International Journal of Future Generation Communication and Networking
Vol.14, No. 1, (2021), pp. 2549–2557

Data Science Approach of COVID-19's Lockdown Impact on Pollution in India

Mala Sundaram[1*] Abhinaya Anand[2] Gitapremnath Raja[3]

[1,2]Department of Data Science, Nehru Memorial College,

Tiruchirappalli, Tamil Nadu, India

[3]NIFTEM, Sonipat, Haryana, India
[1]ursmala@gmail.com*

Abstract

In December 2019, a newly identified novel corona virus similar to the SARS-CoV-2 A pneumonia pandemic broke out in Wuhan, Hubei Province, and quickly spread throughout the country., which in turn spread faster to all corners of the world making it a pandemic trouble. India recorded its first COVID-19 positive case in Kerala on January 30, 2020., as a sequence of that the nation declared a nation-wide lockdown prolonged from the 25th of March to the 31st of May, 2020, with a subsequent unlock period to diminish the spread of COVID-19 syndrome. Due to the imposed limits, pollution levels in cities around the country significantly decreased in just a few days, raising arguments about lockdown as an effective alternative tool for mitigating air pollution. The current study used data from the air quality index (AQI) recorded during this tough phase to examine the effects of the shutdown on the air quality of India. This project compared data on air quality for the ideal phase determining the variations in pollutant concentrations during the lockdown, analyzing daily Air Quality Index data for eight major pollutant parameters (PM10, PM2.5, CO, NO2, O3, BTX, NH3 and SO2). A meta-analysis of continuous data was performed to decide the mean and standard deviation of each lockdown phase, and their differences computed in percentage in comparison to the last five years [2015-2020]. With access to a large amount of granular data relating to the concentration of major air pollutants in India, this work analyses and summarizes the background, key points, and core measures in the country and provinces, and it will be interesting to see if the claim of reduced air pollution is actually backed by data.

Keywords: *Air Quality Index (AQI), COVID-19, Pollution, Pollutant, National Air Quality Standards, Severe Acute Respiratory Syndrome*

1. Introduction

A pollutant is a chemical or energy that is released into the environment and has repelling properties or reduces the utility of a resource. More than 10 million chemicals are utilized commercially in India, according to estimates. Almost two-thirds of these substances are industrial compounds, which pose a variety of risks. The numerous types of air contaminants are grouped into a theoretical framework. A theoretical framework comprising of the various types of air pollutants present in the dataset.

Consider a scenario in which cities in India are rationed to fewer than 30 gallons per day per household by 2050. Alternatively, in 2070, Indians may be forced to go around with oxygen support supplements due to a lack of clean air. This horrible predicament is edging closer to us, and the country's current status is worse by the day.
The saddest thing is: Will India have a sustainable environment by the twenty-first century? India is already the world's fifth most polluted country, with an average PM2.5 concentration of 50.08 in the atmosphere. Furthermore, India has 21 cities on the list of the world's 30 most polluted cities. Vehicles, coal and wood combustion, dust storms, and

ISSN: 2233-7857IJFGCN

forest fires all contribute to India's harmful pollution levels. Delhi, India's capital, is known for having some of the worst air in the country, causing aircraft cancellations, traffic accidents, school closures, and even turning the white marble walls of the Taj Mahal green. The majority of Indian rivers now are quite dangerous. Groundwater, which is a major supply of drinking water, is becoming increasingly contaminated and scarce. Air pollution is also fast increasing in Indian cities. While the government and civic entities work to develop pollution-control regulations.

To comprehend the various categories of air pollutants in the dataset, which have been categorised into seven major groups, each of which contributes significantly to the poisoning of the earth in no particular order. Ozone (O3), Particulate Matter (PM2.5 and PM10), Nitrogen Oxides (NO, NO2, and NOx), Sulfur Dioxides (SO2), Carbon Monoxides (CO), Benzene, Toluene, and Xylene are the substances listed. These contaminants are divided into two categories: primary and secondary air pollutants. The most important are those that originate directly from the sources, such as toxics produced by autos. As a result, when these main pollutants come into direct touch with air particles, they generate secondary pollutants, resulting in huge pollution.

