Air Quality Index: A Comparative Study of Air Quality in Jaipur When the Pre-lockdown and Post-lockdown Phases Are in Effect

Ronak Khandelwal[1], Suraksha Grewal[1], Ashok K. Kakodia[2], and Kumud Tanwar[1](✉)

[1] Department of Chemistry, Kanoria PG Mahila Mahavidyalaya, Jaipur, Rajasthan, India
tanwar.kumud@Gmail.com

[2] Department of Chemistry, Govind Guru Tribal University Banswara, Banswara, Rajasthan, India

Abstract. Excellent air quality is crucial for human health, safety, security, and the environment. Air quality deteriorates as cities and businesses grow, affecting the existence of numerous species as well as the service life and aesthetic appeal of materials. Measuring and evaluating surrounding air quality is the first and most significant step in minimising air toxicity. A large number of water quality surveillance does not always inform the scientific community about the state of the air quality, policymakers, regulating bodies, and, most crucially, the general population. Environmental authorities utilize air quality indexes (AQI) to communicate and interpret information widely due to the health dangers connected with poor air quality. An air quality index is a unique number that represents the air's quality in terms of its impact on human health. In its most sophisticated version, it combines multiple contaminant amounts in some mathematical equations to obtain at a single figure for air quality.

The current study examines into how the COVID-19 pandemic spread affected the quality of the surrounding air during the lockdown and recovery phases. Changes in the air quality index were detected both during phases of the winter period, which lasted from October to January, using data from Adarsh Nagar-Central Pollution Control Board (CPCB) station. The findings found that the city's quality of air had drastically worsened following the lockdown. When compared to the previous years' data during the same era, before to the COVID-19 epidemic, the quantity of particulate and gaseous pollution increased dramatically following the lockdown period. It was noted that, in addition to PM 10, that was the primary pollutants in the air quality index previous to the epidemic, PM 2.5, and PM 10 were all present.This study presents a quick summary of the relatively significant areas that need more focus from lawmakers in order to launch policies targeted at creating adequate air pollution reduction measures.

Keywords: Air Quality index (AQI) · CPCB · COVID-19 Lockdown · Change of air quality · Jaipur city

1 Introduction

Metropolitan areas in developing countries are currently facing significant health concerns as a result of increasing globalisation and urbanisation. Urban clean air is one of

J. Singh et al. (Eds.): ICMMAAC 2022, LNNS 666, pp. 552–561, 2023.
https://doi.org/10.1007/978-3-031-29959-9_36

the biggest issues, which is being addressed by both emerging and developed countries. According to research, poor air quality prevails not just in Asia's metropolises, but also smaller cities with a population ranging between 150,000 to 2 million [1]. Numerous epidemiological studies conducted over the last Vicennial have established air pollution outside as a cause of several respiratory ailments such as asthma, early death, and cardiovascular problems [2]. According to the World Health Organization, inhaling dirty air claims the lives of seven million people (UN Environment Programme 2018).This has been named the biggest cause of death in underdeveloped countries. In such instances, the populace residing near major highways in megacity suffers the most. 80% of people in cities live in concentrations that are above the World Health Organization's limits. Due to manufacturing and consumption activities, ozone (O3), nitrogen oxides (NOx), carbon monoxide (CO), coarse (PM10), fine (PM2.5), and ultrafine (PM0.1) particle mass, black carbon, benzene and polycyclic aromatic hydrocarbons are all present in huge quantities in urban areas [3]. High levels of air pollution have affected human quality of life and health.Furthermore, studies show that particulate matter and NO2 levels are greater in cities with increased traffic activity and urban settings [4]. The composition of particulate matter in the environment is a complicated mix of various chemicals species and sources. Particulate matter is emitted directly into the atmosphere by both anthropogenic and natural processes. PM10 and PM2.5 are the two major particulate pollutants detected worldwide. Because of its greater retention duration and capacity to enter deep into the lungs and into the circulation, PM2.5 poses a larger health hazard than PM10 [5].

