EMPHATIC REPERCUSSION OF LOCKDOWN AND UNLOCK PHASES ON CO, O_3, NO_2 AND PARTICULATE MATTER IN RAJASTHAN STATE DURING PANDEMIC COVID -19

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Abstract

The COVID-19 is a global pandemic and affected many countries, including India. To prevent the spread of COVID-19 pandemic, the nationwide Lockdown was implemented in India from 25 March to 31 May 2020. To study the impact of restrictions during the different phases of COVID-19 Lockdown and Unlock phases (01 Jun to 31 August 2020) on daily mean concentrations of CO, O_3, NO_2, PM2.5 and PM10 in five cities of Rajasthan Jaipur, Jodhpur, Ajmer, Kota and Udaipur. The analysis has been done for different period as pre-lockdown-PLD (01 February to 21 March 2020), COVID-19 lockdown-LD (22 March to 31 May 2020), and unlock-UL (01 June to 31 August 2020) phases. Air quality was very much improved during the COVID-19 lockdown period in all cities compared to the pre-lockdown. The levels of concentration of particulate maters (PM2.5 and PM10) were found to be very much decrease and reach below to NAAQS with respect to pre-lockdown. And also found to be increase during second, third, and fourth LD phases compared to the first LD, indicating these lockdowns with some relaxations. The significant reduction in CO (4-69%), NO_2 (35-77%), PM2.5 (19-49%), PM10 (2-61%) in all five cities of Rajasthan during LD period compared with PLD were estimated whereas significant increase in Ozone (3-43%). It is also found in the rainy season and transport of oceanic air masses in a reduction of particle during the UL period with compare to LD. The study will be helpful to make the policy of control air pollution.

Keywords: *COVID-19 Lockdown, Rajasthan, India, Air quality NAAQS.*

1. Introduction

At the time of end of 2019 year the hall world under the difficult circumstance because of the novel COVID-19 pandemic (corona virus disease). The primary case was recognized in Wuhan, focal city of China on 31 December 2019 (Li et al. 2020). On 11 March 2020, WHO has portrayed COVID-19 as a pandemic (Gorbalenya et al. 2020). To control the spread of COVID-19 pandemic the number of governments of different countries declared lockdown in their nation with strict rules and regulations. In India, 60 active dynamic cases were found until WHO declared Corona as pandemic.

In India the COVID-19 first case was distinguished on 30 January 2020 at Trisharu, Kerla (WHO 2020). Afterward, it's spread to different parts of the India. The COVID-19 cases crossed 500, Prime Minister of India announced 14 hours public curfew in day time on 22 March 2020 (GOI (Government of India) 2020). After that Prime minister declared total lock down across the nation for 21 days beginning from the 25 March to 24 April 2020. Later the nation lockdown was extended up to 3 may 2020 to deal with the decline of the pandemic and then looking the serious situation it was continued until 31 May 2020.

Implement the Lockdown phases in India with LDN-1, LDN-2, LDN-3, LDN-4 on 24 March to 14 April 2020, 15 April to 3 May 2020, 04 May to 17 May 2020 and 18 May to 31 May 2020 respectively given below in Table-01.

In the Indian province of Rajasthan, the main instance of the COVID-19 pandemic was found on 2 March 2020 in Jaipur (GOR (Goverment of Rajasthan) 2020). Indian individuals follow social removing (https://www.mha.gov.in/). In the lockdown, all spots of parties as cafés, films, schools, shopping buildings, instructive organizations were shut and follow the work from the home methodology for social separation. People in general and a wide range of transportation administrations, including rail, road, air, and all assembling and mechanical exercises were additionally required to be postponed. Due to this restrictions there are water, air and noise pollution level recorded as decrease in the time period of lockdown phases (Mandal and Pal 2020; Masum and Pal 2020; Bherwani et al. 2020).

The total lockdown has severely affected on however it has been a decent impact on diminishing the guidelines of air contamination because of restricted transportation and monetary exercises. Many scientists reported mortality and morbidity along with COVID-19, meteorological parameter and air pollution during the lockdown period (Beig et al., 2020; Conticini et al., 2020; Yao et al., 2020; Wu et al., 2020). In the time of COVID-19 restriction many studies reported reduction in air pollution for hall world (Nakada and Urban, 2020; Bashir et al., 2020; Tobias et al., 2020; Kanniah et al., 2020; Chauhan and Singh, 2020; Yadav et al., 2020; 102 Jain and Sharma, 2020; Navinya et al., 2020; Singh et al., 2020).

In India most of the studies have been focused on major cities including Mumbai, Delhi, Kolkata, Ahmedabad, Jaipur, etc but there is not much analysis the air quality of major cities of Rajasthan during the lockdown phases and unlock period. In the current investigation, we evaluated the reduction in air pollution information across six distinct urban areas in the Indian province of Rajasthan (to be specific Udaipur, Jaipur, Jodhpur, Ajmer, Kota, and Alwar) during the Janata Curfew and lockdown and unlock in the COVID-19 pandemic.

Taking into consideration the air quality condition in Rajasthan(India), we have studied the air quality during COVID-19 in six cities of Rajasthan: Ajmer, Alwar, Jaipur, Jodhpur, Kota, and Udaipur.

Table-01 Schedule of Lockdown phases and Unlock phases in Covid-19 pandemic Rajasthan (India)

Lockdown Phase	Start lockdown	End lockdown	Total days
Phase-01	22 March 2020	14 April 2020	24
Phase-02	15 April 2020	3 May 2020	19
Phase-03	4 May 2020	17 May 2020	14
Phase-04	18 May 2020	31 May 2020	14

Unlock	Start Unlock	End Unlock	Total days
UL-01	1 June 2020	30 June 2020	30
UL-02	1 July 2020	31 July 2020	31
UL-03	1 August 2020	31 August 2020	31

1.2 Types of air pollutants and their sources

Based on root, air poisons can be arranged as essential or optional. Essential air toxins are straightforwardly transmitted into the air from their source. For instance, oxides of sulfur, oxides of nitrogen, and oxides of carbon are essential air poisons. Sulfur dioxide (SO_2) is framed because of the consuming of nonconventional powers, horticulture squanders or buildups, or from businesses. It is viewed as harmful after a specific focus. It is additionally answerable for corrosive downpour arrangement. Nitrogen oxides (NO_x), like nitrogen dioxide (NO_2), are shaped during the ignition of petroleum products, biomass, and so forth.

