the environment and helped a lot in improvement of air quality.

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