At the millennium's turn, developing nations such as India are quickly rapidly developing and modernising, resulting in dangerous levels of air pollution akin to the European Industrial Revolution. Car emissions, industrial pollution, coal burning, forest fires, road dust, and trash burning have been recognized as the key contributors of air pollution in the country [6]. As a result, India is presently the world's sixth most polluted country. Air pollution from transportation and industry is a severe environmental concern in urban areas, with traffic outflow accounting for 50% of PM in the urban air. Elevated concentrations of atmospheric PM2.5 and NO2 have been linked to an increased risk of heart disease and lung cancer among humans [7].According to the Swiss business IQAir's World Air Quality Report, India's air pollution will worsen in 2021. In 2021, the Rajasthan district of Bhiwadi was named the world's most polluted city. Jaipur, Rajasthan's capital city, is undergoing commercialization, as are a number of India's fastest developing towns, including traffic jams, poor road conditions, inadequate regulation of industrial emissions, population increase, and a reduction in air quality. As a result, local authorities, decision-makers, and stakeholders face increased scrutiny. This has emphasized the significance of geographical and temporal assessment of gaseous and particle pollutants for management and policy action to lower Jaipur's air pollution levels.

SARS-CoV-2, a new corona virus, triggered a highly infectious illness epidemic in December 2019. In reaction to the COVID-19 epidemic, countries all around the have taken extraordinary steps. In India, the Janta Curfew was introduced on March 22, 2020, accompanied by a lockdown, leading in a notable improvement in the nation's air

quality, as evidenced by meteorological department figures and data. One of the mitigation strategies to prevent the disease's spread in the population has surfaced: lockdown enforcement. People were unable to leave their houses due to the lockdown. Transportation systems, comprising road, air, and rail, as well as institutions and industrial sites, were halted, the exception of critical products and services, and were prolonged until May 3, 2020.The air quality of urban centers has improved noticeably as significant anthropogenic activities have been reduced [3]. However, once the limits were eased and business continued as usual, the previously improved air quality began to degrade more rapidly. This research looks at the air quality in Jaipur both before and after the shutdown. The major purpose of this study was to determine how air pollutant concentrations varied during both stages.

2 Research Methodology

2.1 Study Area

Jaipur district is located in the east-central region of Rajasthan, India, and has an area of 11,061.44 Km^2. It extends within northern latitudes 26° 28′ and 27° 51′ and eastern longitudes 74° 55′ and 76°15′. It is located on the foothills of the Aravali range, flanked on three sides by hillocks and a broad stretch of plains. The density of population in Jaipur district is 470 persons per square kilometre, with a decennial rate of growth of 26.98%, according to the 2011 census (period 2001–2011). Jaipur, popularly known also as Pink City, is the biggest city in Rajasthan and is situated in the state's centre. It is home to interesting forts and exquisite palaces. The Jaipur district has a semi-arid climate.Winter is moderate and enjoyable, with mean temperature ranging from 10 to 20 °C and humidity levels varying from 30 to 65%. The coolest months are December and January, while temperature vary from 7 to 15 °C [9]. March is a nice month for transitioning from summer to winter.The Jaipur transportation system is mostly dependent on the road. The overall traffic in proportion to the traffic limit means that these routes have a significant volume of traffic during peak hours. Transportation complexity, lane shortage discipline, limited public transit, as well as an exponential increase in personal forms of mobility. Two-wheelers represent the most frequent method of transportation in Jaipur, accounting for 70percentage points of all registered vehicles, with four-wheelers placing second at 13%, and buses accounting for only 1% of all registered vehicles [10]. The current study investigates the influence of the COVID-19 pandemic outbreak on Jaipur's ambient air quality during the city's pre and post lockdown periods.Data was collected at the Adarsh Nagar-Central Pollution Control Board (CPCB) station http://www.cpcb.nic.in/, and changes in the air quality index were noted during both periods of the winter season, which lasted from October to January.