It might likewise respond with carbon monoxide in the climate to shape ozone. It is additionally answerable for corrosive downpour. Carbon monoxide (CO) is framed because of fragmented burning of carbon in energizes like engine and industry biomass. Optional air toxins are shaped because of the response of essential air contaminations in the climate. For instance, ozone (O_3) is framed by free extreme responses of nitrogen oxides. Brown haze is framed from smoke and haze. The particulate issue (PM)(aerosols)are the strong and fluid particles suspended noticeable all around, viz., natural mixes, metals, acids, soil, and residue. In this way, they incorporate both natural and inorganic issue. These coarse particles are framed by mechanical separation of enormous strong particles acquired from non-burnable materials delivered during the ignition of petroleum derivatives, rural procedures, mining of metals, development of streets, and so on.

For human health and quality of life very danger of high concentration air pollutant (Tandon et al. 2008).The air pollutants increased level is accountable for deficits in pulmonary functions, neurobehavioral effects, cardiovascular disease, and mortality (WHO 2005a, b).

Table-02; National Ambient Air Quality Standards (NAAQS)

Pollutant	NAAQS
PM2.5	60 (μgm^{-3})
PM10	100 (μgm^{-3})
NO_2	80 (μgm^{-3})
O_3	100 (μgm^{-3})

2. Methodology

To examine the effect of lockdown on air quality, the data from six unique urban city of Indian state of Rajasthan (Jaipur, Jodhpur, Ajmer, Kota, Udaipur).

(a) Before lockdown period (pre-lockdown-PLD): 01 February 2020 to 21 March 2020

(b) Lockdown period: 22 March to 31 May 2020

(c) Unlock period; 01 June to 31 August 2020
The data of air quality parameter as (i) NO_2, (ii) O_3, (iii) CO and particulate matters (iv) PM2.5 and (v) PM10 download from the Central Pollution Control Board, New Delhi (CPCB 2020) for specific cities of Rajasthan (India).

3. Site information

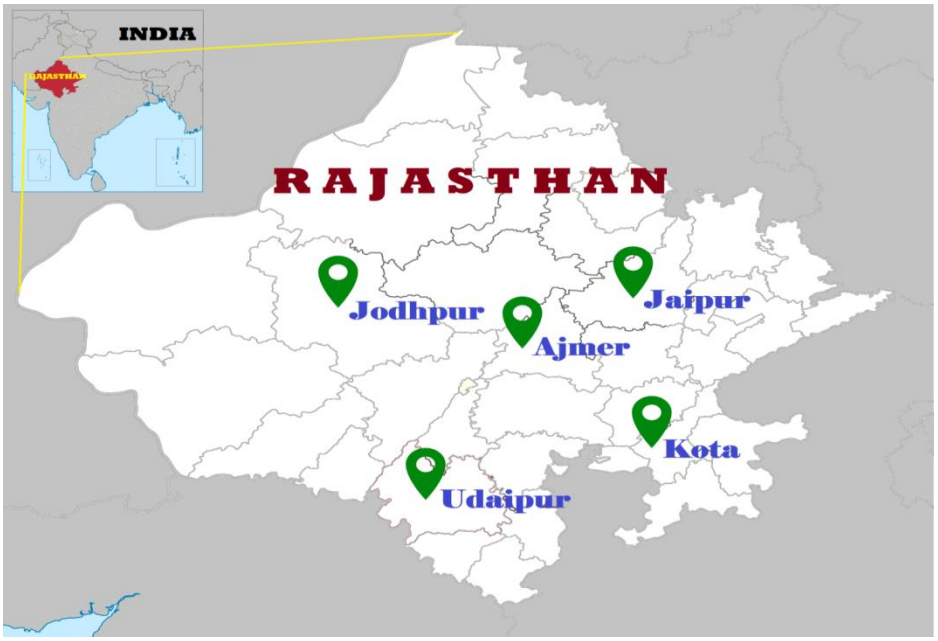

Fig-01; Geographical map Indian state of Rajasthan

Table-03; Location and Coordinates of observations site

Locations	Coordinate
Udaipur	24.5854º N, 73.7125º E
Jaipur	26.9124º N,75.7873º E
Jodhpur	26.2389º N,73.0243ºE
Ajmer	26.4499º N,74.6399ºE
Kota	25.2138ºN,75.8648ºE

The largest state of India is Rajasthan, located at the north-western division of the nation with the population of 6.8 million (http://census2011.co.in). The state lies between N-latitude 23° 31′ to 30° 12′ and E-longitude 69° 3′ to 78° (Fig. 1) with an area of about 3.4 km2 (Maps of India 2011). The Rajasthan has rainfall as high as 819 mm in the eastern part and low as 170 mm in the western part of the state (Maanju and Saha 2013).

The state has various types of soil that help during the cultivation of crops and Rajasthan has farming financial system with nine agro-climatic zones Rajasthan is a Industrial states Including marbels, steel, cement, handicrafts, textiles, chemicals and IT (Report 2018).

The Rajasthan is leading producer of cement grade limestone in India, It has about 26% share in proven limestone reserves in the country (IBEF : India Brand Equity Foundation 2020).

Mainly Rajasthan attract for tourism (forts, lakes, deserts, wildlife sanctuaries, etc). In Rajasthan activities of industrial, mining and automobiles are accountable for air pollution researchers have reported (Kumar and Sharma 2016; Chauhan 2010).The Rajasthan State Pollution Control Board (RSPCB) has been regularly tracking the impact of the industrial activities on air quality in Jaipur, Ajmer, Jodhpur, Kota, and Udaipur. Air pollution caused by industries has been responsible for serious occupational health hazards and adverse effects.

4. Results and discussion

The analysis of the data for the period of seven months (01 February to 29 August 2020) revealed few important trends in the measurement of Ozone, CO, NO_2, PM2.5 and PM10.

In study we have chosen the data of few specific cities of Rajasthan as Jaipur, Jodhpur, Ajmer, Kota and Udaipur where are the pollutants are directly and indirectly decide the air quality and climate conditions of the entire Rajastan state.

The analytical results become more formidably important because of the pandemic COVID-19 during which lockdown and unlock situation were created and made to maintain by the decision of the state and central government in India.

