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Short communication

## Decline in PM<sub>2.5</sub> concentrations over major cities around the world associated with COVID-19

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## ABSTRACT

The COVID-19 started from Wuhan city in China, slowly spread across the globe after December 2019. Due to movement of people from one city to other cities, one country to other countries, infection spreads and COVID-19 became a pandemic. Efforts were made at local, regional and national levels to lockdown the movement of people and to keep infected one in quarantine or isolation to stop the spread of COVID-19. The traffic, market and small industries were closed, as a result pronounced decline in the concentrations of particulate matters (PM) were observed. Normally these sources contribute to the high concentrations of particulate matters (PM<sub>2.5</sub>) which represents air quality of a location. In this short communication, we present analysis of PM<sub>2.5</sub> of major cities (New York, Los Angeles, Zaragoza, Rome, Dubai, Delhi, Mumbai, Beijing and Shanghai) around the world suffered severely with the COVID-19. Our analysis shows decline in PM<sub>2.5</sub> concentration due to lockdown, mainly due to less movement of people to keep “social distancing” to control the spread of CORONA-19. The low concentrations of PM<sub>2.5</sub> reflect the efforts made in the cities to curb the spread of infection, that improve air quality.

### 1. Introduction

COVID-19 is one of the deadly pandemics, the transmission and nature of COVID-19 is not known. The outbreak of COVID-19 started from Wuhan city, capital of Hubei province of China (Raibhandari et al., 2020) in the month of December 2019. The virus gradually spread across neighbouring countries, including South Korea and Japan. With the outbreak of Coronavirus, migrants (students and workers) from India, Bangladesh, Nepal, Iran, Pakistan and other countries; returned to their home countries. In some countries, returning migrants were kept in isolation camp for 14 days, whereas, in a few countries including Iran, there were no testing, and consequently, the spread of the virus increased. In Italy, due to return of Chinese workers, the Coronavirus slowly spread and the northern parts of Italy were badly infected (<https://www.mygov.in/covid-19/?cbps=1>). In US, visitors from China and Europe and US tourists, returning from China/Europe, initially caused infections in major cities: King County in Seattle city, Los Angeles and New York City, and now almost all the states in US are suffering with Coronavirus. In China, Beijing and Shanghai cities were locked immediately when the virus spread, Italy decided to lock in the month of March. In many US cities, partial lockdown was imposed in the beginning of March and later complete

lockdown was started in the first week of April. As of March 20, 2020, lockdown was observed in California state, higher education institutions were asked to have online classes and the company employees started working from home. After seeing the spread of COVID-19 infection in other countries, the Prime Minister of India, announced Janata (People's) Curfew on March 22, 2020 in whole nation, cancelling all the domestic and international flights, trains, bus and almost roads were deserted. After its success, a complete lockdown was announced until April 14, 2020. Such Lockdown is the prime non-pharmaceutical aid to break the chain of COVID-19 (Long, 2020). In India, the complete lockdown is now extended until May 3, 2020 to curb the spread of infection through complete stop of movement of people and also this has helped to maintain criteria of “social distancing”. This is an important move by the Prime Minister of India especially when the country lacks resources and medical facilities. The total lockdown has raised chaos among people, but it has cut down the emissions of particulate matter and greenhouse gas concentrations. We have carried out analysis of PM<sub>2.5</sub> in various cities in India and also in major cities around the world, where partial or complete lockdown have been observed. Our results show a pronounced improvement in air quality due to total lockdown in India and partial reduction in the anthropogenic sources in many cities of the world where people are highly affected by

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the coronavirus.

## 2. COVID-19

Not much information about COVID-19 is known. The size of the virus is about 70–90 nm, smaller than the size of smoke and dust aerosols (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7045880/>). Efforts are being undertaken to find out the characteristics and behaviour of this virus. Infected people, while sneezing, droplets are dispersed in the air and it affect other people close by (Wang and Du, 2020). Scientists are busy in carrying out lab and modelling studies to understand the nature and behaviour of this novel corona virus and its transmission. Currently, social isolation seems to be one of the prime solutions to keep away from COVID-19 infection (Long, 2020). Everyone is trying to maintain social distancing of 6 ft with others so that the probability of transmission can be reduced.

