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Analysis of air pollutants in Covid 19 pandemic lockdown- a case study of Bareilly, UP, India

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ABSTRACT

The contemporary world is dealing with the rise of the novel coronavirus pandemic. Globally, as on September 14, 2020, there have been 28,918,900 confirmed cases of COVID-19, including 922,252 deaths, reported to WHO with the cases still on the rise. In India, as a preventive measure, complete lockdown was imposed all over the country from 25th March 2020 which has significantly reduced the vehicular movement. Bareilly was reported among the seven most air polluted cities of Uttar Pradesh where PM10 was almost four times the annual standard of 60 μg/m³ averaging 226 μg/m³ for the year 2015 and 2016. The city Bareilly of State Uttar Pradesh do not have too much of industries and therefore industries cannot be blamed. Alternatively, vehicular or construction emission sources could not be ruled out and it can be concluded that primary sources of air pollution could be either automobiles or incomplete construction work. The present study is focused on monitoring of air pollutants PM10, PM2.5, SO2 and NO2, at Bareilly district of Uttar Pradesh and analyzed during the lockdown period due to pandemic COVID 19 from three monitoring stations. In the first week of lockdown, i.e. from March 25, 2020 to March 31, 2020 the PM10 and PM2.5 concentration averaged 60 μg/m³ and 47 μg/m³ respectively which is below the NAAQS average limits of 80 μg/m³ and 60 μg/m³ respectively. Whereas the concentrations of gaseous pollutants SO2 and NO2 was found to be much below the monthly NAAQS limits of 60 μg/m³ averaging 21 μg/m³ and 15 μg/m³ respectively. In April 2020, the vehicular movement was minimum and the level of air pollutants, PM10, PM2.5, SO2 and NO2, were found to be 54 μg/m³, 41 μg/m³, 19 μg/m³ and 14 μg/m³ respectively which is minimum in the six months of study from January 2020 to June 2020 and lowest in comparison to the air quality data of last 25 years. It can therefore be concluded that vehicular emissions contribute significantly for air pollution in Bareilly city.

1. Introduction

Air Pollution is one of the burning issues in the world particularly in the urban areas of developing countries. The major sources of air pollutants are due to rapid growth of population, huge construction sites, increase in number of vehicles and industries [WHO,2018]. Air pollutants get added in the atmosphere from different sources that change the composition of atmosphere and affect the biotic environment [CPCB,2003]. In India emissions from vehicles, industries, domestic and natural sources contribute significantly towards air pollution [www.cp ch.nic.in]. These air pollutants may pose harmful effect on human health such as cardio-vascular and respiratory disease, neurological impairments, increased risk of preterm birth and even mortality and morbidity. The rapid urban growth is also associated with transportation sector and road networks which support various vehicular movements on roads [1]. It has been reported that 17% and 28% of total NO2 and PM concentration, respectively, are contributed by vehicular emissions, which was almost equal to the combined sources such as industry, power plants and domestic sectors in Delhi, India [2]. However, over the last two decades petrol and diesel consumption have grown by 400% and 300%, respectively, which was mainly due to rise of vehicular numbers, DG sets, industries and waste incinerators [3,4]. The heavy traffic, thickly populated areas, jams, poor driving patterns, improper town planning and congested and encroached roads have severe impact on the environment in urban areas [5-9]. Emission due to vehicular exhaust is associated with a number of chronic and acute health effects [10,11]. The research studies show that chronic health ailments like cancers, heart attacks and asthma associated with NOx, SO2 and PM emissions from
In urban areas, air pollution is affected mainly due to construction of buildings, traffic composition and meteorological conditions. It has been found and reported that around ten million people from India lose their lives every year due to air pollution. Several reports document the relationship between PM2.5 and cardiovascular disease. Gold et al. demonstrated a significant increase in cardiovascular disease, from 0.5% to 1.5%, for every 5–6 μg/m³ increase in PM2.5. Further, they showed a 69% increase in cardiovascular deaths after acute exposure to particulate air pollution. The most vulnerable senior citizen population are most affected from pulmonary diseases due to emission of pollutant. To understand the chaotic situation and timely action and preparedness to face this sudden health disaster exhaustive monitoring, analysis and remedial steps are needed. CPCB, India and media reported that Bareilly was highly polluted and the third most polluted city in UP. Lack of congenial mass transportation in Bareilly city compels people to use their own transport. As a result, more combustion of fossil fuel takes place leading to high level of pollutants. The traffic congestion due to narrow roads worsens the situation. Less popularity of ecofriendly vehicles in Bareilly city and large number of two and four-wheeler vehicles are equally responsible in increasing PM2.5. In addition, the construction industry contributes to air pollution by emitting PM10. Today, the world faces a stressful time with the rise of the coronavirus pandemic. Globally, as on September 14, 2020, there have been 28,918,900 confirmed cases of COVID-19, including 922,252 deaths, reported to WHO. In India, more than five million people are infected with a death toll of more than 80000. In the Bareilly city of Uttar Pradesh which is almost equidistant from the country capital, New Delhi and the state capital Lucknow, more than 8000 people have tested positive so far for novel corona virus COVID19 and more than 150 people lost their lives due to this pandemic, with the cases still on the rise. When WHO declared COVID19 as pandemic, India took immediate measure by conducting a Janata curfew on March 22, 2020 followed by nationwide lockdown from March 25, 2020 to fight with coronavirus outbreak. The lockdown was initially imposed for a period of 21 days which was then further extended as a precautionary measure. During the lockdown period only essential services such as banks, ATM, hospitals and grocery shops were allowed to operate and all other commercial, industrial and institutional activities including transport were suspended. During May 2020 some relaxation were given in order to bring normalcy in the country. In the present scenario in Uttar Pradesh, the government has now lifted lockdown with school, colleges, cinema halls still closed. Amidst pandemic COVID19 significant improvements in air quality were reported from different media sources regarding the better air quality, visibility of mountain ranges clean rivers and clear skies. In a report, Aircalypso II, published by GreenPeace in 2018 the city Bareiwas reported among the seven most air polluted cities of Uttar Pradesh where PM10 was almost four times the annual standard of 60 μg/m³ averaging 226 μg/m³ for the year 2015 and 2016. The present study focused on annual air monitoring of possible air pollutants PM10, PM2.5, SO₂ and NO₂ is being done in Bareilly district of Uttar Pradesh, India from three monitoring stations covering approximately 11 km. Significant variation in the concentration of air pollutants of Bareilly city were observed during the COVID 19 lockdown period.
2. Material and methods

