Impact of Lockdown Measures on Air Quality; A Case Study of Jodhpur

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Abstract: Air quality index (AQI) is an assessment technique carried out to analyse and gather database on how polluted the atmosphere is. As air pollution is becoming a bigger known threat with modernization, various countries are taking different measures to assess how the amount of contamination present in the air we breathe. In this research, the impact of the pandemic of 2019 on the air quality in Jodhpur has been analysed and also compared the AQI on monthly basis. This index is a national airquality ratingsystem based on the national ambient air quality standards. The process to measure AQI can be used globally by changing the standards accordingly. In this study we observed the changes in the air quality throughout the year 2020. Measurements for the four monitoring sites (Maha-Mandir, Sojati Gate, Shastri Circle and Basni Industrial area) in Jodhpur were keenly observed and a comparative analysis was recorded. To measure the AQI of all the four zones a "Maximum Operator Function" method was initially tested in IIT Kanpur, was applied in this study. Basni Industrial Areawas followed by Shastri Circle in depicting the best air quality,since both of the areas were categorized as industrial areas, it showed that policy measures relating to theindustries in the city during past years have helpedin improving the air quality.

Introduction

The large percentage of parts of Southern Asia have exceptionally high concentrations of urban air pollution, primarily in the form of microparticles. Annually, it is predicted that urban air pollution causes about 2,050,000 fatalities and billions of episodes of pulmonary sickness in the area. Atmospheric pollution in urban areas kills and sickens five times more people as influenza and is

one of the principal causes of serious illness in the region (1). Airborne pollution is an issue that affects the major portion of Asia's 300 million urban residents, who account for around 30percent of total of the country's population (2).As shown in a local survey, the occurrence of lung infections in India is 12 times higher than the general population, and 30 percent of the country's population suffers with pulmonary problems as a result of carbon emissions.

India has experienced industrialization over the last twenty - five years, that had undoubtedly resulted in the improvement of life for its citizens, as clearly illustrated by the growing vehicle fleet mostly on roadways. Additional challenges and opportunities arose as a result of industrialisation, one of which includes carbon emissions. According to a WHO factsheet on May 2018, approximately 7.2 million deaths worldwide each year was being recorded as a result of particulate contamination in smog. According to the 2019 State of India's Environment Report, polluted air is responsible for 11.9 percent of all mortality in India.In response to the rising number of COVID-19 cases in India and the rising turmoil, India's honourable Prime Minister, Shri Narendra Modi, proclaimed a 3-week nationwide shutdown on March 24, 2020, which again was later extended for another 19 days on April 14, 2020 in the II phase, 14 days until May 17, 2020 in the III phase, and another 14 days in Phase IV. Countless occupations such as infrastructure sector, vehicle mobility, building construction, travel, and other conventional processing and transportation experienced a "never before" sluggish state as a result of several limitations set by the Government of India (6) (10).Besides from carrying out the necessary administrative measures such as limiting social functions, restricting travel, and containing and treating COVID-19 suspects, the Indian government has directed citizens to maintain adequate social distance and use personal protective equipment such as masks and sanitizers. As the Outbreak of 2019 occurred, it triggered a series of awful catastrophes, but it also had a good result in terms of purifying our surroundings. Throughout two months, several nations practiced self-quarantine and social separation, which provided a "healing and regeneration" for the overall biodiversity with less anthropogenic presence in the local habitat (4).The epidemic has had a significant influence on the environment, which is now being sensed by others and documented in numerous government publications. In Delhi, a clear environment had also been noticed as smog dissipated; enhanced marine wildlife interaction had also been recorded; air quality in major metropolitan areas reduced dramatically; and living creatures travelled from their own inclination. Since the energy consumption remained enormous in metropolitan areas like Delhi, Mumbai, and Kolkata, it was also established that perhaps the lockout benefited quality of air on a larger scale.After 2 weeks of isolation, there was a 65 considerable decrease in Pm10 and pm2.5 in the atmosphere of four stone crushing regions in the Dwarka basin in Northeast India.

Numerous academics have already investigated the influence of air pollution on the Indigenous population and their health. In this study, data was gathered and examined from a variety of official and non-government institutions in order to comprehend how the Outbreaks has affected the quality of different ecosystems.