In the past, during 1918–1919 Spanish flu (H1N1) more than one billion people were infected, killing around 17–20 million people (Spreeuwenberg et al., 2018; WHO, 2002). During the early 21<sup>st</sup> century, more than 8000 people were infected by SARS and 774 people died (WHO, 2002). Compared to earlier pandemics, COVID-19 is one of the deadliest pandemics where people living in more than 208 countries were affected.

## 3. PM<sub>2.5</sub> data

The air quality is monitored in every country throughout the world. The PM<sub>2.5</sub> provides information about the air quality; high values of PM<sub>2.5</sub> impact the human health and affect the day to day weather conditions. We have analysed PM<sub>2.5</sub> data from ground stations located in different cities in different countries. In these cities, people are severely infected and killed. We have considered December 2019–March 2020, and compared with earlier years 2017–2019 (depending upon the data availability), to compare changes in PM<sub>2.5</sub> from earlier years with the periods after the outbreak of COVID-19 from beginning of December 2019 until March 2020. Our results show decline in PM<sub>2.5</sub> during different months, associated with the lockdown implementation in a city.

We have considered PM<sub>2.5</sub> data available through US Environmental Protection Agency (EPA) (<https://www.epa.gov/>) which maintains data of US Embassies in Delhi and Mumbai, India, Beijing and Shanghai, China and Dubai, UAE, available through the AirNow platform ([https://www.airnow.gov/index.cfm?action=airnow.global\\_summary](https://www.airnow.gov/index.cfm?action=airnow.global_summary)). For Rome, Italy and Zaragoza, Spain, we have used PM<sub>2.5</sub> data through PurpleAir sensors (<https://www.purpleair.com/>). The name of the sensor, “Rome-Vatican City” is located in Rome, Italy and “La Puebla de Alrinden” is located in Zaragoza, Spain. All the PurpleAir sensors are well calibrated and the PM<sub>2.5</sub> data are very comparable with EPA sensors deployed in US Embassies around the world. We have made comparison of PM<sub>2.5</sub> data observed in US Embassy Delhi through US EPA and PurpleAir sensor and observed a strong correlation ( $R^2 = 0.80$ ). PurpleAir sensors are located across the world and data sets are freely available to anyone. PM<sub>2.5</sub> data from Rome-Vatican City is available since December 2018 and data from La Puebla de Alrinden is available from December 2019. Table 1 provides sources of data considered in the present study. We have also carried out analysis of rainfall data available through Weather Underground ([www.wunderground.com/history](http://www.wunderground.com/history)) for cities considered in the present study. The rainfall data are available in near real time and earlier months. These data have been used widely by scientific community. The data are updated on the website through observations made at the airports worldwide.

## 4. Results and discussion

The particulate matter (PM<sub>2.5</sub>) concentrations vary in different

locations in different countries depending on the local meteorological conditions. The transmission of infection may also vary like PM<sub>2.5</sub>, depending on the meteorological parameters especially surface air temperature and relative humidity in a closed environment (Wang, and Du, 2020). Recently, Wang et al. (2020) have carried out analysis of PM<sub>2.5</sub> data in Beijing, Shanghai, Guangzhou, and Wuhan cities during COVID-19 and found pronounced reduction in atmospheric pollution attributed to the reduction of emissions in transportation and industries.

We have shown changes in the average monthly PM<sub>2.5</sub> data for the months of Dec.–March and compared with the average value of PM<sub>2.5</sub> cities around the world listed above. In some of the cities, and country, partial to complete lockdown were started beginning from January. In the month of March 2020 all the cities considered in the present study observed lockdown, although degree of the lockdown varies. In US, even during no lockdown, people did stay in their houses and tried to maintain “social distancing”, limit of 6 ft. The traffic on the roads were reduced but the flights, buses and essential services were not stopped. The decline in PM<sub>2.5</sub> compared with other years is attributed to the decline in traffic in US and also in many cities of the world considered in the present study, except in India where complete lockdown (no domestic and international flights, no trains, complete closure of small and big shopping centres and industry) was observed. The decline in different months in different cities in some countries reflect partial lockdown in different months where large number of people suffer from COVID-19 especially in the month of February and March 2020. In USA, a partial lockdown was observed in the month of March as a result, a linear decline in PM<sub>2.5</sub> was observed in New York and Los Angeles in the month of March 2020 (Fig. 2). The average PM<sub>2.5</sub> concentrations in New York, is 9.48 µg/m<sup>3</sup> during December 2019 to March 2020. In New York city, pronounced linear reduction (32%) is seen in PM<sub>2.5</sub> during March 2020 compared with March 2019, and 20% with compared to February 2020. In New York, PM<sub>2.5</sub> was reduced due to rainfall in the month of March 2020 (Fig. 2). In Los Angeles, 4% reduction in PM<sub>2.5</sub> is observed during March 2020 with respect to March 2019, about 30% compared with February 2020. Such changes are associated with the lockdown and due to rainfall, clearly showing improvement in air quality.