The trends of pollution during lockdown and unlock conditions turned out to be notable from the situation as it wearer before the period of industrialization when there was no production of pollution due to industries and vehicles and climate was clean according to standards set at present time by Nation Ambient Air Quality

Standards (NAAQS).

We critically matched our results with another pogenic and natural activities occurred over the Rajasthan in order to protect our lines from pandemic COVID-19, and tried to understand its role in directly improving the quality of air as under.

The daily means of Ozone, CO, NO_2, PM2.5 and PM10 concentration measured in Udaipur, Kota, Ajmer, Jodhpur and Jaipur are shown in Fig. 2, 3 and 4.

The daily mean time series concentrations of air quality parameters (Ozone, CO, NO_2, PM2.5 and PM10) for all cities are divided into three different periods of PLDN (2 February to 21 March 2020), COVID-19 LDN (22 March to 31 May 2020), and ULC (1 Jun to 31 August 2020). The daily mean concentration of CO were in the range of 0.2 to 2.11, 0.32 to 0.84, 0.27 to 1.26, 0.19 to 2.14, and 0.39 to 1.73 µgm-3, while those of NO2 varied in the range of 2.74 to 41.9, 4.74 to 66.24, 4.3 to 45.22, 7.97 to 110.81, 10.23 to 85.84 µgm-3, respectively in Udaipur, Kota, Ajmer, Jodhpur and Jaipur during the study period. The daily mean concentration of O3 were in the ranges of 15.4 to 77.09, 8.08 to 77.75, 9.36 to 101.78, 9.34 to 80.96 and 11.7 to 88.95 µgm-3, while those of PM2.5 varied in the ranges of 14.16 to 77.26, 12.89 to 64.03, 10.63 to 114.13, 18.83 to 141.18, and 7.3 to 81.25 µgm-3, while those of PM10 varied in the ranges of 26.26 to 202.51, 23.11 to 136.04, 15.9 to 266.15, 39.31 to 282.8 and 20.38 to 256.76 µgm-3, respectively in Udaipur, Kota, Ajmer, Jodhpur and Jaipur.

The average value of CO in PLD for all cities were 1.28, 0.57, 0.64, 0.95, and 0.85 μgm^{-3}, respectively in Udaipur, Kota, Ajmer, Jodhpur, and Jaipur.

In PLD maximum value was observed in cities are Udaipur and Jodhpur as 1.28µgm-3, and 0.95µgm-3 respectively. In Udaipur city highly decreased CO in LD-01 (61.77%) whereas 14.82% minimum decrease in the Jodhpur city. In LD-02, LD-03, and LD-04 the value of CO was continuously increased in Jaipur. The value of CO is approximately constant in Kota whereas LD-03 to UL-01 in Udaipur and Jodhpur continuously increase. And it again decreases in UL-02 and UL-03. On other hand the mean concentration of NO_2 in pre lockdown 24.87, 34.43, 28.01, 35.59, and 40.23 μgm^{-3} while those of O_3 varied in 46.07, 34.91, 53.42, 38.49 and 59.91 μgm^{-3}, respectively in Udaipur, Kota, Ajmer, Jodhpur and Jaipur. The value NO_2 maximum decrease in Udaipur 6.23 μgm^{-3} (75.57%) in LD-01and minimum decreases in Jodhpur 20.42 μgm^{-3} (36.22%) with compare to pre-lockdown. LD-1 to UL-3 concentration of NO_2 in Jaipur and Udaipur cities showed increased.

During the lockdown phases there was increase in ozone level in all cities where maximum increase in Jaipur 68.44 μgm^{-3} and minimum increase in Kota 41.46 μgm^{-3} it is the 28.09% and 18.77% with compare to pre-lockdown respectively Jaipur and Kota but after LD-04 means during the unlock it decreased again.

Looking the data of PM2.5 during pre-lockdown in Jodhpur city, it was 78.34μgm^{-3} which much over the standard set by NAAQS, but decreased 38.40% in first lockdown (LD-01) showing 48.26μgm^{-3} only. In Jaipur city it was decreased from 35.40μgm^{-3} to 20.39μgm^{-3} in LD-01 and register 42.40% decrease, where in other cities of Udaipur, Ajmer decrease is measured to be 42.96%, 47.40% respectively. In the time of LD-4 cities near desert Thar of Rajasthan, exclusively in Ajmer, Jaipur, and Jodhpur PM2.5 is observed to be much high then pre-lockdown due to dust storm which is Ural feature during the months of March-April and may. In period of lockdown 3 and 4, government started the transportation of labour clouds to there parental lid to increase PM2.5 level at all places. Under unlock period, PM2.5 is decreased and at all place due to rain. We found the level of PM10 more than standard NAAQS (100μgm^{-3}) in city Ajmer, and Jodhpur in pre lockdown period to be 107.75μgm^{-3} and 170.05μgm^{-3} respectively, but during LD-01, it is recorded with decrease of 43.9%, and 42.55% in both city. On other hand in Udaipur city it was 43.2% and in Kota city 21.4% only. During summer dust storm raise in there desert increased the PM10 level to 140.21μgm^{-3}, 126.4μgm^{-3} and 165.82μgm^{-3} in near cities like Ajmer, Jaipur, and Jodhpur respectively. However in unlock stages consequently PM10 decreased in almost all cities due to rain.