Literature review

Origin & Concepts of air quality index (AQI): - Aside from surface and groundwater resources, air is the most significant source of life support. Alongside advancements in technology, a vast quantity of information on ambient air quality has been collected, and it is now necessary to define air quality standards in a variety of areas (3). The proportions of all contaminants with permitted limits are reported as one way of explaining air quality (standards). Even among the technical and scientific community, such air quality statements tend to get complex when the number of monitoring stations and pollutant metrics (and their sample frequency) expand.

Collected information, standard statistical graphs, scientific techniques, and other sophisticated findings relating to air quality are typically unsatisfactory to the common society. As an outcome, the general public feels uncomfortable and may be unable to grasp the current status of air quality or regulatory attempts to reduce pollution (5). Because persons who experience with ailments induced by polluted air need to be informed of frequent concentrations of pollutants, the problem of communicating polluted air must be discussed.Furthermore, a country's effectiveness in improving air quality is contingent on the assistance among its residents, who are well-informed regarding regional and national pollution issues, as well as the status of mitigation measures.

For the past 30 years, the notion of an Air Pollution Levels has been established and successfully employed throughout many industrialized countries to address the above problems. An Air Quality Index is a technique that combines the measured values of different contamination factors (SO2, CO, visibility, and so on) together into single value or a subset of figures (8).Throughout India, there have been several opportunities to improve and implement an Environmental Parameters, attributed to the fact that perhaps a minor air quality measurement scheme began only in 1984, and public understanding concerning polluted air would be almost non-existent (6). The concern of engaging with people in a way that they can understand has multiple components:

i. translating complicated scientific and medical facts into clear and simple understanding, and

ii. interacting among inhabitants in an ancient, present, and contemporary perspective.

Resolving, as well as building an efficient and understandable National Ambient Air quality framework, is necessary for individuals and officials to draw conclusions about how to reduce carbon emissions exposure and the illnesses that result from it.

Applications of Air Quality Index (AQI): - Ott outlined the following six characteristics that an Ambient Air Quality can help with in 1978:

1. Resource Management: to assist authorities in allocating funding and prioritising projects. Allow for the analysis of market in different pollution reduction systems.
2. Destinations are ranked to aid in evaluating ambient air situations in various sectors. As a response, possible hazard regions and intervals are marked.
3. Guidelines Implementation: Determine the extent to which legal rules and established guidelines are followed. This even aids in the detection of incorrect regulations and insufficient monitoring methods.
4. Trend Evaluation: to determine whether there has been a variation in polluted air (breakdown or enhancement) over a certain time period. This allows for ambient air forecasting (i.e., tracking the behaviour of contaminants in the air) and environmental management planning.
5. Verifiable Facts: to notify the general population on the global environment (state of environment). It's beneficial for persons who have ailments that are worsened or worsened by contamination. As a result, when people are warned of excessive air pollutants, individuals are capable of changing their everyday routines.
6. Medical Evidence: As a means of condensing a large body of information into a comprehensible manner that enables the researcher to have an improved understanding of particular environmental occurrences while doing experiments. The above allows for a more impartial assessment of specific pollutants' and sources' contributions to average polluted air. When used in association with other inputs, such as local emission assessments, such methods become even more valuable.

Briefly, an Air Quality Index is beneficial for (11):

- The common man to understand in a simplified way what air quality is,
- Political leaders to invoke actions,
- Decision makers to compose corrective methods in order to control pollution,
- Officials of the government to monitor the effect of the taken regulatory measures, and
- Scientists to execute scientific research regarding air quality and pollution using the data provided by the AQI.

In order to demonstrate the air quality and its physical and biological effects on human health, the following description categories have been adopted for India Air Quality Index (Table 1) (7):

TABLE I. India Air Quality Index- AQI Category and AQI Range

Sr.No.	AQI values (when the AQI value is in this range)	Levels of health concern (Air quality conditions)
1	0 to 50	Good
2	51 to 100	Moderate
3	101 to 200	Unhealthy or sensitive groups
4	201 to 300	Unhealthy
5	301 to 400	Very unhealthy
6	401 to 500	Hazardous

Air Quality Monitoring: - The Indian government has established the National Air Quality Index as a regulatory organisation to assess air quality levels to make comparisons across cities, since new methods are frequently designed to reduce the level of pollution present in the air. Without a doubt, the National Air Quality Index understates the fact that 25% of workspaces across India are increasing at an astonishing speed, with a 68 percent growth above acceptable limit, declaring air pollution a national crisis in various cities around the country (12). Because China's population is larger than India's, pollution levels in India were compared to those in China. In Figure 1, when analysing levels of pollution in Chinese and Indian cities, it was discovered that Indian levels of pollution are much higher than in China, implying that such levels are 10 times higher than World Health Organization regulations, exposing contamination as a severe problem in India.

