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Rohini Singh[1], Shalendra Pratap Singh[2], Pratima Gupta[1], Narayan Prasad[1], Ashok Jangid[2], Kamal Kumar[3] and Ranjit Kumar[1]*

[1]Department of Chemistry and [2]Department of Physics and Computer Science
Faculty of Science, Dayalbagh Educational Institute (Deemed University), Dayalbagh, Agra, INDIA
[3]Central Pollution Control Board, Agra, INDIA

Email: rkschem@rediffmail.com

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[1]Department of Chemistry and [2]Department of Physics and Computer Science
Faculty of Science, Dayalbagh Educational Institute (Deemed University), Dayalbagh, Agra, INDIA
[3]Central Pollution Control Board, Agra, INDIA

Email: rkschem@rediffmail.com

ABSTRACT

Air pollution has posed threats to the survival of human being, became a big issue all over the world and mitigation remained a challenge. In November 2019, $PM_{2.5}$ reached to the worst level in most of the cities of India and outbreak of COVID-19 arose in China. The first case of COVID-19 in India was reported on 30 January 2020. India currently has the largest number of confirmed cases in Asia. Lock-down in India to contain spread of COVID-19 disease was part of world strategy. COVID-19 associated lock-down has improved the air quality. This paper deals with a preliminary study on indirect effect of COVID-19 pandemic on air quality in 15 cities of 12 states of India. $PM_{2.5}$ level showed fall in concentration all over the country. The complete lock-down in India due to COVID-19 has resultant into reduction in pollution due to complete ban on movement of vehicles. Exponential model further confirmed. The 2020 lock-down amid corona pandemic has resultant into like blessings in disguise. This study will help in setting the background value and making the long-term plan although impact of COVID-19 associated lock-down may be short-term.

Keywords: *Air pollution, air quality, concentration, amid corona pandemic etc.*

INTRODUCTION

Particulate matter has been considered as one of the most important parameters to check the air quality of any air shed. Recently, WHO released a report in 2014 and identified 20 most polluted cities in the world based on $PM_{2.5}$. Out of the 20 most polluted cities, thirteen were from India and most of them are situated over the Indo-Gangetic basin. The high rate of population growth and rapid urbanization accompanies industrialization; construction and motorization in India are a major cause of high air pollution. This has resulted in a threat to the survival of human beings in the last few decades and has attracted the attention of the scientific community worldwide for pollution reduction. However, all the efforts have gone in vain so far and none of the cities in India meets WHO standard [1].

Recently, the corona pandemic has spread all over the world and claimed thousands of lives and made millions of people affected [2-3]. The symptoms of disease due to corona virus (COVID-19) are similar to airborne diseases like sneezing, coughing, short breathing, lung impairment, and associated with excess morbidity and mortality. During COVID-19 pandemic, lockdown has been practiced all over the world to contain the diseases. This has led to improve in air quality in various countries but it is far too early to speak of long-term change [4-5]. India was under the biggest lockdown with around 130 crore people asked to stay home in view of the corona virus outbreak. This has minimized the use of reduction of private vehicles, other non-essential transportation, construction activity etc. The entire country has been put under a lockdown as a measure to curb the spread of the corona virus. Due to the non-availability of specific drugs and vaccines, COVID-19 has become pandemic. Lockdown or detention was the only way of prevention. The lockdown has minimized the movement of the human being. The aim of the present investigation is to see the indirect effect of Corona 19 pandemic on air quality in India and recognize the sources.

MATERIAL AND METHODS

The CPCB (Central Pollution Control Board, India) has air quality monitoring stations in major cities across India. The monitoring network covers almost all states and territories and selected stations are representative of the Indian population. We have selected 15 CPCB stations (Agra, Ajmer, Bengaluru, Delhi, Dewas, Hyderabad, Jorapokhar, Kanpur, Lucknow, Ludhiana, Nagpur, Patna, Rajamahavendrum, Siliguri, and Thiruvananthapuram) (Fig.1a) stations of 12 states

*Author for correspondence

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where corona pandemic have been reported. CPCB stations are primarily used to monitor air quality and to provide an air quality health index measurement; as a result, sites are mainly located in populous and urban areas. In this study, these sites were selected to represent current $PM_{2.5}$ and PM_{10} levels over current sites in India.

Data were obtained from the CPCB (www.cpcb.nic.in) [6]. The CPCB monitors ambient atmospheric $PM_{2.5}$ concentrations in microgram per cubic meter. All available data during the period January to March 2020 were downloaded for all the selected stations for this study. The daily mean concentration was used for investigation. The days with at least an hour data value were considered for the study.