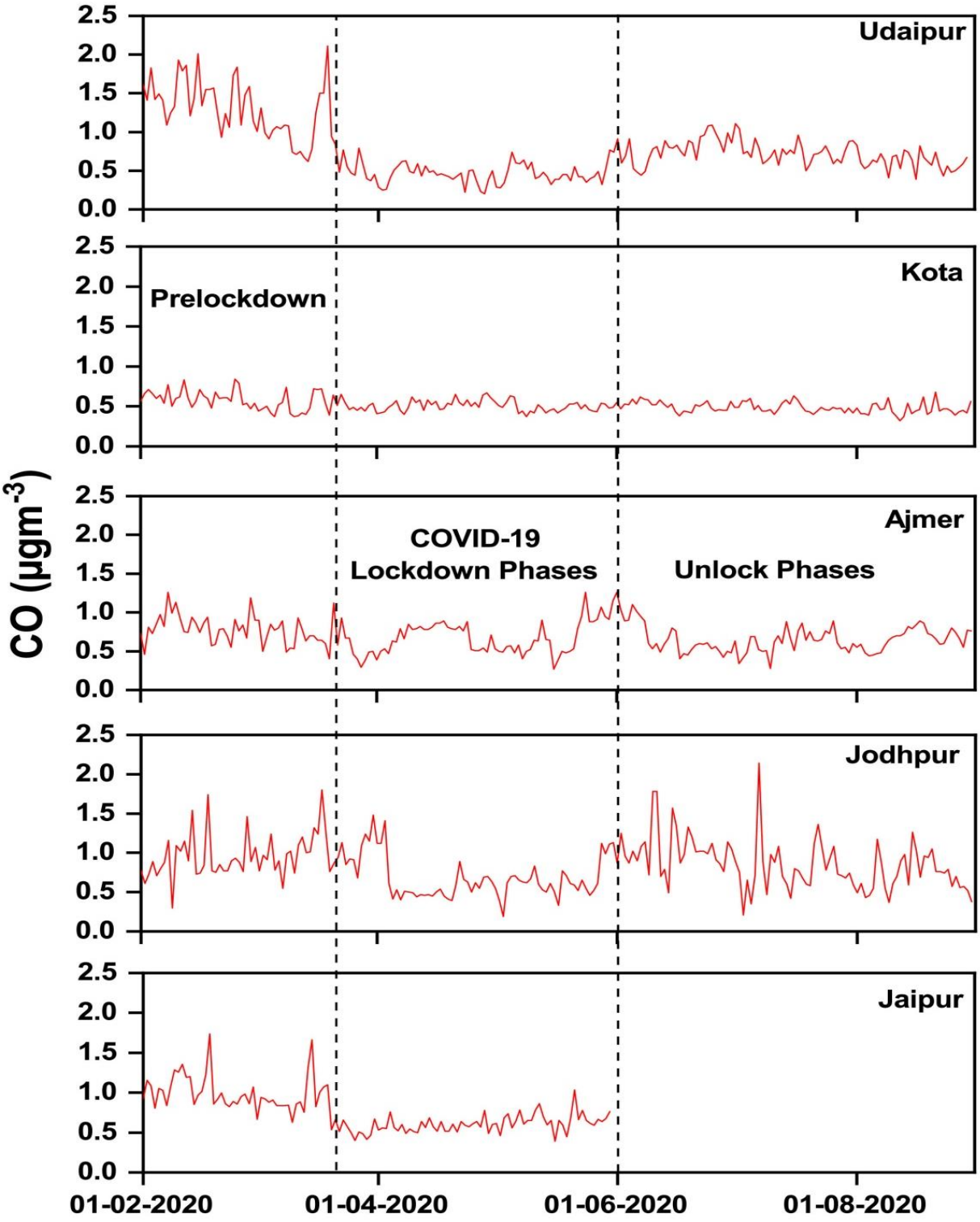

Fig.2: The daily time series variations of CO in five major cities from 01 February to 31 August 2020.

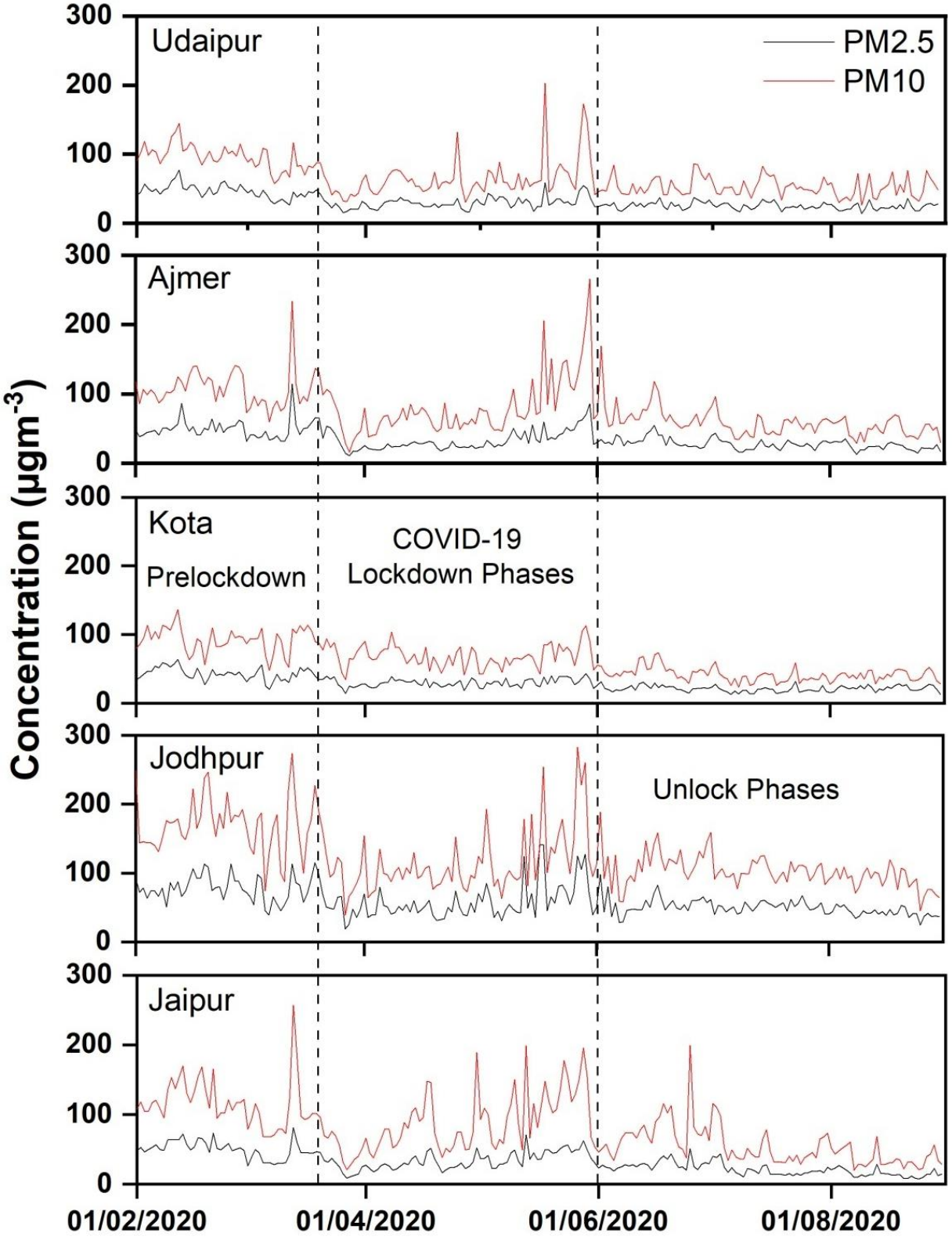

Fig.3: The daily time series variations of PM2.5 and PM10 in five major cities from 01 February to 31 August 2020.