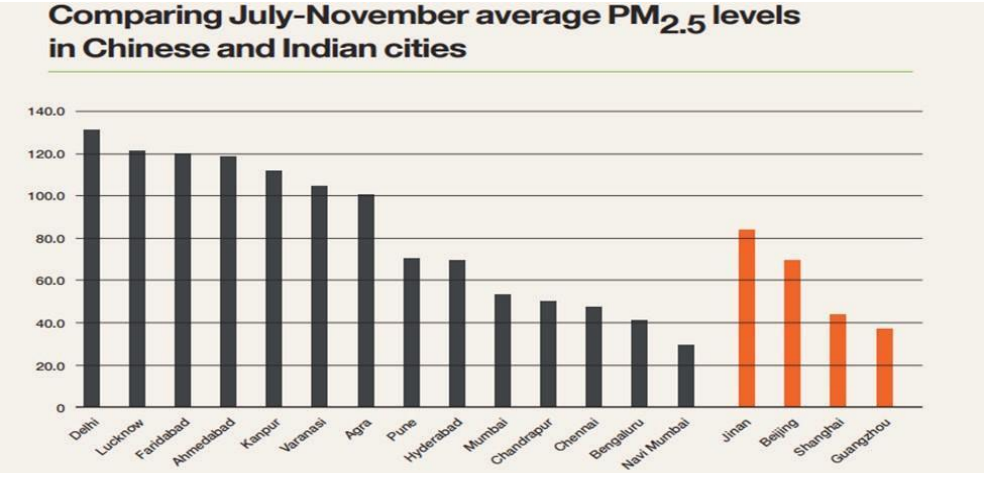

Figure 1. Comparison of Pollution Levels in various Indian Cities and Cities of China.

According to Green Peace India's (GPI) examination of data released by the national Air Quality Index portal, polluted air is not only a significant problem in the capital, but it is also frighteningly high in the other locations, as seen in Figure 2. The organization's main goal is to reduce the quantity of fine particulates in the PM10 and PM2.5 range. According to the WHO (World Health Organization), Delhi has levels of pollution that seem to be more than 12 times the acceptable limits, whereas some other locations such as Kanpur, Agra, Faridabad, Varanasi and Lucknow having concentrations that are 10 times greater. According to the WHO (World Health Organization) most recent survey from 2016, 22 cities were named as the most polluted cities of the world, 14 of those were in India (9). Without a doubt, the primary cause of such a scenario is rapid industrialisation and unregulated motorization; thus, attention should be directed to this because it has become a global concern.

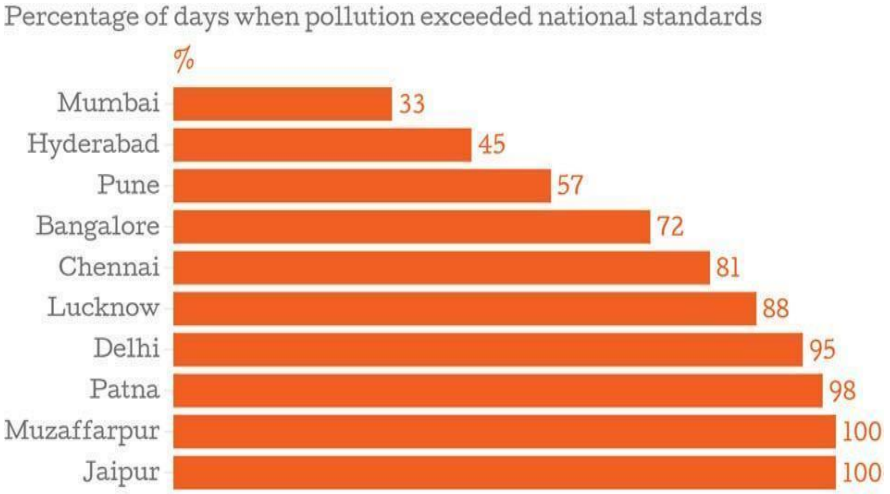

Figure 2. Pollution Levels of Various Indian Cities.

Polluted air has a huge effect on human health, agricultural practises, climatic variances, and general ecosystem dynamics in developing country like India. Each year, almost 06 lakh Indians die as a result of pollution's adverse effects, making it the fifth biggest cause of mortality in the nation behind water contamination, nuclear contamination, and other causes (2). Nearly 37 thousand people die in Delhi, with the remaining 14 thousand deaths occurring in each industrial sector. Although the national capital receives practically all of the emphasis, other cities and towns suffer as a result.