The methodology used to study seasonal trend and modeling of air quality of Bareilly district from three air monitoring sites is done as per the guidelines of Central Pollution Control Board of India CPCB.

Three monitoring stations were selected on the basis of traffic frequency and concentration sites. Respirable Dust Sampler with Gas analyzer were installed at three stations namely A,B,C within the Bareilly city as shown in Fig. 1. Station A is situated at Petrol Pump, near Rampur Garden Bareilly in the heart of the Bareilly city which has the maximum vehicular frequency of 70–80 vehicles per 5 min and is supposed to be a heavy traffic site. Station B, which is supposed to be a medium traffic site is located in the residential area at D.D Puram, Bareilly, has the average vehicular frequency of 50–60 vehicles per 5 min and Station C is at IVRI, Izatnagar, Bareilly which has low vehicular frequency of 20–30 vehicles per 5 min. From these stations sampling of Particulate Matter (PM10 and PM2.5) was done on eight hourly basis and gaseous pollutants (SO2 and NO2) sampling was done on four hourly basis as per the guidelines of CPCB, New Delhi. The methods used to monitor and analyze the possible air pollutants (PM, SO2, NO2) are as follows.

2.1. Cyclone flow technique

In order to measure Suspended Particulate Matter Respirable Dust Sampler Envirotech make APM460 DXNL is used. Air is drawn through a size-selective inlet and through a 20.3 × 25.4 cm (8 × 10 in) glass wool filter paper at a flow rate which is typically 0.9–1.4 m³/min free flow. Particles with aerodynamic diameters less than the cut-point of the inlet are collected by the filter. Particles of 10 μm are collected on filter paper holder. The mass of these particles is determined by the difference in weight gain of the holder. The mass of these particles is determined by the difference in weight of the sample (g) and stabilized though the complexation. The complex is made to react with 2 ml pararosaniline and 2 ml formaldehyde to form the intensely colored pararosaniline methyl sulphonic acid. The absorbance of the solution is measured by means of a suitable spectrophotometer at 560 nm wavelength. The working sulphite-TCM solution is measured by pipette with graduated amounts of 0.5, 1, 2, 3 and 4 ml into a series of 25 ml volumetric flasks and further adding sufficient TCM solution to each flask to bring the volume to approximately 10 ml. A calibration curve is prepared which is the plot of the absorbance against the total concentration in micrograms sulphur dioxide for the corresponding solution. The total micrograms sulphur dioxide in solution equals the concentration of the standard in micrograms sulphur dioxide per milliliter times the milliliter of sulphite solution added ( μg SO2 = μg/ml/SO2 x ml added). A linear relationship should be obtained, and the Y-intercept should be within 0.03 absorbance unit of the zero standard absorbance. For maximum precision determine the line of best fit using regression analysis by the method of least squares. The calibration factor is determined by the slope of the line of best fit and its reciprocal is denoted as B, which is the calibration factor.