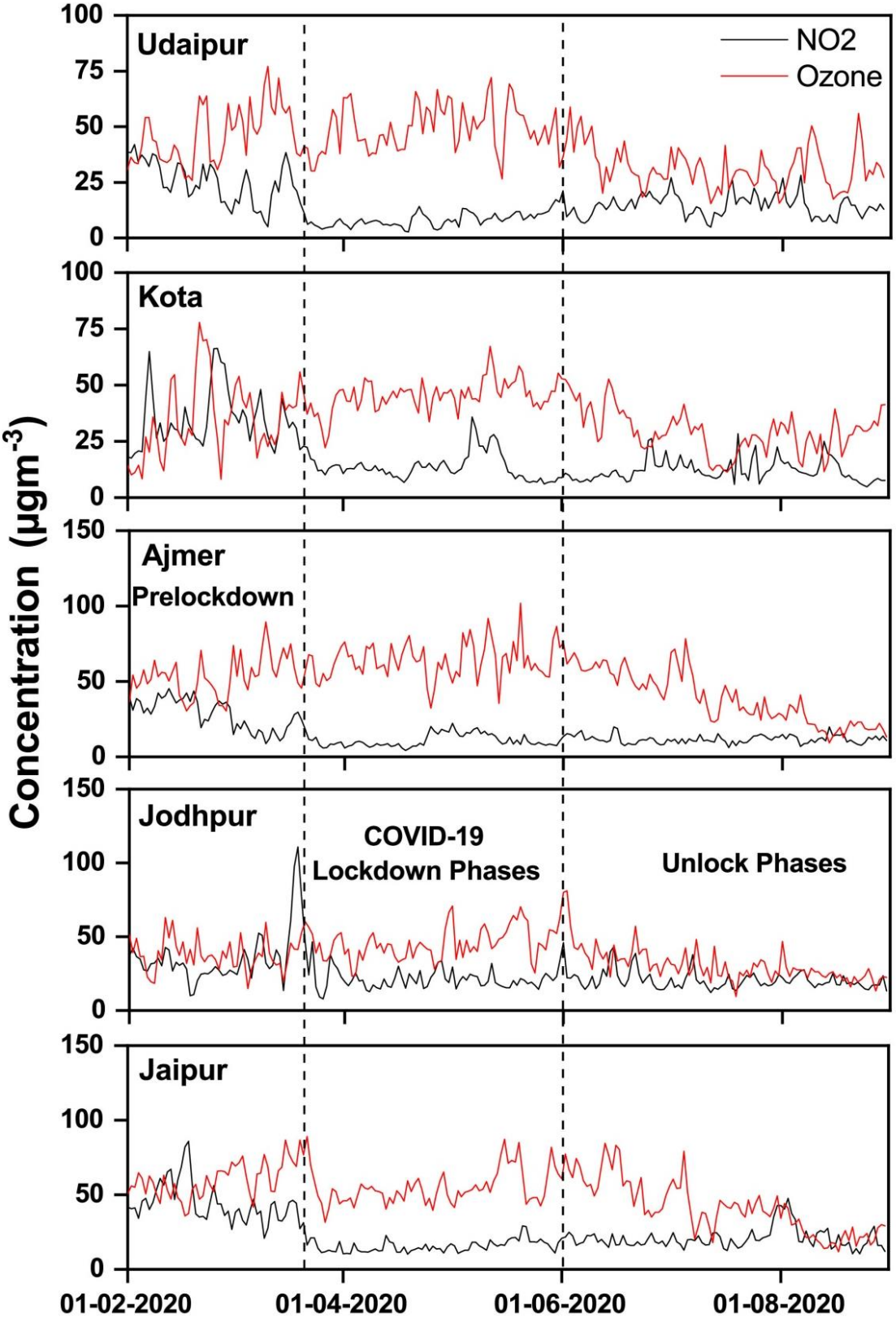

Fig.4: The daily time series variations of NO2 and Ozone in five major cities from 01 February to 31 August 2020.