This includes other cities and towns that suffer somewhat similar danger due to pollution such as Patna, Raipur, Punjab, Agra,Ghaziabadandmany more. Just about all the cities are struggling from rising levels of Particulate Matter (PM) in the air, as well as pollutant gases such as nitrogen oxides

(NO/ NO2/ N2O), sulphur (S), and other harmful elements which are already wreaking havoc on the ecosystem (6). Very few urban areas are frequently highlighted in the list of cities that began Air Quality Monitoring (AQM), the result of which the improvement in air quality is minimal, but the majority of those impacted are small and medium-sized cities that are experiencing a massive adverse environmental effect in a critical way.

Since 1984, the CPCB(Central Pollution Control Board) has been conducting a nationwide air quality monitoring programme wherein different air pollutants such as sulphur dioxide (S02), nitrogen dioxide (NO2), and particulate matter smaller than 10 microns (PM10) are measured in 268 towns and cities across 28 states and five union territories. This programme maintains 618 monitoring stations located throughout several cities. Constant monitoring has revealed that 48 Indian cities with populations above one million are extremely polluted (10).

The objective of this research is to provide a comprehensive analysis of air pollution monitoring practises in India, with the objectives of identifying critical problematic areas with severe air pollutants through an objective assessment of the current practise and recommending appropriate strategies for improvement where appropriate. In this research, four urban areas in Jodhpur were considered for air pollution monitoring. Those areas were selected because they are the busiest locations of the city and the vehicular movement is immensely high during day times.

Methods and Methodology

Study Area: - Found in the north-west region of the country, Rajasthan is the largest state of India. It is situated between latitude 23° 31′ to 30° 12′ N and longitude 69° 3′ to 78° E with a neighbourhood of about 3.4 kms. Geo-morphologically, the state is often categorised into four sections,

• The Eastern plains,

•Aravalli hill ranges and its adjacent areas,

•Western sand dunes and plains, and

• The Low Lying Vindhayan hills.

Monsoon is inconsistent and the state undergoes impulses of rainfall, showing from a low count of 165mm in the western region to a high of 822mm in the eastern region of the state. Having nine agro-climatic zones, Rajasthan has a well-versed agricultural economy and a variety of soil that contribute towards the cultivation of crops.

The Jodhpur city of Rajasthan comes amongst one of the fastest growing cities in India but also suffers with problems like improper road conditions, expanding urbanization, traffic jams, uncontrolled commercial emission and a hike in pollution.Immensely high concentration of air pollutants like PM10, PM2.5, and dioxide has severely impacted the quality of living. Many defects in pulmonary functions, neuro-behavioural effects, disorders, and increased mortality rates are due to the increase in air pollutants across the city.

In order to better understand the traffic-prone areas, a node map is carried out. The chosen sites for analysing the air quality in jodhpur are as follows: Mahamandir; Basni Industrial Area; Sojati Gate; Shastri Nagar. These areas are represented in the city of jodhpur as a node map shown in figure 3.

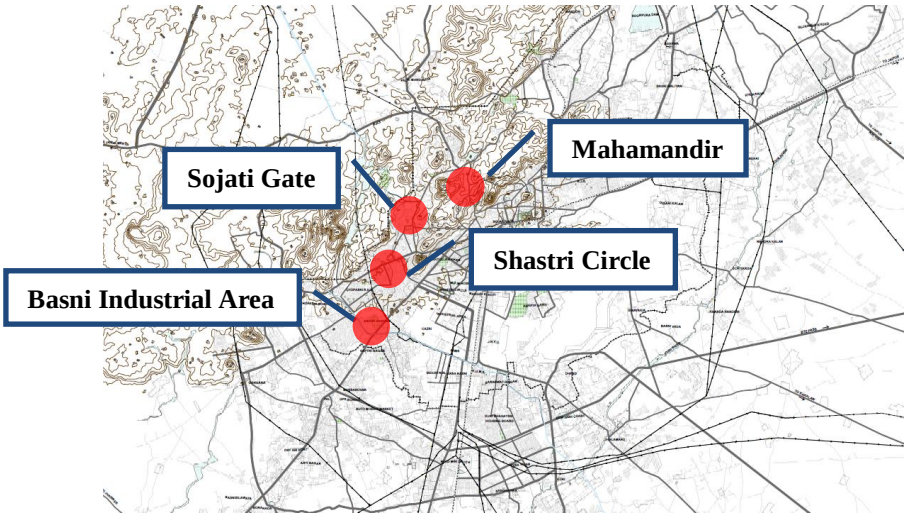

Figure 3: Node Map of Jodhpur indicating the study area for this research

Methodology: - In order to calculate AQI in an accurate manner, Maximum Operator Function method was used. The above-mentioned methodology was used for the purpose of AQI estimation by the USEPA as well as the CPCB. An exceedance factor in the formula is used by the CPCB in which the factor of 100 as a multiple is not required.