Concentration of sulphite solution:

\[ C = \frac{(V_1 - V_t) \times N \times K}{V} \]  
(5)

Where.

\[ C = \text{SO}_2 \text{ concentration in \text{mg/ml}} \]
\[ V_1 = \text{Volume of thiosulfate for blank, ml} \]
\[ V_t = \text{Volume of sample, ml} \]
\[ N = \text{Normality of thiosulfate} \]
\[ K = 329000 \text{ (Milliequivalent weight SO}_2/\mu g) \]
\[ V = \text{Volume of standard sulphite solution, ml} \]

2.2. Improved West Gaake method

Absorption and stabilization of SO2 from air is done by a solution of sodium tetrachloromercurate(TCM). 30 ml of absorbing solution in glass impinger was sampled for 4 h with air flow rate 1 lit/m². SO2 is trapped and stabilized though the complexation. The complex is made to react with 2 ml pararosaniline and 2 ml formaldehyde to form the intensely colored pararosaniline methyl sulphonic acid. The absorbance of the solution is measured by means of a suitable spectrophotometer at 560 nm wavelength. The working sulphite-TCM solution is measured by pipette with graduated amounts of 0.5, 1, 2, 3 and 4 ml into a series of 25 ml volumetric flasks and further adding sufficient TCM solution to each flask to bring the volume to approximately 10 ml. A calibration curve is prepared which is the plot of the absorbance against the total concentration in micrograms sulphur dioxide for the corresponding solution. The total micrograms sulphur dioxide in solution equals the concentration of the standard in micrograms sulphur dioxide per milliliter times the milliliter of sulphite solution added ( μg SO2 = μg/ml/SO2 x ml added). A linear relationship should be obtained, and the Y-intercept should be within 0.03 absorbance unit of the zero standard absorbance. For maximum precision determine the line of best fit using regression analysis by the method of least squares. The calibration factor is determined by the slope of the line of best fit and its reciprocal is denoted as B, which is the calibration factor.

\[ \text{Concentration of Sulphur dioxide, } \mu g/m^3 \]

\[ \text{Absorbance of reagent blank} \]
\[ \text{Absorbance of sample} \]
\[ \text{Calibration factor} \]
\[ \text{Volume of air sampled, m}^3 \]
\[ \text{Volume of aliquot taken for analysis, ml} \]
4. Results and discussion

During the pre-lockdown period i.e. before March 25, 2020 the PM10 and PM 2.5 of Bareilly city had exceeded the NAAQS limits of 80 μg/m³ and 60 μg/m³.

The results for the air pollutants obtained for the Pre-COVID 19 period i.e. before lockdown period from January 2020 to March 25, 2020 were studied, analyzed and compared with Post –COVID19 period from 25th March to June 30, 2020.

Figs. 2 and 3 shows the monthly average value of PM10 and PM2.5 from three monitoring station viz. Station A: COCO Petrol Pump near Rampur Garden Bareilly, Station B: D D Puram Bareilly and Station C: IVRI, Bareilly and compared with NAAQS limits for the period of January 2020 to March 25, 2020.

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industrial and institutional activities were suspended since March 25, 2020. Only essential goods and services such as groceries, medicine, banks, ATM and hospitals were allowed to operate. As a result, the movement of vehicles was very low and vehicular emissions and construction works were supposed to drop down significantly. To study the impact of lockdown on air pollutants during the pandemic COVID19 daily air monitoring and analysis for the air pollutants PM10, PM2.5, gaseous pollutants SOx and NO2 was done from March 25, 2020 to March 31, 2020. Figs. 5–7 shows the daily analysis of air pollutants from March 25, 2020 to March 31, 2020.