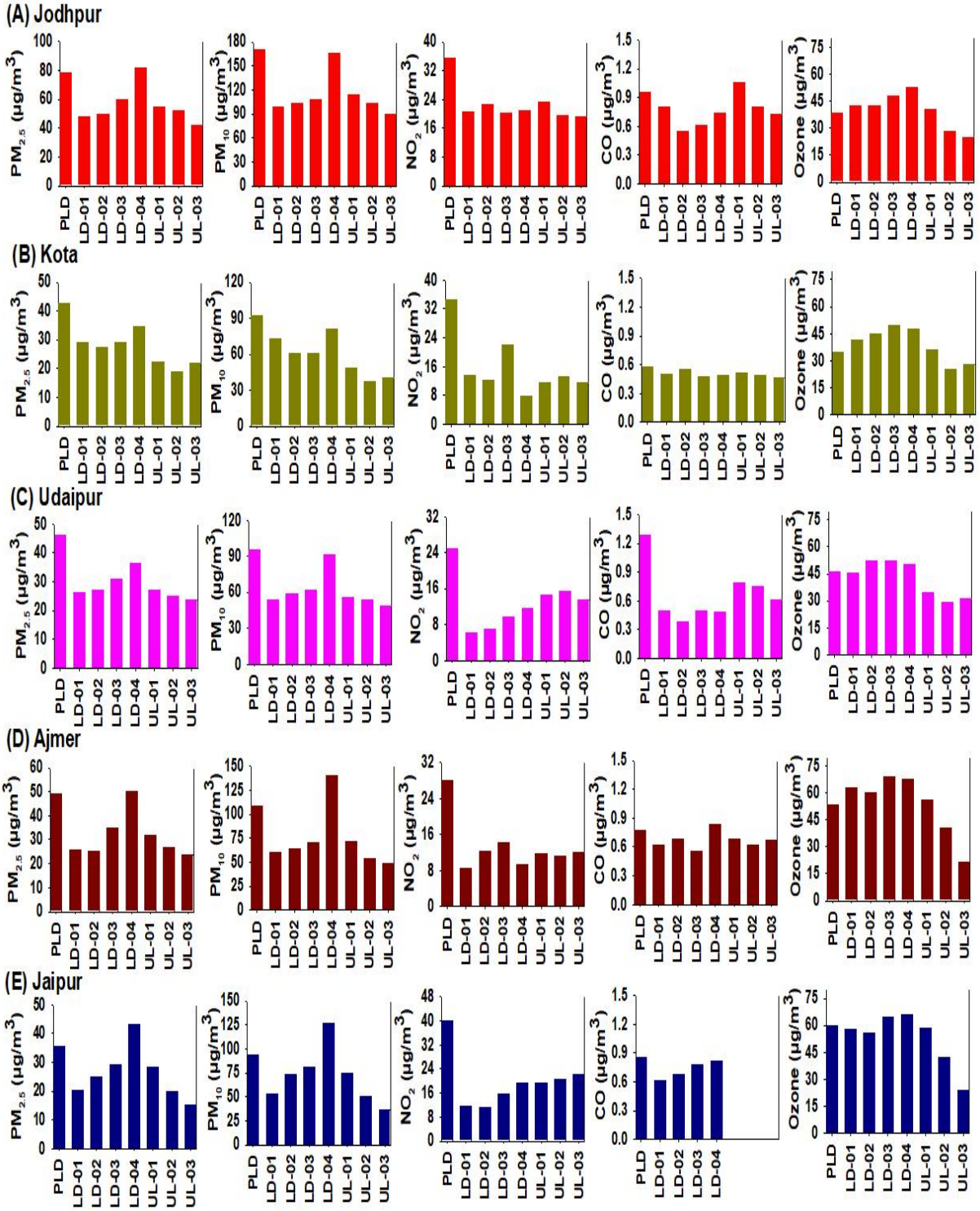

Fig.5: Air pollutants in different cities before lockdown (pre lockdown), Lockdown phases and Unlock phases. (A) Jodhpur (B) Kota, (C) Udaipur. (D) Ajmer and (E) Jaipur

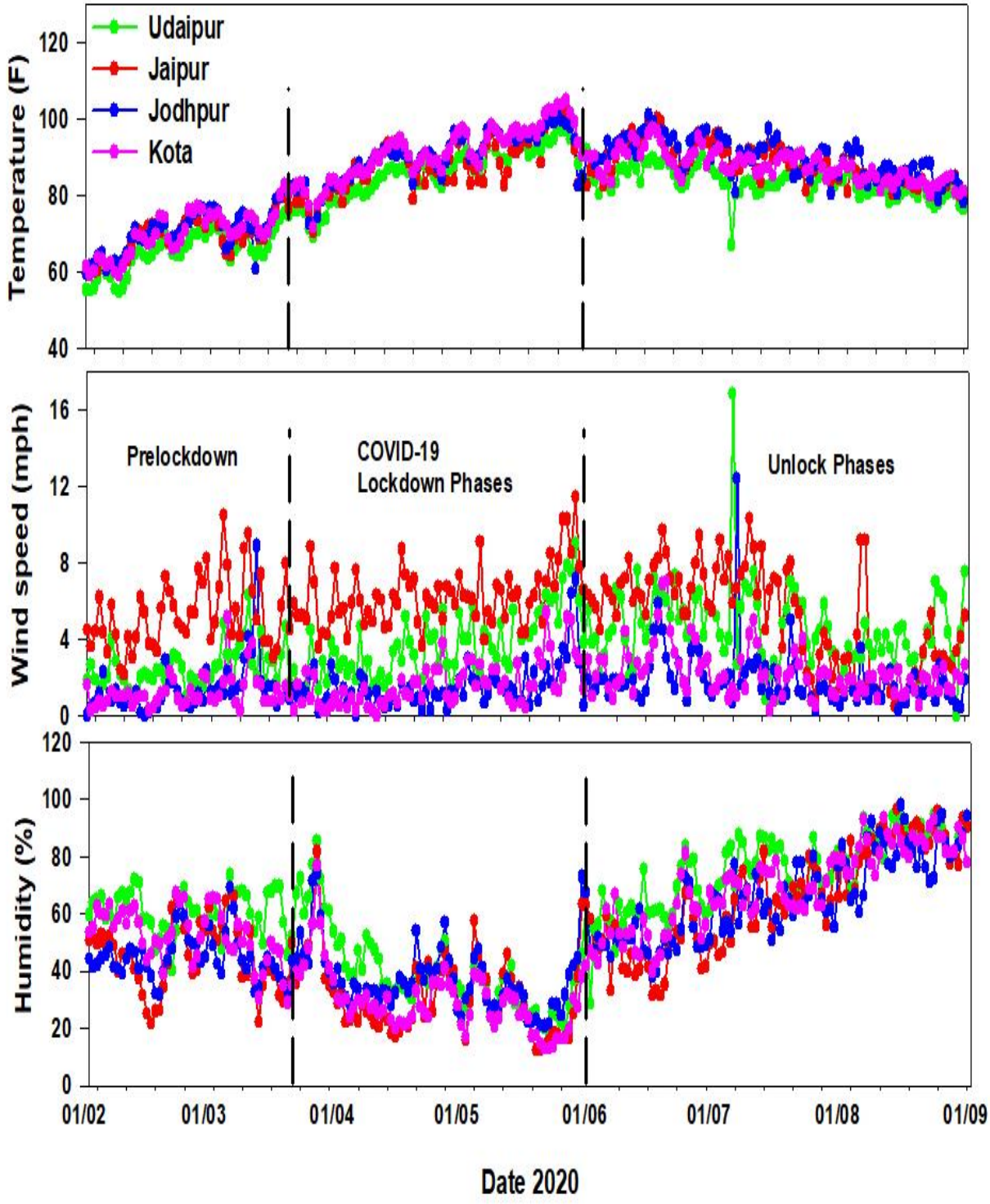

Fig.6: Meteorological parameters (Temperature, Wind speed and Humidity) from 01 February to 31 August for different cities (Udaipur, Jaipur, Jodhpur and Kota).