The huge socio-economic ramifications of COVID-19 over the planet, which necessitated a "wartime" plan from every corner of humanity, have also served as a silver lining for the ecology and atmosphere. According to recent studies, the large reduction in the countries' transportation and the limits imposed on businesses resulted in an improvement in air quality in the highly crowded major cities in India like Mumbai, Bangalore, Kolkata, Delhi and Lucknow.

2. Literature Review

According to Ronak Sutaria, CEO of Respirer Living Sciences, "the lockdown period helped us comprehend the consequences of anthropogenic (human-generated) pollution on our ecosystem." This research focuses on comparing and evaluating the AQI levels of contaminants in the data set, and then visualising them to gain a clear picture of pollutant concentrations across India's cities.

Dr. Ben. Anderson and Dr. Kim Dirks, “A Preliminary Analysis of Changes in Outdoor Air Quality in The City of Southampton During the 2020 COVID-19 Outbreak t Date” (2020), in their quantitative research stated that because of COVID-19 lockdown in Southampton observed that the NO2 parameter level was recorded 92% lower than the 2017-2019 average [1]. There was a significant decrease in NO2 concentration due to the influence of the wind direction. Jesse D. Berman and Keita Ebisu, “Changes in U. S. Air Pollution During The COVID19 Pandemic” (2020), in their research an analysis by comparing the pre-lockdown data from January 8, 2020 to March 12, 2020 and notice a decrease in NO2 significant 25.5% with an absolute decrease of 4.8ppb and meanwhile PM2.5 also showed a decrease of 11.3%. Thus, they concluded the highest decrease is the NO2 parameter during the lockdown in US. Sneha Gautam, “COVID-19: Air Pollution Remains Low as People stay at Home” (2020), observed that NO2 reduction during lockdown occurred in India by 70% and in China by 20-30%. Meanwhile, in European countries (i.e., Spain, Italy, and France) there was a decrease of NO2 concentration by 20-30% and thereby recording the highest reduction of NO2 being observed in India. Guojun He, Yuhang Pan, and Takanao Tanaka, “COVID-19, City Lockdowns, and Air Pollution: Evidence from China” (2020), reflected from their research that the air quality increased by 25% (28.2 points decrease for AQI, and 22.3 μg/m3 for PM2.5)[2]. PM2.5 concentrations in control cities decreased by 8.40 μg/m3, and city locking further reduced PM2.5 in lockdown cities by 13.9 μg/m3 resulting in a total of 22.3 μg/m3 [3,4] . Wang and Su, “To explore the impact of COVID-19 on the environment” (2020), observed from their research that significant reduction of air pollution due to full or partial lockdown in the short run,

ISSN: 2233-7857IJFGCN

which results in reduced GHG [5, 20, 21]. Zambrano-Monserrate et at. (2020), "To study the indirect effect of COVID-19 on the environment"[12], concluded from their research that COVID-19 improved air quality, beaches and reduced noise levels[13,14]; it also increased the bulk amount of domestic and medical waste and reduced initiatives to recycle waste; GHGs reduction is for a shorter time period. Chakraborty and Maity (2020), "To examine the consequences of Global COVID-19 on environment and society", in their research stated that COVID-19 helps recover the environment and create a positive effect on the environment [6, 7, 8]. Abdullah et al. (2020), "To examine the impact of MCO of Malaysia on air quality", in their research concluded a significant influence of MCO of Malaysia on reduction of PM2.5. Dantas et al.(2020), "To consider the consequences of partial lockdown of COVID-19 on air quality", they found evidence that CO decreases significantly during lockdown period; NO2 decreases due to lockdown; PM10 reduced to a low level and O3 increased due to reduction in NO2[9,10]. Muhammad et al. (2020), "To explore the level of air pollution before and after the COVID-19 pandemic", examined the air pollution reduce by around 30% during the COVID-19 and reduce of mobility by around 90% [6, 11]. Tobias et al. (2020), "To inspect the air pollution level of Barcelona during COVID-19 [15, 16] lockdown", explore reduce of NO2 and BC reduce during lockdown; PM10 reduce and increase of O3 by 50% during the lockdown period. Saadat et al. (2020), "To explore the environmental aspect of COVID-19", identified in improvement in air and water quality worldwide; analyzed the bulk amount of generated medical waste [17, 18, 19].