As shown in Figs. 5 and 6 during the first week of lockdown, from March 25, 2020 to March 31, 2020, the PM10 and PM2.5 concentration averaged 60 μg/m³ and 47 μg/m³ respectively at all three monitoring stations which are below the daily NAAQS limits.

During the same period the concentrations of gaseous pollutants SO2 and NO2 was also found to be much below the daily NAAQS limits of 60 μg/m³ averaging 21 μg/m³ and 15 μg/m³ respectively as shown in Fig. 7. The lock down period during the pandemic COVID19 was extended till Mid of May2020 and then phase wise unlock was done in different parts of the country depending on the number of infected people in a particular locality. In Bareilly city, commercial activity were permitted with certain restrictions and guidelines issued by state administration. Air monitoring was further studied in the phase wise unlock period for the month of April to June 2020. Fig. 8 represents the comparison of air pollutant during pre COVID19 and post COVID19 for the period of six month i.e. January2020 to June 2020.

From Fig. 8, the results clearly indicate that during the lockdown period due to pandemic COVID19 there is a sharp cut in the concentration of air pollutants in Bareilly city and all the three stations reported the air pollutants concentration within the permissible limits. This could be due to low vehicular emissions, restricted use of DG sets and suspended construction work. A further data was collected from three petrol pumps regarding the sale of diesel and petrol fuel from petrol pump in the vicinity of the monitoring station.

From Table 1 it is evident that the fuel sale shows a decreasing trend in the month of March 2020 and is least in April 2020 when the Bareilly city was under lockdown and a gradual rise in the fuel sale was observed from May2020 onwards. The sale of diesel at Coco Pump, DD Puram and Dhruv Pump during the month of April 2020 has decreased by 38%, 58% and 46% respectively as compared to the sale in the month of March whereas the sale of petrol has crashed during the month of April 2020 at Coco Pump, DD Puram and Dhruv Pump by 53%, 63% and 60% respectively. During these two months i.e. March and April 2020 the vehicular movement was minimum. The level of air pollutants, PM10, PM2.5, SO2 and NO2, were found to be 54 μg/m³, 41 μg/m³, 19 μg/m³ and 14 μg/m³ respectively(Fig. 8) which is minimum in the six months of study. This clearly indicates that vehicular emissions contribute significantly for air pollution in Bareilly city.

4. Conclusion

From the analysis of the air pollutants over a period of six months from three monitoring locations depending on the traffic frequency in the vicinity of 11 km, it can be concluded that the concentration of air pollutants in Bareilly city was greatly affected and dropped down during the lockdown period especially in the end of March and April 2020 and showed gradual increasing trends from May onwards as the city stepped in to the unlock phase. Bareilly city do not have too much industrialization and hence air pollution largely depends on vehicular emissions.

Table 1

| Month    | Coco Pump Diesel (KL) | Coco Pump Petrol (KL) | DD Puram Diesel (KL) | DD Puram Petrol (KL) | Dhruv Pump Diesel (KL) | Dhruv Pump Petrol (KL) |
|----------|-----------------------|-----------------------|----------------------|----------------------|------------------------|------------------------|
| January  | 303                   | 349                   | 69                   | 171                  | 66                     | 174                    |
| February | 283                   | 345                   | 72                   | 192                  | 81                     | 183                    |
| March    | 248                   | 301                   | 51                   | 141                  | 39                     | 129                    |
| April 2020 | 153               | 139                   | 21                   | 51                   | 21                     | 51                     |
| May 2020 | 203                   | 181                   | 42                   | 102                  | 36                     | 66                     |
| June 2020 | 275                 | 311                   | 75                   | 153                  | 45                     | 123                    |

Fig. 8. Comparison of air pollutant (PM10,PM2.5, SOx and NOx) during pre COVID19 and post COVID19 for the period of six month i.e January2020 to June 2020.
which is evident from the sale of diesel and petrol fuel reported from the fuel pumps in the study area, Bareilly. Future monitoring and analysis can be done by increasing the number of monitoring stations. This could yield more accurate results in the estimation of air quality of Bareilly city.

CRediT authorship contribution statement

Sachin Agarwal: Data curation, Writing – original draft, Software.
Dinesh K. Saxena: Supervision, Software, Validation. Rupini Boyina: Conceptualization, Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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