2.2 Air Quality Index

The air quality index (AQI) seems to be a metric that compares pollutant concentrations to ambient air quality in different regions. It condenses complex data regarding air quality produced by several contaminants together into decimal statistic (index value), name,

and colour. The greater the AQI number, the worse the air quality and the more significant the health risk. The AQI is classified into six levels (Table 1). So each category denotes a different gravity of the public health issue. Each group has a unique colour as well. Individuals can immediately tell from the hue whether the air quality in their area has deteriorated to a harmful degree.

Table 1. Various Category of NAQI (National air quality index, CPCB, October 2020)

Category	Range
Excellent	0–50
Tolerable	51–100
Reasonably contaminated	101–200
Dreadful	201–300
Alarming	301–400
Serious	401–500

One of the most important methods for consistently analysing and displaying the status of the air quality is the AQI. In the form of a sub-index, the aggregate impact of individual pollutant concentrations in ambient air is typically reported as a single value. [12]. The AQI index or the sub-index value of the individual pollutant is calculated using the following equation [13]:

$$I_i = [\{(I_{GC} - I_{SC})/(B_{GC} - B_{SC})\} * (C_{pc} - B_{SC})] + I_{SC};$$

where, B_{GC} = Breakpoint concentration greater or equal to given concentration;

B_{SC} = Breakpoint concentration smaller or equal to given concentration; I_{GC} = AQI value corresponding to B_{GC}; I_{SC} = AQI value corresponding to B_{SC}; C_{pc} = Concentration of Pollutant (Table 2).

For e.g., Let the Concentration of PM10 pollutant be 85 $\mu g/m^3$.

So, value of sub-index Ii = {[100–50]/[100–50]*[85–50]} + 50 = 50.

And finally;

AQI = Max (I_i; (where i = 1, 2, 3,….., n; denotes n pollutants).

3 Result and Discussion

3.1 Particulates, Fine (PM2.5)

PM2.5 particles are able to enter the lungs after passing via the respiratory system. Exposure to small particles can cause eye, nose, throat, and respiratory issues as well as coughing, sneezing, nasal congestion, and shortness of breath in the short term. Exposure to fine particles can also compromise lung function and aggravate medical disorders such as asthmatic and cardiovascular disease [22]. As a result, it is deemed critical to explore this clean air parameter, and the findings of both the pre and post closure phases during

Table 2. Break Point concentration of various pollutants (Units: $\mu g/m^3$)

AQI Category Array	PM_{10} 24- hr	$PM_{2.5}$ 24- hr
Excellent (0–50)	00–50	0–30
Tolerable(51–100)	51–100	31–60
Reasonably polluted (101–200)	101–250	61–90
Dreadful (201–300)	251–350	91–120
Alarming (301–400)	351–430	121–250
Serious (401–500)	>430	>250

the cold weather are shown in Fig. 1. The AQI index in Jaipur city has clearly increased significantly following the lockdown period as shown in the figure. The maximum value observed in the pre lockdown phase for the months of October, November, December, and January was 201,144,113,88, while the maximum value in the post lockdown phase was 289,356,244,226 observed.

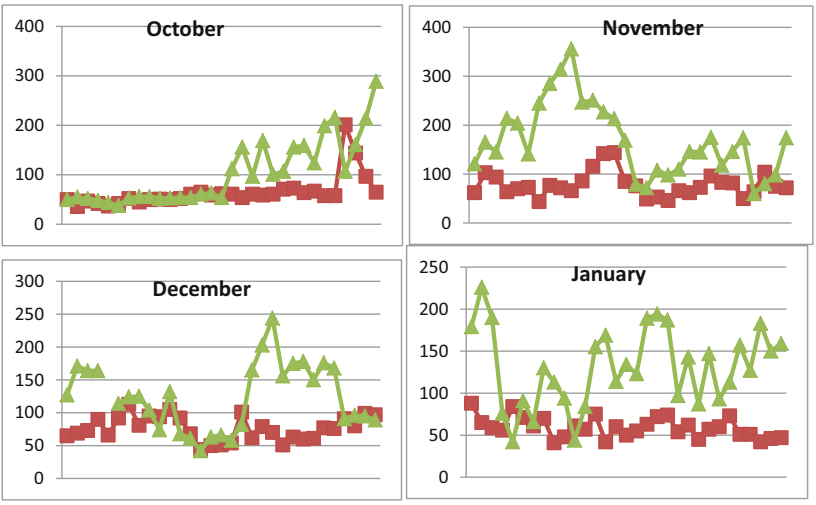

Fig. 1. AQI index Variations of PM2.5 in pre and post lockdown phases

Table 3. Shows the average PM2.5 concentration for the months mentioned, both before and after the lockdown phases.