The daily average levels of ambient fine particulate matter were determined for the period March to April 2020 for each station (15 current stations). Short-term forecast was made using regression analysis and two point methods. The hourly average concentration was considered for mean, median, minimum and maximum value calculation and exponential model has been used for source attribution.

RESULTS AND DISCUSSION

Amid, the disguise of lockdown due to the COVID-19 pandemic, we found blessings in terms of improvement in the ambient air quality in India. We undertook the analysis of air quality data for the month of January, February and March 2020 (during the COVID-19 pandemic and lockdown) of 15 cities (Agra, Ajmer, Bengaluru, Delhi, Dewas, Hyderabad, Jorapokhar, Kanpur, Lucknow, Ludhiana, Nagpur, Patna, Rajamahavendrum, Siliguri, and Thiruvananthapuram) (Fig.1a) of different states or parts of India (CPCB, 2020) where COVID-19 cases have been reported. The average mean mass concentration of $PM_{2.5}$ was highest at Siliguri (164.5 μg m^{-3}) followed by Patna (145.8 μg m^{-3}) and the lowest concentration was monitored at Bengaluru (28.8 μg m^{-3}). Similarly, the concentration of PM_{10} was highest at Siliguri (265.9 μg m^{-3}) followed by Patna (195.2 μg m^{-3}) and the lowest concentration was found at Thiruvananthapuram (61.04 μg m^{-3}). These variations are akin to site characteristics. We found that during the COVID-19 pandemic the concentration of PM_{10} and $PM_{2.5}$ was lowest in the month of March in comparison to January and February. On the day of Janta curfew (March 22, 2020), there was a dip in the concentration of particulate matter, which further built up on 23-24 March, 2020. We observed steep declination in the concentration of particulate matter from 25 March 2020 (starting date of lockdown in India) (Fig. 1b). 130 crore people were confined to their houses, no movements of the vehicle were allowed on the road except for essential services during the lockdown period. In the initial days of lockdown, there was a steep decline in pollution at Agra (Fig. 1c) but latter on declination was not in continuous rather there was fluctuation which may be due to restricted permission of vehicles of government agencies to provide essential commodities and medical facilities. The surprise decrease in pollution was like a blessing in disguise amid the corona pandemic. There was a linear decrease in the concentration of $PM_{2.5}$ during lockdown days. This decrease in the concentration of $PM_{2.5}$ in Agra may be probably due to a decrease in vehicular emissions as there was a complete ban on the movements of private vehicle on the road. A regression equation established (Fig. 1c) for short term forecast and deviation was just 6-10 %, which may be due to climatic factors. We computed hourly difference of $PM_{2.5}$ with and without (during lockdown period) vehicular emissions to estimate the contribution of vehicular emissions in $PM_{2.5}$ in Agra. The vehicular emissions estimation has been done assuming that traffic load is almost same every day with same vehicular emissions and the variation in $PM_{2.5}$ on daily basis is because of other sources/contributors (Fig. 2). Various studies have also shown the reduction in the concentration due to a pandemic situation was observed in many cities 108 of India as well as across the globe [7-10].

We also computed hourly mean difference in $PM_{2.5}$ with (normal weekdays 3rd to 8th March 2020 with vehicular emissions) and without traffic / vehicular emissions (under lockdown 26th to 31st March 2020) and found very small change in $PM_{2.5}$ after 10:00 PM to 4:00 AM (IST) (Fig. 2a). Further investigations has been carried out for six different selected sites by exponential model using model equation: $f(x) = \alpha e \beta x$ (where, α and β are coefficients associated with the model). Fig. 2b showed the measured and model value of $PM_{2.5}$ before and during the lockdown. The model coefficient has been computed for the given data set using the nonlinear least-squares method for all six sites (Fig. 2c). The negative coefficient β associated with the model for all cities signifies the exponential

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lowering of $PM_{2.5}$ during the lockdown and higher value of the coefficient α indicated higher $PM_{2.5}$ load before lockdown. The lower value of β signifies a steep decline of $PM_{2.5}$ and the higher contribution of vehicular and industrial emission. The concentration of $PM_{2.5}$ depends upon the different sources viz., natural and anthropogenic sources (such as industries, automobile, biomass combustion, etc.) [11-13]. This study is going to set a new paradigm of research plan in India particularly for improving urban air pollution. Reduction in pollution improves the immunity. This study signifies the need of further investigation on impact of air pollution on severity of COVID-19 pandemic [7, 14-15].