*AQI = Concentration of Pollutant * 100/ Standard Concentration of Pollutant*

Table 2 displays the national ambient air quality guidelines for criterion contaminants. The Air Quality Index across all four zones in Jodhpur was calculated employing 4-h or 8-h daily data for the relevant period (January 2020 to December 2020). The Air Quality Index was calculated using the Maximum Operator Function Method. The proportions of numerical codes shown in Table 2 were obtained using everyday AQI computed dependent on concentrations of criterion air pollutants

from each of the seven sites throughout the appropriate average intervals, i.e., yearly basis, for further evaluation.

TABLE II. National ambient air quality standards in as per Environment (Protection) Act, 1986 in India

Pollutants	Time-Weighted Average	Concentration of Ambient Air (in μg/m3)		
		Industrial Area	Residential Area	Sensitive Area
SO2	Annual Average	80	60	15
	24 hr	120	80	30
NO2	Annual Average	80	60	15
	24 hr	120	80	30
SPM	Annual Average	360	140	70
	24 hr	500	200	100
RSPM	Annual Average	120	60	50
	24 hr	150	100	75

Results and discussions

The AQI trends are evaluated and compared annually for all the sites while assessing the contributions from categories 4, 5 and 6 towards deteriorating the air quality which depicts unhealthy, very unhealthy andhazardous categories respectively. Comparisons across years are challenging since the proportions in each of these classes have a fluctuating trend and varied severity levels each year. When examining percentage distribution in each of these categories for developing intensity trend, AQI 6 should be weighted more heavily than 5, and AQI 5 should be taken more seriously than 4. The weights used per AQI category is considered to be similar to the category number in order to make significant correlations and make conclusions. As a result, the percentage distributions in each AQI category are calculated by multiplying the number of AQI categories and then summed.

Study Area 1."Mahamandir":-When we analyze the monthly Air quality index of the Maha Mandir area, we can see that it climbed by roughly 21.34 ppm on average, but it has not decreased much. However, these figures are well before the lockdown. In August, the AQI amid lockdown was 49. Maha mandir is located in the heart of Jodhpur's historic district. Because of the minimal user

mobility and automobile traffic, as well as the decline in commuter trains, a railway line runs through the region, an important road runs through the area, but it also seems to have several hospitals and commercial locations. From June to September, the contaminants in the region dropped dramatically, indicating how polluted it must have been before.