Year	October	November	December	January
2018	83.32	99.53	76.80	97.06
2019	64.30	78.30	76.41	59.35
2020	103.54	169.33	120.16	130.83
2021	89.74	224.93	173.32	131.96

3.2 Coarse Particulate Matter (PM10)

Coarse particulates, which are typically created by processes such as physical grinding, road dust, and agricultural practices, deposit preferentially in the upper and bigger airways. These particles can easily pass thru and settle in the airways of the thoracic region. When these particles are inhaled, they induce lung problems and respiratory difficulties [23]. Figure 2 depicts the air quality index for PM10 throughout the winter season, both before and after lockdown. Again for months of October, November, December, and January, the largest value observed in the pre lockdown period was 233,170,159,127, whereas the maximum value seen in the post lockdown phase was 182,247,220,142.

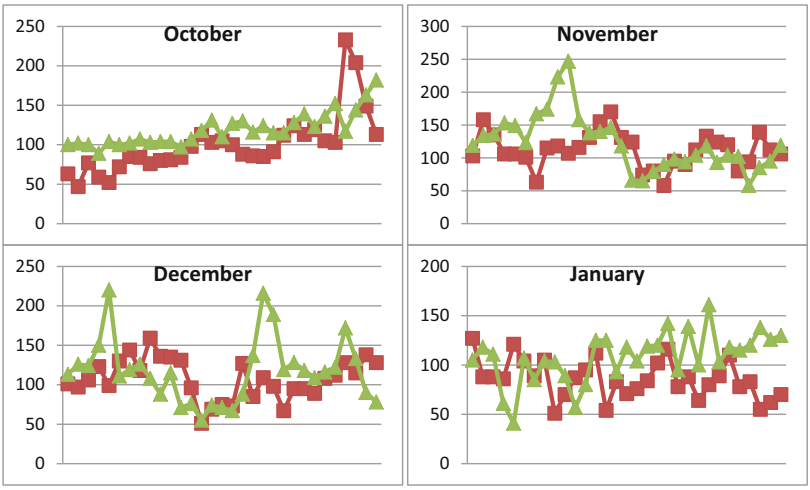

Fig. 2. AQI index Variations of PM10 in pre and post lockdown phases

Table 4. Shows the average PM10 concentration for the months mentioned, both before and after the lockdown phases.

Year	October	November	December	January
2018	137.38	140.60	128.00	116.25
2019	100.12	111.86	107.64	86.00
2020	119.00	123.16	117.06	104.09
2021	89.87	146.96	116.83	101.03

3.3 Major Pollutant

Because the major pollutant determines the AQI, it is critical to understand the major pollutant before and after the pandemic. as illustrated in Fig. 3. Prior to the pandemic, PM10 was the major pollutant, while PM2.5 was the minor pollutant; however, this situation changed dramatically after the pandemic, resulting in an increase in the concentration of PM2.5 pollutant.