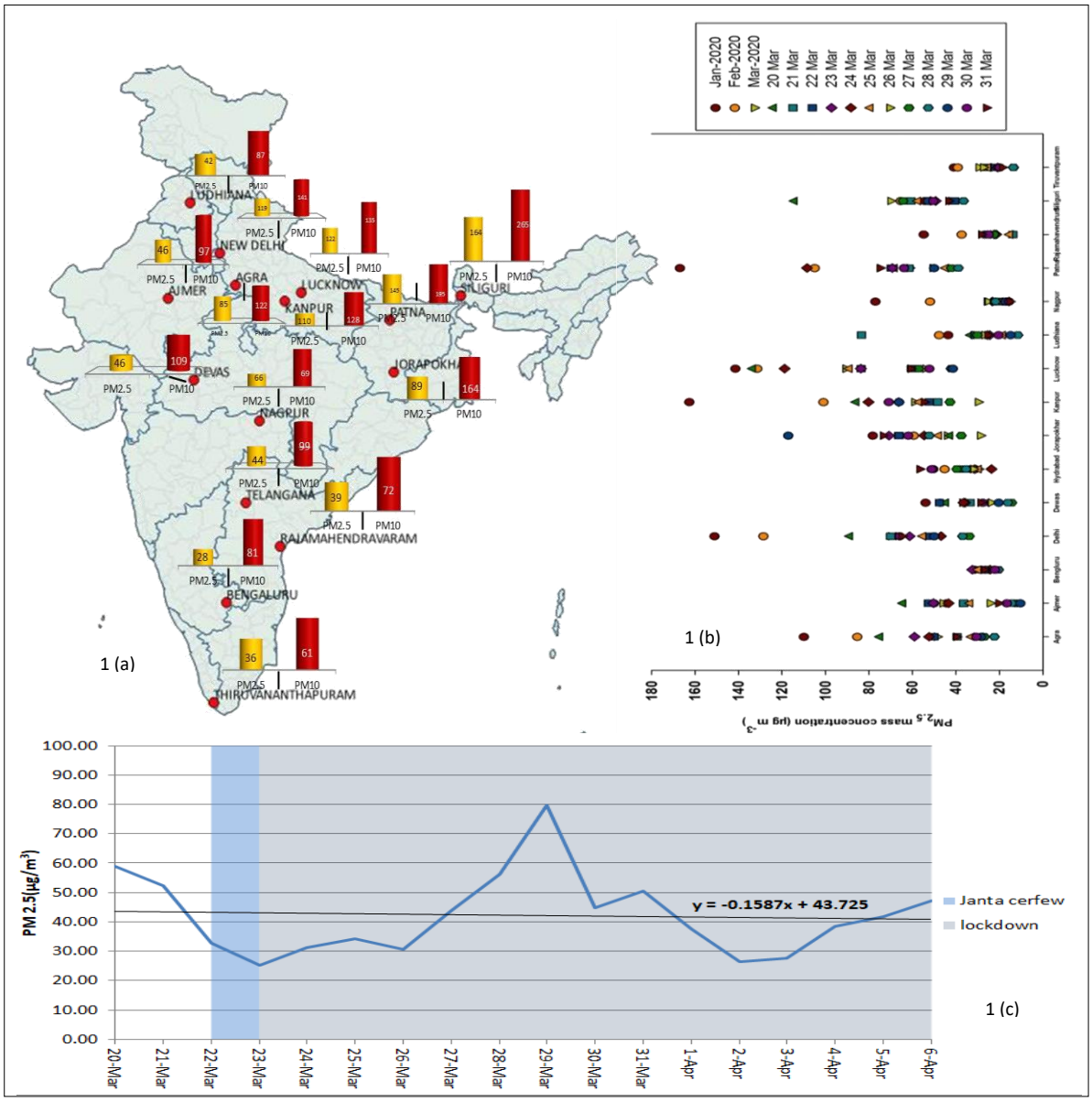

Fig. 1. (a): Geography of selected study sites along with the mean mass concentration of the particulate matter (PM_{10} and $PM_{2.5}$). Fig. 1 (b): shows the monthly (January- March 2020) and daily (20-31 March 2020) mean mass concentration of particulate matter (PM_{10} and $PM_{2.5}$) at different locations. Fig. 1 (c): daily variation of $PM_{2.5}$in Agra.