3. Materials and methods

To understand the diverse groups of air pollutants in the dataset, it is being categorized into seven predominant ones, with respect to the pollutant which desperately contribute to the contamination of earth in no particular order. These are listed below: i. Ozone (O3) ii. Particulate Matter (PM2.5 and PM10) iii. Nitrogen Oxides (NO, NO2, and NOx) iv. Sulfur Dioxides (SO2) v. Carbon Monoxides (CO) vi. Benzene, Toluene and Xylene (BTX) vii. Ammonia (NH3). These pollutants are generally categorized as primary and secondary air contaminators. The primary ones are those comes directly from the sources, namely the toxics emitted from the vehicles. Consequently these primary pollutants when comes in direct contact with the atmospheric particles ends in emitting secondary pollutants thereby triggering off to the massive defilement.

The data is available at the official portal of Central Pollution Control Board https://cpcb.nic.in/ managed by the government. The AQI-Index can also be monitored real time using the app https://app.cpcbccr.com/AQI_India/. The dataset downloaded from the official Kaggle: Home for Data Science website.

In this work, the analysis done in two categories:

- Study of the pollution level in India using the time series dataset from 2015 to 2020. This visualizes the level of pollutants in India, their change over with respect to time and its present accumulation level.
- Consequence of the pollution level in India because of lockdown.

This session examines the level of pollutants in India in two stages namely the pre and post period of the first lockdown. In addition, the pollutant levels compared with that of the 2019 data, to see the notable changes in its accumulation. Furthermore, the report also examines the difference in pollutant levels between the current dates with that of winter months (October, November and December) of 2019, to explore the relationship between seasons and pollution level. The Figure 1 depicts sample data from the dataset.

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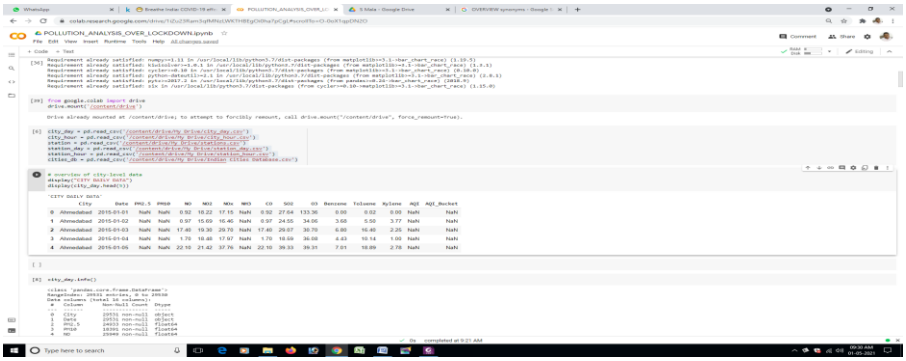

Figure 1: Data Sample

Figure 2 displays that there are large amount of missing values particularly in columns like Xylene and NH3. These missing values handled by combining the attributes with the most predominant ones. Even though a lot of columns made available in the dataset, this work selected only the most evident ones and stored and used in our work. This data frame consists of the major air pollutants responsible the air pollution namely, PM2.5, PM10, NO2, C0, SO2, O3, and BTX. The Figure 3 shows various pollutants by year wise.