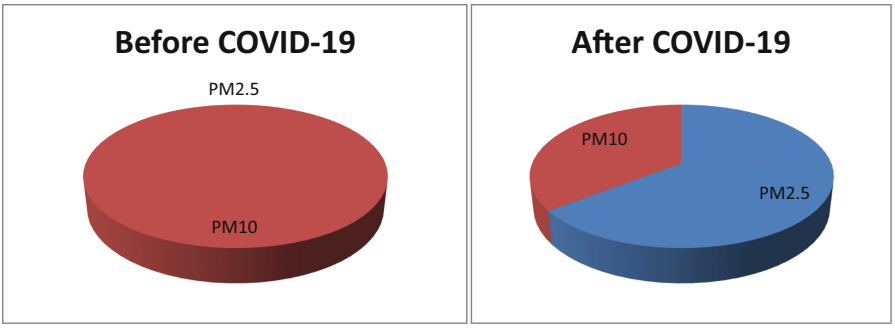

Fig. 3. Major pollutant during both the phases

4 How to Control Air Pollution?

Air pollution can only be controlled if the general public and the government work together as a team to improve air quality. We attempted to illustrate the problem in simple terms so that both parties understand the gravity of the situation and can work together to improve air quality. During the lockdown period, the environment had time to heal itself; now, as we return to our normal routine, we should keep the environment in our minds as well. It is our responsibility to ensure that the air quality does not deteriorate further over time.

4.1 Control Measures to be Taken by the Government

- The government organization should develop strong policies and ensure their implementation.

- Organizations can use this paper to identify the most affected areas and plan accordingly.
- Vehicle emissions are the most major cause of air pollution.Administrators should plan to reduce them by promoting public transportation, carpooling, and other alternatives.
- Cleaner and alternate fuels should be introduced like CNG, LPG, etc.
- In the industrial sector, strict rules and regulations should be put on practice.

4.2 Control Measures to be Taken by the General Public

- RRR- Reduce, reuse and recycle, one of the most important rules that everyone must follow.
- Avoid the burning of garbage, leaves and other items.
- Start using public transport and carpooling
- Avoid the burning of fireworks and spread awareness about their negative consequences
- Practice energy conservation; For ex: Switch off lights when they are not in use

5 Conclusions

Jaipur, Rajasthan's state city, faced significant air pollution following the COVID epidemic. As a result, this study focuses on the airborne pollutants PM10 and PM2.5. According to the findings, the city's quality of air has considerably deteriorated following the lockdown. The particulate matter concentration increased dramatically following the lockdown period when compared with previous years' statistics during the same timeframe prior towards the COVID-19 epidemic. In contrast to PM 10, that was the dominant pollutant in the index of air quality previous to the pandemic, it was revealed that PM 2.5, which is more destructive than PM 10, emerged as a serious worry after the epidemic.According to the data, the greatest concentration of PM10 was 387 g/m^3, whereas the maximum concentration of PM2.5 was 306 g/m^3. Tables 3 and 4 revealed that, independent of the COVID 19 lockout, the average content of both PM2.5 and PM10 was greatest in November every year.

Before going into the information and data, it is necessary to understand the primary cause of pollution. The use of fossil fuels in automobiles, emissions from different businesses, local dirt, and natural events are the primary sources of increased particulate matter (PM) concentrations. Furthermore, inversion events restrict the distribution of particulates and pollution in major cities with just a growing population and more enterprises. As a result, the city's PM concentration increases. We picked the winter months for our investigation since this phenomena is more widespread during that season. The worldwide shutdown gave us a once-in-a-lifetime chance to identify the reference levels of pollution in numerous big centres throughout the world. COVID- Because to the 19 lockdowns, there was reduced energy consumption and decreased oil demand, which had a substantial impact on industrial and transportation activity. The study's conclusion will assist governmental authorities and decision makers in calibrating an acceptable response plan to reduce Jaipur's ever-increasing pollution levels. This study will also aid administrators in allocating funding and deciding priorities.