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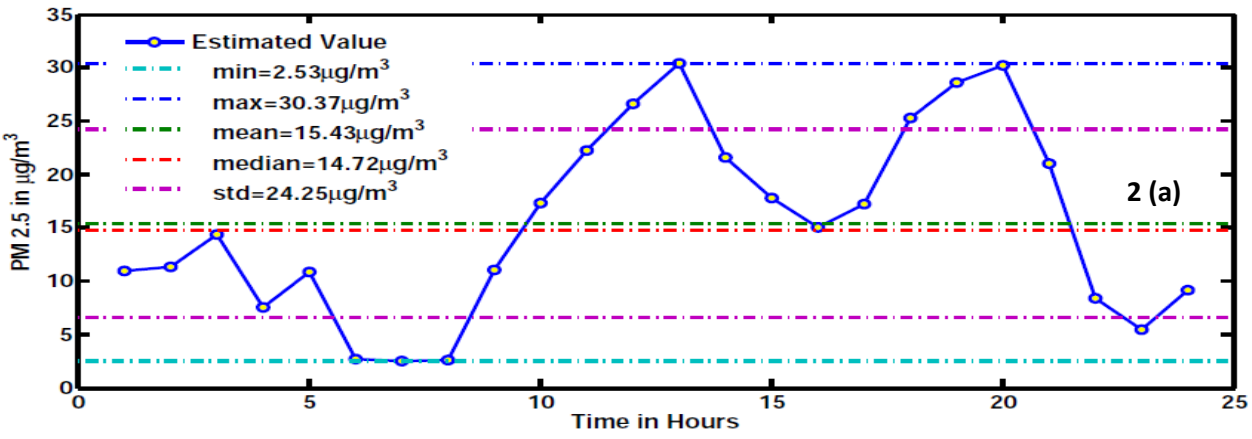

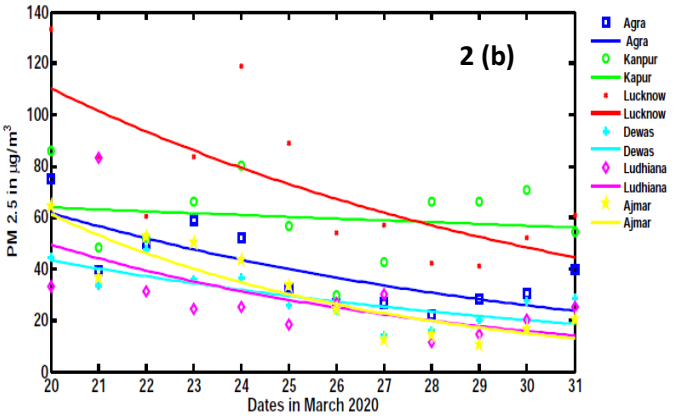

2 (c)

City	α (with 95% confidence bounds)	β (with 95% confidence bounds)
Agra	355.1 (-107.9, 818.1)	-0.087 (-0.14, -0.032)
Kanpur	80.79 (-24.09, 185.7)	-0.012 (-0.06, 0.039)
Lucknow	574.3 (-217.6, 1366)	-0.083 (-0.14, -0.025)
Dewas	202.3 (-32.74, 437.4)	-0.077 (-0.13, -0.028)
Ludhiana	484.3 (-776.5, 1745)	-0.114 (-0.22, -0.002)
Ajmer	1039 (-377.4, 2455)	-0.141 (-0.20, -0.081)

Fig. 2 (a): Average daily estimated value of $PM_{2.5}$ in Agra exclusively due to regular vehicular emissions. To nullify the effect of other contributors to $PM_{2.5}$ in the estimation, we have assumed that the traffic load is almost the same every day with the same vehicular emissions and the variation in $PM_{2.5}$ on daily basis is because of other sources/ contributors. (b): the value of $PM_{2.5}$, before and during lockdown markers and the line represents measured values and output of the model, respectively. The lifetime of $PM_{2.5}$ is typical of six to seven days, therefore during the lockdown, the $PM_{2.5}$ value must decay exponentially as vehicular and industrial emission sources are shut down. $PM_{2.5}$ data of two days before lockdown i.e., 20th and 21st March and ten days during lockdown i.e. 22nd to 31st march have been used to develop an exponential model for six cities; (C): the computed value of coefficients of the exponential model for different cities based on the nonlinear least-squares method.

CONCLUSION

The results showed the air quality impacts fall all over India. Corona pandemic indirectly reduces the concentration of particulate matter in 15 cities of 12 states in India. The main restriction started from March 25, 2020. The confinement of human being reduced traffic on road. $PM_{2.5}$ fall suggests that background level can be achieved in India which may match WHO standard in some urban cities. The health risk of $PM_{2.5}$ is more acute but short-term lock-down has decreased the pollution level so there will be decrease in mortality and increase in the ability to fight against corona virus. The proposed model explains the role and contribution of vehicular emissions and this is the first of its kind in which the contribution of vehicular emission is quantified. COVID-19 indirectly improves air pollution. Research outcome will be helpful to academicians, researchers, government agencies, planers, modelers, and NGOs also.

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