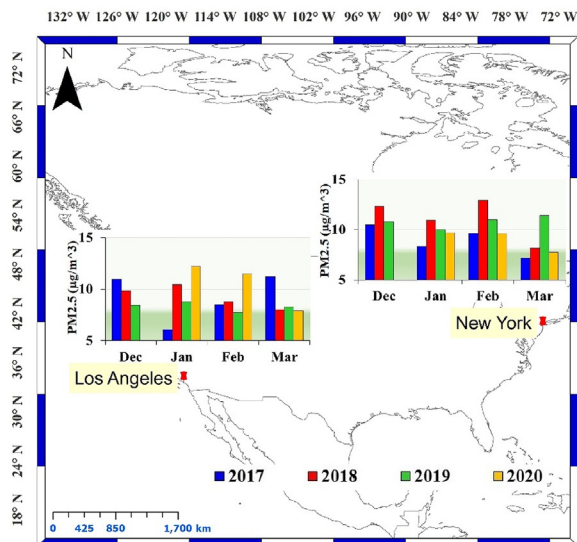
In Zaragoza, Spain, average PM<sub>2.5</sub> concentration is about 29.38 µg/m<sup>3</sup> during December 2019 to March 2020. Significant decline (58%) in PM<sub>2.5</sub> is observed in during March 2020 compared to February 2020. The average PM<sub>2.5</sub> in Rome is 35.0 µg/m<sup>3</sup> since December 2019 to March 2020, the average value of PM<sub>2.5</sub> in the month of March 2020 is similar to March 2019 but it is 24% lower compared with February and 159% compared to the month of January 2020. In Rome, Italy and Zaragoza, Spain during the period considered here, no rainfall occurred.

Variations of PM<sub>2.5</sub> in Dubai, UAE; Delhi and Mumbai, India are shown in Fig. 1c. In Dubai, PM<sub>2.5</sub> reduced to 11% during March 2020 compared with March 2019. During 2018 and 2019, PM<sub>2.5</sub> increased in the month of March compared to February due to rise in temperature, during this time dust is also common (Otaibi et al., 2019) that enhances PM<sub>2.5</sub>. Decline of 6% is found in PM<sub>2.5</sub> concentrations in the month of March 2020 with compared to February 2020 due to partial lockdown in Dubai. In Dubai lockdown was implemented in different phases, in the first phase schools were closed, later shopping malls, small shops and at the last religious places were closed. From the last week of March, night time curfew was imposed. Now a complete lockdown was announced. Due to different phases of lockdown a small change in PM<sub>2.5</sub> was observed in Dubai (personal communication with one of my students Waseem Mehdi and also through <https://gulfnnews.com/uae/health/coronavirus-uae-schools-parents-adjust-to-month-long-closure-1.70151639>; <https://www.livemint.com/news/world/dubai-imposes-2-week-lockdown-to-suspend-metro-and-tram-service-11586057661057.html>)

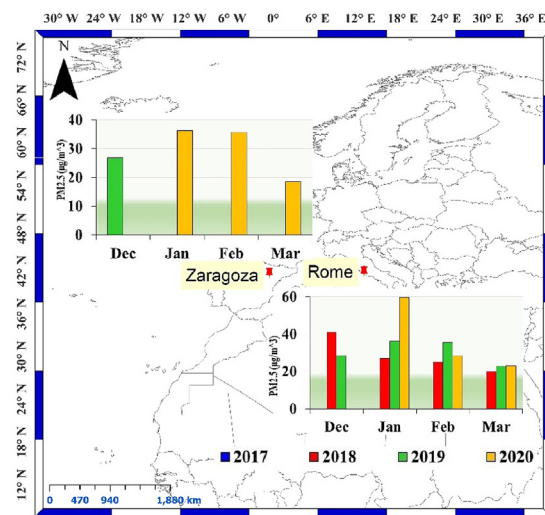
Low value of PM<sub>2.5</sub> due to cool temperature (Otaibi et al., 2019) was