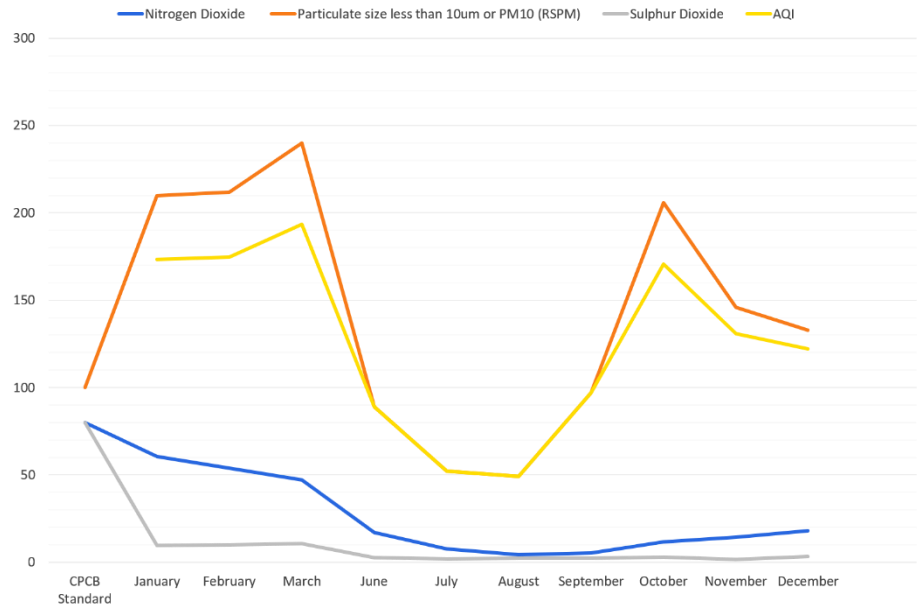

Figure 4. Average Air Quality Index in Year 2020 at Mahamandir, Jodhpur

Study Area 2. “Basni Industrial Area, Jodhpur”: - When we examine the monthly AQI (Air Quality Index) of the area RIICO Office Basni Industrial Area, we see that it climbed by roughly 9.33 ppm, which hasn't been much decreased. However, these figures are well before the lockdown. RIICO (Rajasthan State Industrial Development and Investment Corporation) is located in the heart of Basni, Jodhpur's major manufacturing sector.This was among the most contaminated environments due to the industrial pollution, as well as pollution from big machinery vehicles, and a loco shade in close vicinity, but following the closure of the vast bulk of industry sectors during the lockdown, the threshold of toxins declined significantly, but as we've seen, the thresholds rose very quickly in October especially in comparison to theresidential area, as the industries started opening up again in August and September.

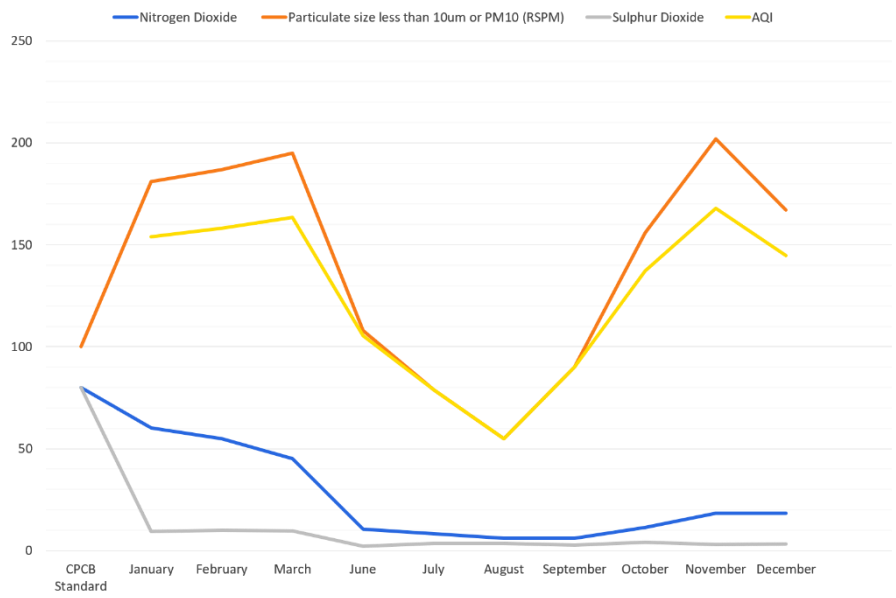

Figure 5. Average Air Quality Index in Year 2020 at Basni Industrial Area, Jodhpur

Study Area 3. "Sojati Gate, Jodhpur": - If we examine the monthly AQI (Air Quality Index) of the area Sojati Gate Jodhpur, we can see how it has fallen by roughly 7.33 ppm, but not significantly. However, these figures are well before the lockdown. Sojati Gate is located in the city's core, flanked by major market districts and heavily populated. The lockdown had some positive effects here, but because this is the centre of the city and that there was a lot of activity here for essential and vital services during the lockdown, the air quality index did not vary more than it did in other places.