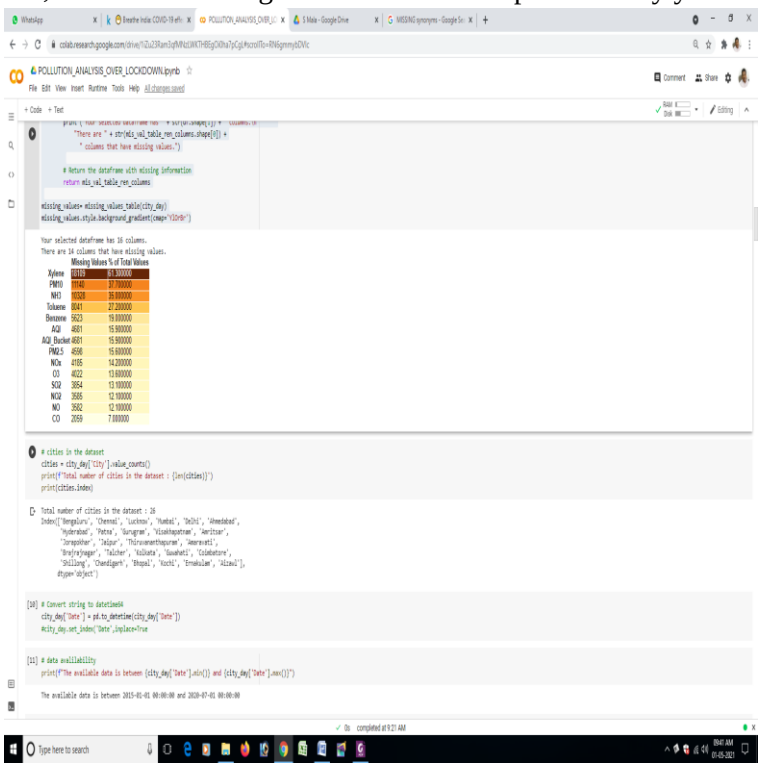

Figure 2: Percentage of Missing Values

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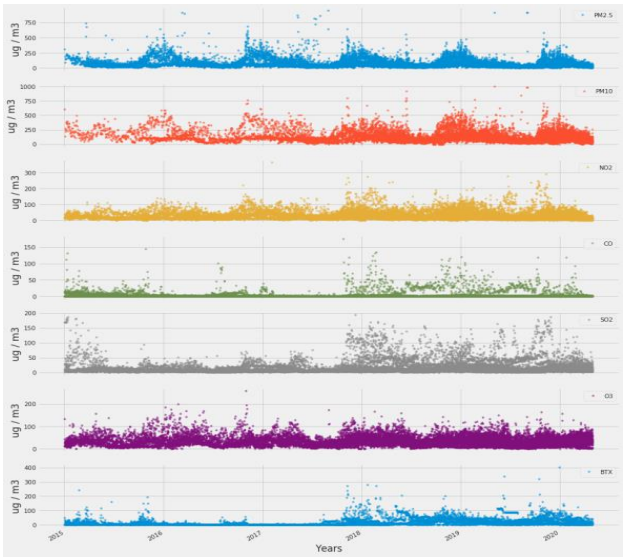

Figure 3: Visual depiction of year wise pollutants

From Figure 3 it is evident that:

- There is a sudden increase in the levels of PM2.5 and PM10 distinctly during the winter months
- The level of SO2 and BTX showed a drastic increase soon after 2018
- Additionally the SO2 levels were at its lowest during the period of 2016 and 2017

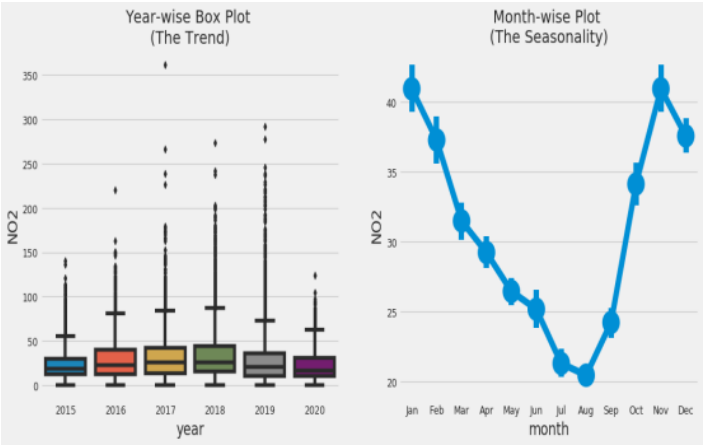

Figure 4: NO2 Concentration

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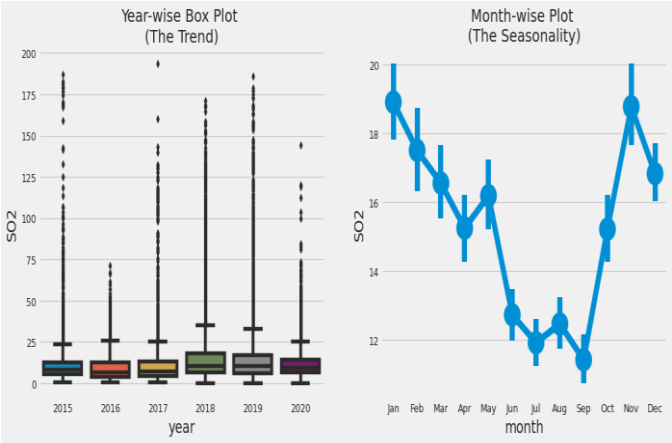