The maximum percentage reduction shows in Udaipur 69.67% (LD-02), 75.57% (LD-01), 49.55% (UL-03), 50.59% (UL-03) respectively in air quality parameter CO, NO_2, PM2.5 and PM10, while those of in Kota shows maximum percentage reduction 66.78% (LD-04), 76.97% (LD-04), 55.74% (UL-02) and 59.2% (UL-02) respectively in CO, NO_2, PM2.5 and PM10 and Ajmer shows 28.93% (LD-03), 69.92% (LD-01), 51.9% (UL-03), and 54.26% (UL-03) respectively in CO, NO_2, PM2.5, PM10 and on other hand Jaipur shows maximum percentage reduction 28.78% (LD-01), 71.89% (LD-02), 57.76% (UL-03), 60.72% (UL-03) respectively in CO, NO_2, PM2.5 and PM10. Ajmer, Udaipur, Kota and Jodhpur cities shows approximately increasing order in Ozone sunlight (temp.) and reduce air pollution as we see in fig.04 as increase temp. (sun light) as increase O3. In the time of COVID-19 lockdown period the average value of Ozone was found to be increased in other parts of world (Xu et al. 2020; Jain and Sharma 2020) In current study approx all pollutant shows decrease pattern in lockdown period but on other hand Ozone increases a parts in Rajasthan and the maximum percentage increase in Udaipur 25.83% (LD-03), Kota 42.93% (LD-03), Jodhpur 39.48% (LD-04), and Ajmer 26.26% (LD-04). There is also maximum percentage reduction shows Jaipur 60.11% (UL-03).

5. Percentage change table-

Udaipur	CO	Ozone	NO2	PM2.5	PM10
LD-01	-61.77	-1.70	-74.94	-42.96	-43.29
LD-02	-69.67	13.07	-71.68	-41.35	-38.44
LD-03	-60.20	13.17	-61.31	-33.60	-35.83
LD-04	-62.92	8.00	-53.03	-21.13	-4.32
UL-01	-38.82	-24.38	-41.05	-41.79	-41.84
UL-02	-41.99	-37.29	-38.39	-45.54	-44.25
UL-03	-52.52	-31.96	-45.26	-48.72	-48.69

Kota	CO	Ozone	NO2	PM2.5	PM10
LD-01	-12.65	18.77	-60.86	-31.82	-21.04
LD-02	-4.89	28.52	-64.69	-35.22	-34.49
LD-03	-17.42	42.93	-36.06	-31.94	-34.28
LD-04	-14.18	36.29	-76.97	-19.11	-12.46
UL-01	-11.73	3.41	-66.91	-47.13	-47.87
UL-02	-15.14	-28.5	-62.19	-55.74	-59.2
UL-03	-19.62	-19.61	-66.38	-48.42	-56.2

Jodhpur	CO	Ozone	NO2	PM2.5	PM10
LD-01	-15.80	9.54	-42.22	-38.46	-42.55
LD-02	-43.11	10.26	-36.37	-36.3	-39.22
LD-03	-36.45	24.02	-43.18	-24.49	-36.45
LD-04	-22.78	35.63	-41.07	3.98	-2.49
UL-01	9.83	4.53	-34.72	-30.19	-33.42
UL-02	-15.88	-27.83	-45.35	-33.97	-39.00
UL-03	-24.83	-36.56	-45.75	-46.28	-47.66

Jaipur	CO	Ozone	NO2	PM2.5	PM10
LD-01	-28.78	-3.78	-70.74	-42.4	-42.66
LD-02	-20.7	-7.09	-71.89	-29.33	-20.91
LD-03	-9.45	7.64	-60.67	-17.46	-12.28
LD-04	-4.74	9.35	-52.26	22.12	35.72
UL-01		-2.44	-52.26	-19.99	-20.21
UL-02		-29.36	-48.89	-43.78	-45.43
UL-03		-60.11	-44.54	-57.76	-60.72

Ajmer	CO	Ozone	NO2	PM2.5	PM10
LD-01	-20.84	17.1	-69.92	-47.4	-43.9
LD-02	-11.53	12.17	-56.09	-48.63	-40.78
LD-03	-28.93	28.09	-49	-28.86	-34.25
LD-04	8.1	26.26	-66.89	1.94	30.12
UL-01	-12.99	4.34	-57.67	-35.27	-33.04
UL-02	-20.66	-25.05	-59.78	-46.07	-49.73
UL-03	-14.41	-59.95	-57.49	-51.9	-54.26

References

[1] *Li, L., Li, Q., Huang, L., Wang, Q., Zhu, A., Xu, J., Liu, Z., Li, H., Shi, L., Li, R. and Azari, M. 330 (2020), "Air quality changes during the COVID-19 lockdown over the Yangtze River Delta Region: An insight into the impact of human activity pattern changes on air pollution variation", Sci. Total Environ. 732, 139282. https://doi.org/10.1016/j.scitotenv.2020.139282.*

[2] *A. E. Gorbalenya, S. C. Baker, R. Baric, R. J. D. Groot, C. Drosten, A. A. Gulyaeva, D. Penzar, "Severe acute respiratory syndrome-related coronavirus: the species and its viruses", a statement of the Coronavirus Study Group* ***(2020)***.

[3] *World Health Organization (WHO), (2020). Rolling Updates on Coronavirus Disease (COVID-19) Retrieved from https://www.who.int/emergencies/diseases/novel-coronavirus-2019/events.*

[4] *GOI (Government of India) 2020 https://www.mygov.in/covid-19/*

[5] *I. Mandal, S. Pal, "COVID-19 pandemic persuaded lockdown effects on environment over stone quarrying and crushing areas", Science of The Total Environment:139281* ***(2020)***.

[6] *M. H. Masum, S. K. Pal, " Statistical evaluation of selected air quality parameters influenced by COVID-19 lockdown", Global J. Environ. Sci. Manage. 6(SI):85–94* ***(2020)***.

[7] *H. Bherwani, M. Nair, K. Musugu, S. Gautam, A. Gupta, A. Kapley, R. Kumar, "Valuation of air pollution externalities: comparative assessment of economic damage and emission reduction under COVID-19 lockdown", Air Qual Atmos Health 13:683 –694* ***(2020)***.