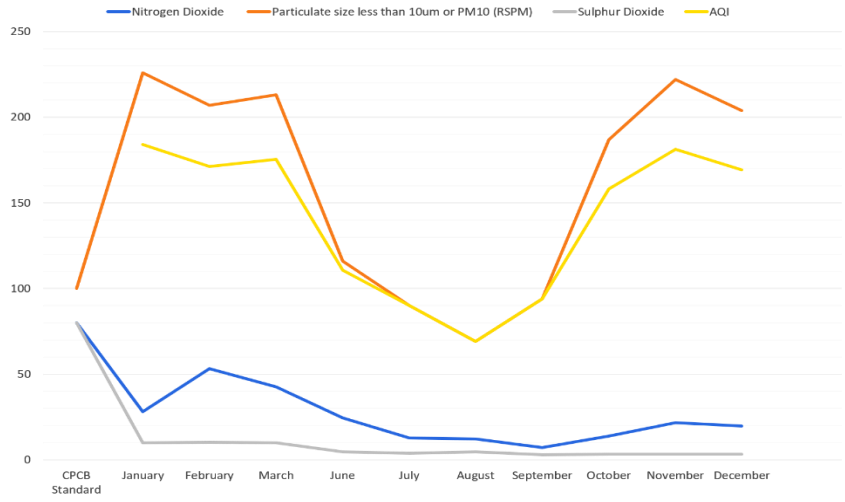

Figure 6. Average Air Quality Index in Year 2020 at Sojati Gate, Jodhpur

Study Area 4."Shastri Nagar, Jodhpur": - When we examine the monthly AQI (Air Quality Index) of the area Shastri Nagar Thana, we can see that it reduced by roughly 3.34 ppm on average,

although it hasn't retreated significantly. However, these figures are from before the shutdown. Shastri Nagar is one of the city's most prestigious residential neighbourhoods, and as can be seen, automobile and human movement was severely restricted in this region, resulting in a significant reduction in pollutant levels.

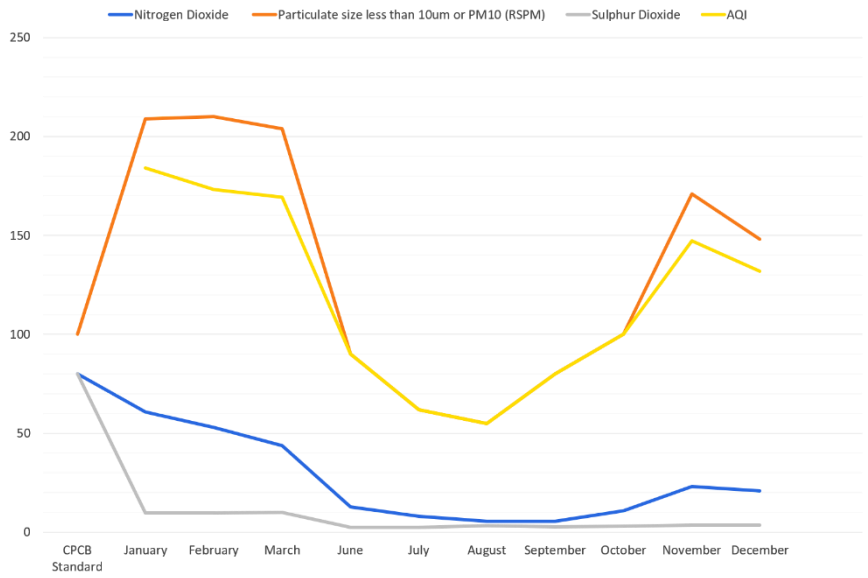

Figure 7. Average Air Quality Index in Year 2020 at Shatri Nagar, Jodhpur

Comparative Analysis

The contrast between all four areas, as shown in the chart above, demonstrates the significant impact of lockdown on air pollution levels. Residential areas like Shastri Nagar and Maha Mandir had a massive rise in air quality as the commute ceased and they only had a few emergency services of essential industries in the near vicinity, whereas Basni and Sojati gate, which are industrial zones and city centres respectively, showed less variability as the important service.

Basni, in specific, has a city transportation area that met the city's necessary criteria, so trains and trucks continued to run, resulting in less polluted air, whilst Sojati gate is located at the intersection of two of the city's major thoroughfares and is among the most congested areas, so the commotion of automobiles did not entirely stop. However, as the results of our research reveal, monitoring and regularising movement of vehicles and industrial pollutants may be extremely environmentally beneficial.

TABLE III. Average Air Quality Index Level at Different Places in Jodhpur City

Monthly Average	AQI at Shastri Nagar	AQI at Basni Industrial	AQI at Sojati Gate	AQI at Maha Mandir

		Area		
Jan-20	172.67	154.00	184.00	173.33
Feb-20	173.33	158.00	171.33	174.67
Mar-20	169.33	163.33	175.33	193.33
Jun-20	90	105.33	110.67	89.00
Jul-20	62	79.00	90.00	52.00
Aug-20	55	55.00	69.00	49.00
Sep-20	80	90.00	94.00	97.00
Oct-20	100	137.33	158.00	170.67
Nov-20	147.33	168.00	181.33	130.67
Dec-20	132	144.67	169.33	122.00

TABLE IV. % of Change in The Criteria Pollutants of Jodhpur City of Rajasthan, Before and During Lockdown (Average of The Three Phases of Lockdown)