Figure 5: SO2 Concentration

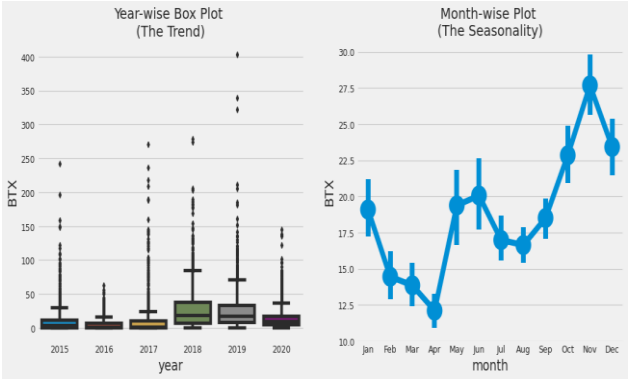

Figure 6: BTX Concentration

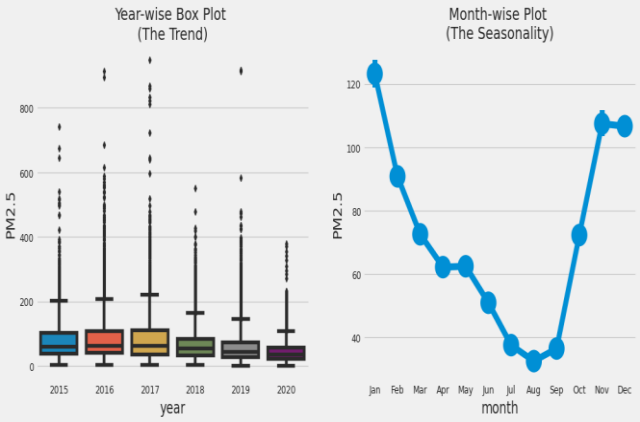

Figure 7: PM2.5 Concentration

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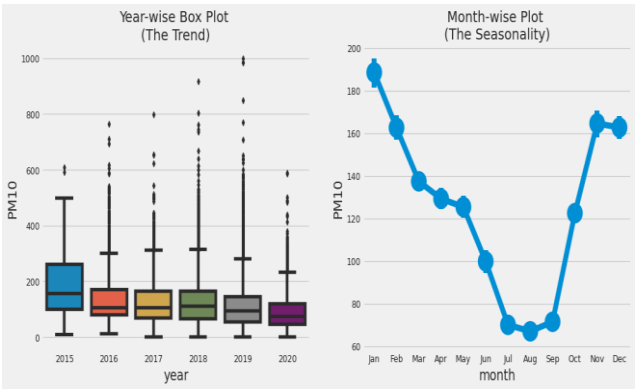

Figure 8: PM10 Concentration

- With respect to the monthly and yearly analysis, from Figure: 4 to Figure: 8 for various pollutants like NO2, SO2, BTX, PM2.5 and PM10 it is depicted that there is a clear trend that the level of pollution declines by the months of July and August, might be due to the monsoon climate.
- In addition, the BTX level shows a gradual decrease during the months around April. Thus, the level of pollutants increases especially during the winter months.
- The median values of 2020 are principally less as compared to the other years that gives us an idea that there might be depletion in pollution level lately.