[8] *G. Beig, S. Bano, S.K. Sahu, V. Anand, N. Korhale, A. Rathod, R. Yadav, P. Mangaraj, B. S. Murthy, S. Singh, R. Latha and R. Shinde, "COVID-19 and environmental -weather markers: Unfolding baseline levels and veracity of linkages in tropical India, "Environ. Res. 191, 110121* ***(2020)***.

[9] *E. Conticini, F. Bruno, C. Dario, "Can atmospheric pollution be considered a co-factor in extremely high level of SARS-CoV-2 lethality in Northern Italy?", Environ. Poll.114465, 10.1016/j.envpol.2020.114465* ***(2020)***.

[10] *Y. Yao, J. Pan, Z. Liu, X. Meng, W. Wang, H. Kan, " No association of COVID-19 transmission with temperature or UV radiation in Chinese cities", European Respiratory Journal, 55, 2000517. DOI: 10.1183/13993003.00517-2020* ***(2020)***.

[11] *A. Wu, Y. Peng, B. Huang, X. Ding, X. Wang, P. Niu, J. Meng, Z. Zhu, Z. Zhang, J. Wang, and J. Sheng, "Genome composition and divergence of the novel coronavirus (2019-nCoV) originating in China", Cell host & microbe, 27(3), 325-328,* ***(2020)***. https://doi.org/10.1016/j.chom.2020.02.001.

[12] *L. Y. K. Nakada, and R. C. Urban, "COVID-19 pandemic: Impacts on the air quality during the partial lockdown in São Paulo state, Brazil", Sci. Total Environ. 730, 139087* ***(2020)***. https://doi.org/10.1016/j.scitotenv.2020.139087.

[13] *M. F. Bashir, B. J. M. Bilal, B. Komal, M. A. Bashir, T. H. Farooq, N. Iqbal, M. Bashir, "Correlation between environmental pollution indicators and COVID-19 pandemic: a brief study in Californian context", Environ. Res. 187, 109652. 10.1016/j.envres.2020.109652* ***(2020)***.

[14] *A. Tobías, C. Carnerero, C. Reche, J. Massagué, M. Via, M. C. Minguillón, A. Alastuey, and X. Querol, "Changes in air quality during the lockdown in Barcelona (Spain) one month into the SARS-CoV-2 epidemiC", Sci. Total Environ. 726, 138540* ***(2020)***. https://doi.org/10.1016/j.scitotenv.2020.138540.

[15] *K. D. Kanniah, N. A. F. K. Zaman, D. G. Kaskaoutis and M. T. Latif, "COVID-19's Impact on the Atmospheric Environment in the Southeast Asia Region", Sci. The Total Environ. 736, 139658* ***(2020)***.

[16] *A. Chauhan and R. P. Singh, "Impact of lockdown on air quality in India during COVID-19 pandemic", Air Qual Atmos Health, 13(8), 921-928* ***(2020)***. https://doi.org/10.1007/s11869-020-00869-1.

[17] *R. Yadav, N. Korhale, V. Anand, A. Rathod, S. Bano, R. Shinde, R. Latha, S. K. Sahu, B. S. Murthy, and G. Beig, "COVID-19 lockdown and air quality of SAFAR-India metro cities", Urban Clim, 34, 100729* ***(2020)***. *https://doi.org/10.1016/j.uclim.2020.100729.*

[18] *S. Jain, and T. Sharma, "Social and travel lockdown impact considering corona virus disease (COVID-19) on air quality in megacities of India: present benefits, future challenges and way forward", Aerosol Air Qual. Res. 20(6), 1222-1236* ***(2020)***. https://doi.org/10.4209/aaqr.2020.04.0171

[19] *C. Navinya, G. Patidar, and H. C. Phuleria, "Examining effects of the COVID-19 national lockdown on ambient air quality across urban India", Aerosol Air Qual. Res. 20(8), 1759-1771* ***(2020)***. https://doi.org/10.4209/aaqr.2020.05.0256.

[20] *V. Singh, S. Singh, A. Biswal, A. P. Kesarkar, S. Mor, and K. Ravindra, "Diurnal and temporal changes in air pollution during COVID-19 strict lockdown over different regions of India", Environ. Pol. 266, 115368* ***(2020)***. *https://doi.org/10.1016/j.envpol.2020.115368.*

[21] *A. Tandon, S. Yadav, A. K. Attri, " City-wide sweeping a source for respirable particulate matter in the atmosphere", Atmos Environ 42(5):1064–1069* ***(2008)***.

[22] *WHO (2005a) WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide. https://apps.who.int/iris/ bitstream/handle/10665/69477/WHO_SDE_PHE_OEH_06.02_ eng. pdf?sequence=1*

[23] *WHO (2005b) Air quality guidelines global update published by World Health Organisation WHO* ***(2016)***.

[24] *S. K. Maanju, K. Saha, "Impact of mining industry on environmental fabric a case study of Rajasthan state in India", Journal of Environmental Science Toxicology and Food Technology 6(2):8– 13* ***(2013)***.

[25] *IBEF : India Brand Equity Foundation (2020 https://www.ibef.org/ download/Rajasthan-*

March-2020.pdf

[26] *S. Jain, T. Sharma, "Social and travel lockdown impact considering coronavirus disease (COVID-19) on air quality in megacities of India", present benefits, future challenges and way forward. Aerosol Air Qual Res 20:1222–1236* ***(2020)***.

[27] *S. S. Kumar, K. Sharma, "Ambient air quality status of Jaipur city Rajasthan, India", Int Res J Environment Sci 5:43–48* ***(2016)***.

[28] *S. S. Chauhan, "Mining, development and environment: a case study of Bijolia mining area in Rajasthan, India", J Hum Ecol 31(1):65–72* ***(2010)***.

[29] *K. Xu, K. Cui, L. H. Young, Y. K. Hsieh, Y. F. Wang, J. Zhang, S. Wan, "Impact of the COVID-19 event on air quality in Central China", Aerosol Air Qual Res 20(5):915–929* ***(2020)***.

[30] *S. Jain, T. Sharma, "Social and travel lockdown impact considering coronavirus disease (COVID-19) on air quality in megacities of India: present benefits, future challenges and way forward", Aerosol Air Qual Res 20:1222–1236* ***(2020)***.