	% Change in PM2.5	**% Change in PM10**	**% Change in NO_2**	**% Change in Ozone**	**% Change in SO_2**
Jodhpur	-33%	-36%	-58%	+1.3%	-39%

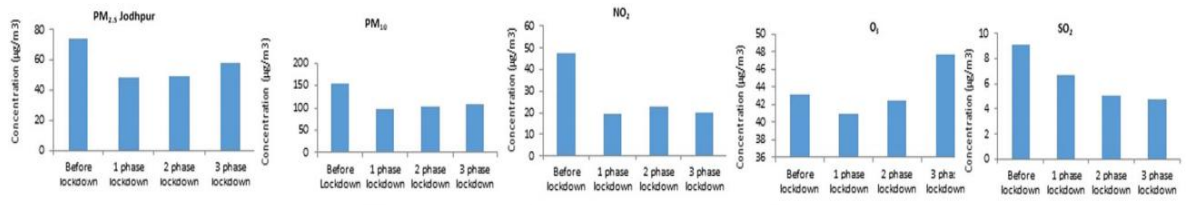

Figure 8. Air pollutants in Jodhpur city before lockdown and during lockdown of three phases

Conclusions

The research of pollution levels under lockdown and shut down situations, when anthropogenic (human) activities were reduced or closed, is a fantastic opportunity to identify the impact of human operations on environmental degradation. During the lockdown, most activities such as tourism, industry, and transportation were halted, leading to an improvement in the environmental quality of Rajasthan's designated towns.

During the lockdown and restriction period (March 2020 to August 2020), the quality of air in Jodhpur City, Rajasthan, exhibited a pattern of lower concentrations of all toxins (excluding ozone) comparing to before the lockdown period. Under VOC-limited settings, a rise in ozone O3 content is frequently coupled with a drop in NO2.We can fairly assume that the pandemic of 2019 could serve as a cautionary tale in determining the benefits of restricting anthropogenic activity during lockdown periods, not only in order to improve the air quality index but also with regard to safety. According to a WHO report, fatalities from air pollution account for 7.8% of all untimely deaths worldwide. Decreased pollution levels can aid in the restoration of nature and should assist to minimise pollution-related deaths.

According to the World Health Organization, lowering PM2.5 levels by 23 grammes per cubic metre (from 35 to 12 grammes per cubic metre) will result in a 15% reduction in early deaths (mortality). And although contamination has a long-term effect, it does not result in an immediate death. As a result, the positive benefits would be greater in terms of decreased morbidity and also more healthier days. The lockout has been shown to be an effective approach for reducing pollution and its negative health impacts.

Conclusions and Major Highlights: (a)The lockdown and restriction have made a significant difference in the state's atmospheric air quality index. The Air Quality Index now has improved to "Satisfactory" at all stations, up from "Poor" to "Satisfactory" previously.(b)The Air Quality Index substantially increased in all locations; nonetheless, the greatest improvements have been seen in Bhiwadi as a result of the suspension of industrial activities, which has resulted in a reduction in motorized vehicles and the resumption of road dust.(c)In terms of specific contaminants, Bhiwadi has seen a 68 percent reduction in PM10, PM2.5, and nitrogen oxide concentrations as a result of the lockdown. (d)Several other cities wherein vehicular emissions and roadway dust re-suspension are the primary contributor to air pollution have seen considerable reductions in key contaminants varying from 28% to 74%.PM2.5 levels are lower later in the lockdown, which might be attributed to much stricter implementation of the lockdown, as well as an increase in ambient temperatures in most regions, allowing for greater pollutant dispersal.

The Ambient Air Quality can provide you with a comprehensive picture of the environment and the major contaminant that is primarily responsible for dirty air. The AQIs were calculated based on the CPCB content at the end-point. Small particles (mainly PM10) were mostly related to a larger number of times in the designated study area, Jodhpur city, according to the AQI research. PM10

was also identified as the most common pollutant in the index score. Particulate Matter is causing major global public health concerns for residents due to its synergism.The use of this console in strategy development for advancement could be unsafe since it does not explain clearly the sequential AAQ variance to atmospheric science, estate use, area biogeographical science and its impact, population exposure (poor) who cannot afford air conditioning convenience, chemical conversion and synergistically influence particulate mixture of gases resulting to smoke acid rain as well as other global climate change occurrences, and health consequences of increased AAQ due to the agglomeration of pollutants.

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