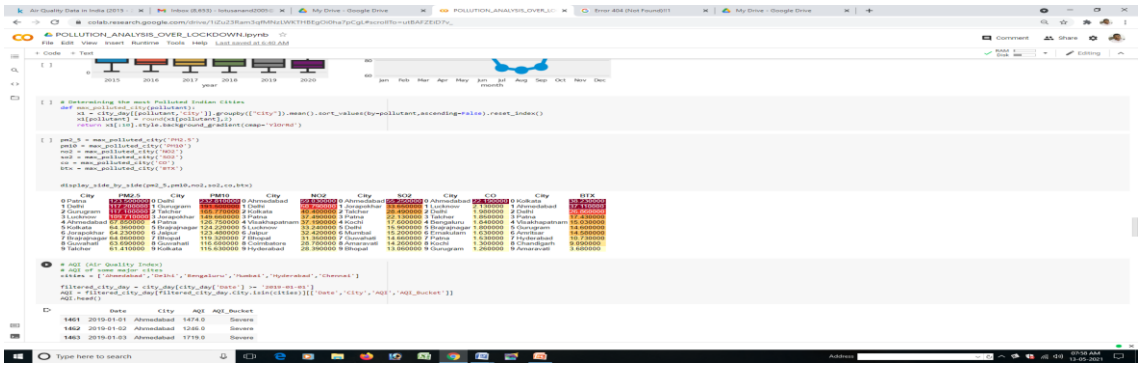

Figure 9: Most polluted Indian Cities

Indian Government has enacted the National Ambient Air Quality Standards (NAAQS) for twelve vital air pollutants (PM2.5, PM10, CO, SO2, NO2, O3, Lead, Arsenic, Nickel, Benzene and Benzo (a) Pyrene). Figure 9. Depicts Patna, Ahmadabad, Delhi and Kolkata seems to be on top of the chart contributing to the highest level of toxic waste. Figure: 10 shows the pre and post lockdown statistic of various cities.

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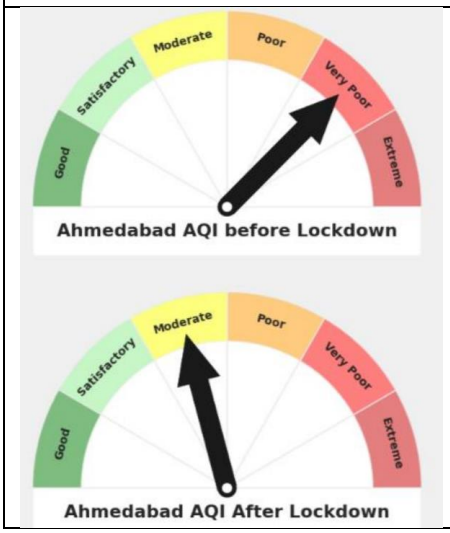
Ahmedabad AQI before and after Lockdown	Pre-post lockdown statistic



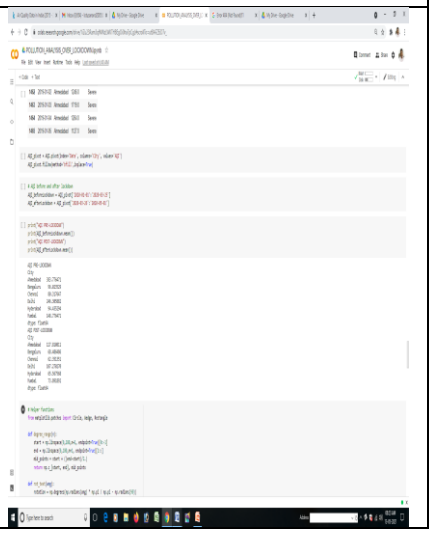


Figure 10: Pre-Post Lockdown Analysis

Results and discussion

Despite the fact that the lockdown was only temporary, the long period of limits on economic activity allowed the nature to heal from the constant exploitation by human activity. The research still clearly shows that the humiliations during the lockdown phase resulted in a significant reduction in pollutants. The average drop in AQI levels of 58 percent is significant noticed in the industrial cities of Ahmedabad and Delhi. In Ahmedabad, the levels of NO2, PM2.5, and PM10 in the atmosphere increased dramatically in the latter period. During the first week of lockdown phase-1 in Delhi, the level of pollutants was the lowest in the last five years, with PM2.5 concentrations dropping to 42g/m3 in this region. During the post-lockdown phase, PM10, PM2.5, NO2, and SO2 concentrations decreased by 55%, 49%, 60%, and 19% in Delhi and 44%, 37%, 78%, and 39% in Mumbai, respectively, resulting in significant improvements in air quality. During the pre-lockdown phase, mean pollution concentrations were reduced in more than ten cities classified as hotspot zones, covering over two-thirds of the country.

Conclusions

The data clearly shows that a lockdown strategy implemented in various locations to restrict the spread of COVID-19 infections had a favorable influence during the epidemic. It is just a natural blessing, which has provided the opportunity to actualize the atmosphere's repair ability by lowering ambient levels of air pollutants, resulting in an improvement in air quality. This work examines the air quality index (AQI) data of seven of India's largest cities, which were among the most polluted in the recent decade. The current study, on the other hand, revealed a significant overall drop in pollution levels in those cities. As seen in previous research and at this stage, there is a definite reduction in pollution levels due to the influence of COVID-19-related shutdown boosting air quality in most of India's biggest cities.

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ISSN: 2233-7857IJFGCN