**Table 1**  
Shows name of the city, source of data and web link.

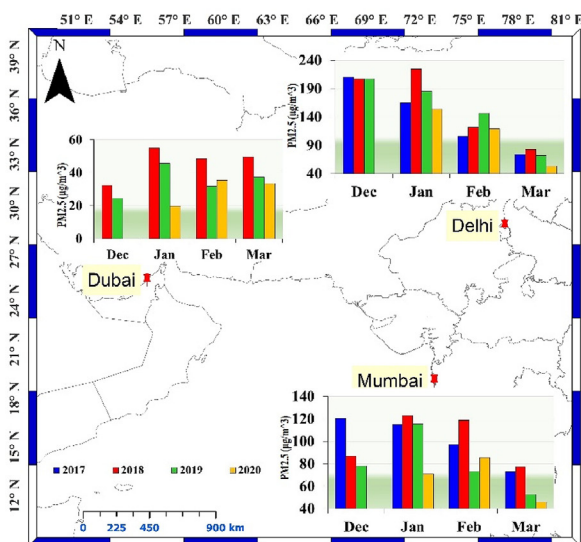
	Name	Lat	Lon	Source of Data	Webpage
1	Rome	41.85	12.57	PurpleAir	<a href="http://www.purpleair.com/Sensor Name: Rome-Vatican City">www.purpleair.com/Sensor Name: Rome-Vatican City</a>
2	Shanghai	31.23	121.46	AirNow	<a href="http://www.airnow.gov/index.cfm?action=airnow.global_summary">www.airnow.gov/index.cfm?action=airnow.global_summary</a>
3	Mumbai	19.07	72.87	AirNow	<a href="http://www.airnow.gov/index.cfm?action=airnow.global_summary">www.airnow.gov/index.cfm?action=airnow.global_summary</a>
4	Dubai	25.26	55.31	AirNow	<a href="http://www.airnow.gov/index.cfm?action=airnow.global_summary">www.airnow.gov/index.cfm?action=airnow.global_summary</a>
5	Delhi	28.60	77.19	AirNow	<a href="http://www.airnow.gov/index.cfm?action=airnow.global_summary">www.airnow.gov/index.cfm?action=airnow.global_summary</a>
6	Beijing	39.95	116.46	AirNow	<a href="http://www.airnow.gov/index.cfm?action=airnow.global_summary">www.airnow.gov/index.cfm?action=airnow.global_summary</a>
7	Los Angeles	34.14	-117.85	US EPA	<a href="http://www.epa.gov/outdoor-air-quality-data/download-daily-data">www.epa.gov/outdoor-air-quality-data/download-daily-data</a>
8	New York	40.85	-73.97	US EPA	<a href="http://www.epa.gov/outdoor-air-quality-data/download-daily-data">www.epa.gov/outdoor-air-quality-data/download-daily-data</a>
9	Zaragoza	41.63	-0.75	PurpleAir	<a href="http://www.purpleair.com/Sensor Name: La Puebla de Alfinden">www.purpleair.com/Sensor Name: La Puebla de Alfinden</a>



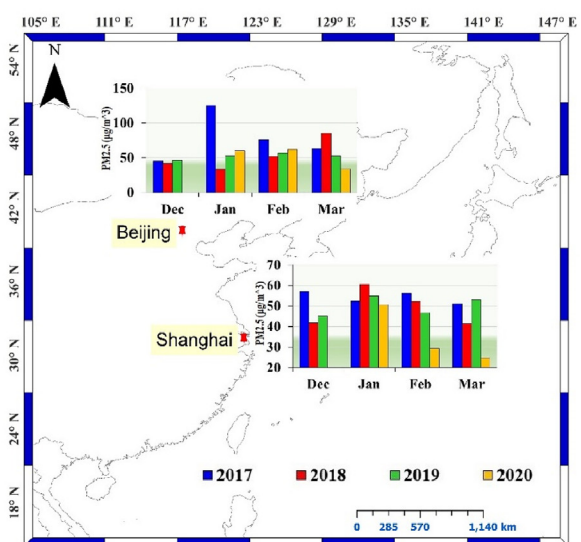
a



b



c



d

**Fig. 1.** Location of various stations across world along with average  $PM_{2.5}$  concentrations ( $\mu g/m^3$ ) during 2017 (blue bar), 2018 (red bar), 2019 (green bar) and 2020 (yellow bar) for Dec to March for (a) New York and Los Angeles, USA; (b) Zaragoza, Spain and Rome, Italy, European cities; (c) Dubai, UAE, Delhi and Mumbai, India; and (d) Beijing and Shanghai, China. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