References

1. Indonesia: Air Quality Profile - 2010 Edition
2. Parl, S., Allen, R.J., Lim, C.H.: A likely increase in fine particulate matter and premature mortality under future climate change. Air Qual. Atmos. Health **13**, 143–151 (2020). https://doi.org/10.1007/s11869-019-00785-7
3. Agarwal, A., Kaushik, A., Kumar, S., Mishra, R.K.: Comparative study on air quality status in Indian and Chinese cities before and during the COVID-19 lockdown period. Air Qual. Atmos. Health **13**(10), 1167–1178 (2020). https://doi.org/10.1007/s11869-020-00881-z
4. Liu, H., Tian, Y.H., Song, J., Huang, C., Li, M.: Effect of ambient air pollution on hospitalization for heart failure in 26 of China's largest cities. Am. J. Cardiol. **121**(5), 628–633 (2018)
5. US EPA, Particulate matter (PM) basics (2018). https://www.epa.gov/pm-pollution/particulate-matter-pm-basics
6. Pant, P., Harrison, R.M.: Critical review of receptor modelling for particulate matter: a case study of India. Atmos. Environ. **49**, 1–12 (2012)
7. Li, S., Feng, K., Li, M.: Identifying the main contributor. J. Clean. Prod. **163**, S359–S365 (2017)
8. Indian Meteorological Department (IMD), Climate of Jaipur. Government of India Press, New Delhi (2011)
9. Kumar, A., Garg, A., Pandel, U.: A study of ambient air quality status in Jaipur city (Rajasthan, India), using air quality index. Nat. Sci. **9**(6), 38–43 (2011). (ISSN: 1545–0740), http://www.sciencepub.net/
10. Kala, J., Sharma, G., Kumar, S., Pipralia, S.: Study of ambient air quality status on urban roads using air quality index -a case of Jaipur city (Rajasthan, India). Int. J. Theor. Appl. Sci. **6**(1), 138–147 (2014)
11. National air quality index; Central pollution control board. http://www.cpcb.nic.in/
12. Sarella, G., Khambete, A.K.: Ambient air quality analysis using air quality index – a case study of vapi. Int. J. Innovative Res. Sci. Technol. (IJIRST) **1**(10), 1–4 (2015)
13. Ott, W.R., Hunt, W.F., Jr.: A quantitative evaluation of the pollutant standards index. J. Air Pollut. Control Assoc. **26**, 1051–1054 (1976)
14. Dadhich, A.P., Goyal, R., Dadhich, P.N.: Assessment of spatio-temporal variations in air quality of Jaipur city, Rajasthan, India. Egypt. J. Remote Sens. Space Sci. **21**(2), 173–181 (2018). https://www.sciencedirect.com/journal/the-egyptian-journal-of-remote-sensing-and-space-science
15. Pandey, M., George, M.P., Gupta, R.K., Gusain, D., Dwivedi, A.: Impact of COVID-19 induced lockdown and unlock down phases on the ambient air quality of Delhi capital city of India. Urban Clim. **39**, 100945 (2021)
16. Kumar, A., Mishra, R.K.: Human health risk assessment of major air pollutants at transport corridors of Delhi India. J. Transp. Health **10**, 132–143 (2018)
17. Manmeet K.: A Comparative Study to assess the air quality of Ludhiana, India amid COVID-19. In: IOP Conference Series: Earth and Environmental Science, vol. 889, p. 012069 (2021)
18. Nigam, S., Rao, B.P.S., Kumar, N., Mhaisalkar, V.A.: Air quality index-A comparative study for assessing the status of air quality. Res. J. Eng. Technol. **6**(2), 267–274 (2015)
19. Cheng, W.L., et al.: Revised air quality index derived from an entropy function. Atmos. Environ. **38**, 383–391 (2004)
20. Mahato, S., Pal, S., Ghosh, K.G.: Effect of lockdown amid COVID-19 pandemic on air quality of the megacity Delhi India. Sci. Total Environ. **730**, 139086 (2020)
21. Dhamaniya, A., Goyal, R.: Use of GIS in transportation planning of Jaipur city. GIS Dev. **8**(11), 38–43 (2004)

22. Xing, Y.F., Xu, Y.H., Shi, M.H., Lian, Y.X.: The impact of PM2 5 on the human respiratory system. J. Thorac. Dis. **8**(1), E69–E74 (2016)
23. Saharsodoudi, H.T.: **S**tatistical modeling approaches for PM_{10} prediction in urban areas: a review of 21st-century studies. Atmosphere **7**(2), 15 (2016). https://doi.org/10.3390/atmos7020015