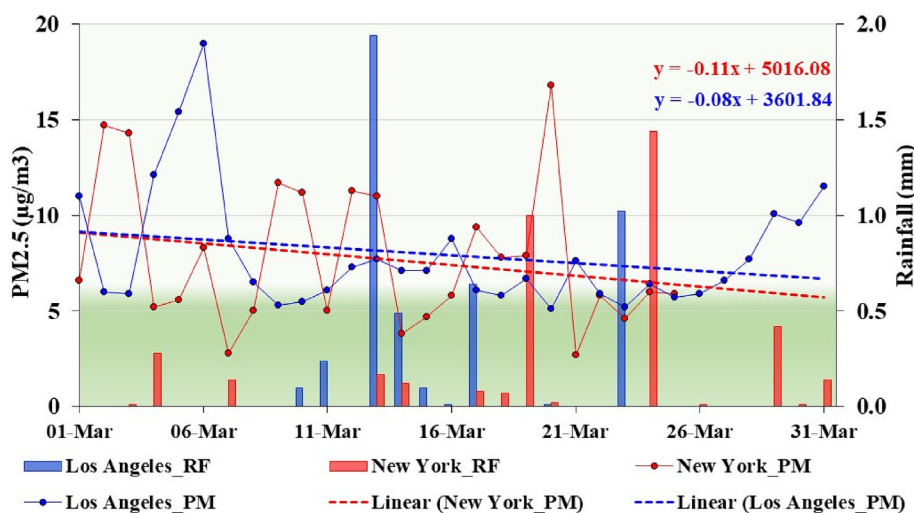


Fig. 2. Variations of PM<sub>2.5</sub> and rainfall in New York, Los Angeles. A pronounced decline (linearly in the month of March) in PM<sub>2.5</sub> is observed at both cities due to lockdown.

also observed in the month of December 2019 and January 2020. In Indian cities, Delhi and Mumbai (Fig. 1c), a decline of 35% and 14%, respectively, compared to March 2019 is observed. Similar changes are also observed in Beijing and Shanghai cities of China (Fig. 1d). In both cities, lockdown started in mid of February 2020. The effect of decrease in PM<sub>2.5</sub> is observed in the month of March 2020. In Beijing, a decline of 50% is observed whereas in Shanghai PM<sub>2.5</sub> was decline half of PM<sub>2.5</sub> concentration in the month of March 2019. In Dubai, Delhi, Mumbai, Beijing and Shanghai no rainfall was observed in the month of March 2020.

Variations of PM<sub>2.5</sub> depends on season to season, and months to months, depending upon the anthropogenic activities, dust events, crop residue burning and emissions from traffic. Due to total lockdown, the PM<sub>2.5</sub> is declined in New Delhi and Mumbai in the month of March 2020, much lower compared to other months and other years 2017–2019 (Fig. 1c). Similar decline in PM<sub>2.5</sub> is observed in Beijing and Shanghai (Fig. 1d) and Zaragoza, Spain (Fig. 1b). In US cities, New York and Los Angeles pronounced decline in PM<sub>2.5</sub> clearly show impact of lockdown.

## 5. Conclusion

The lockdown around the world helped to curb the pollution and to break chain of spread of virus. Many nations ordered for the total lockdown within city or state or in whole country (e.g. India). Such conditions helped in improving the air quality which is directly reflected by the decline in PM<sub>2.5</sub>. The decline also suggests less movement of traffic, which directly shows lockdown and observing social distancing. Here, we have not discussed about the greenhouse emissions monitored using ground sensors in most of the cities, and such data are available through satellite also. A preliminary data analysis shows pronounced decline in the greenhouse emissions in most of the cities due to complete lockdown when practically no traffic on the roads. Such reduction in greenhouse emissions will have local, regional and global impact in radiation budget which will have a long-term impact on climate.

## Statements of authors

Conceptualization: Ideas of this study of Ramesh Singh. Data analysis - Ramesh Singh and Akshansha Chauhan. Writing and review – Ramesh Singh and Akshansha Chauhan.

## Data statement

All the data used in the present study are freely available, if needed we will provide data used in the present study to anyone.

## 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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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.envres.2020.109634>.

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