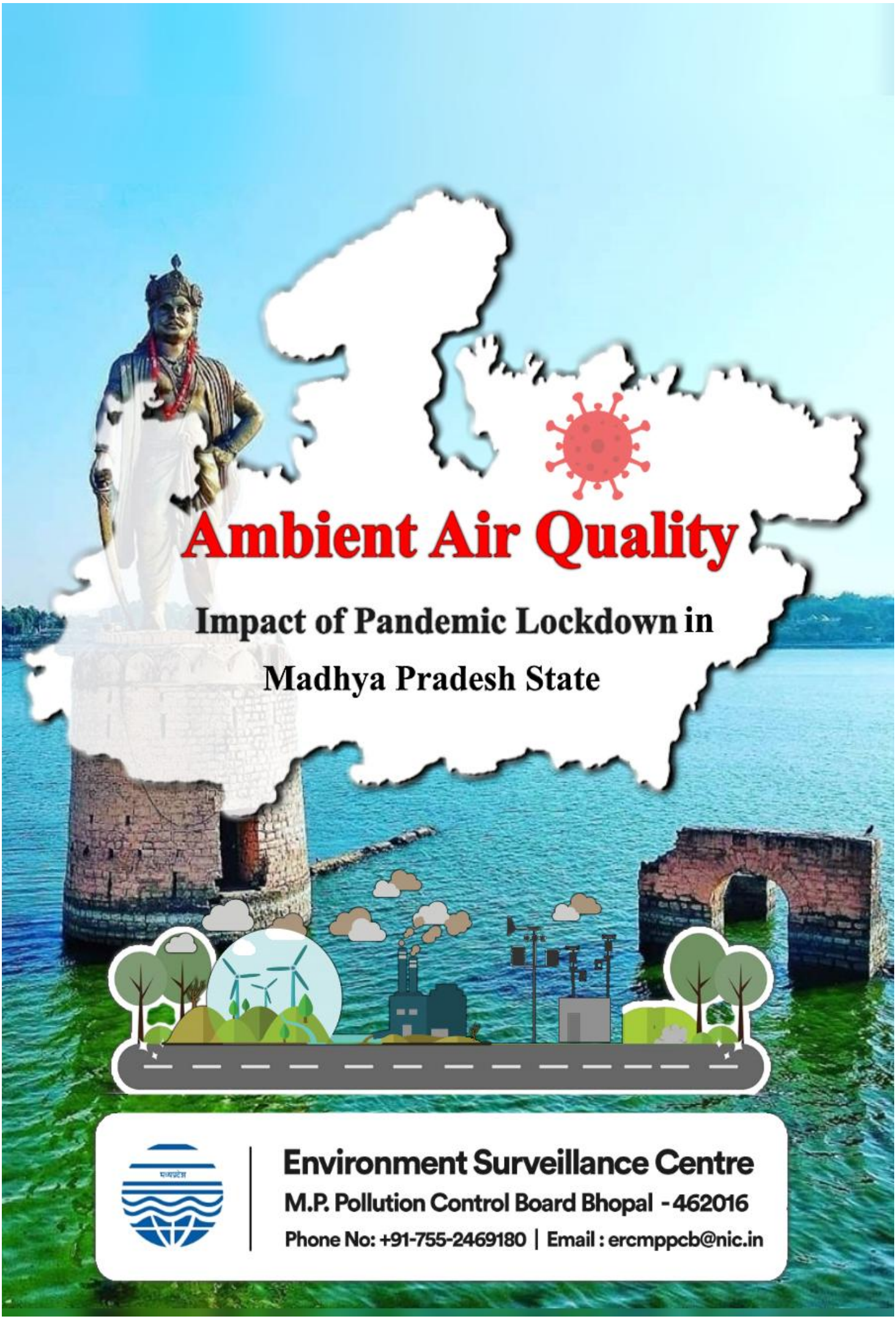

Ambient Air Quality

Impact of Pandemic Lockdown in Madhya Pradesh State

Environment Surveillance Centre

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PREFACE

The pandemic lockdown across the country due to Covid-19 brought the country to a standstill with all industrial activities coming to a total halt, cancellation of all means of transport, shutting of all kind of business activities, ban on all types of construction activities and closure of all government and private offices and institutions. This pandemic has casted a global gloom by causing damage to health, economy and general societal well-being.

The environment segment has, however, emerged as the most benefitted one during lockdown. The lockdown, in one way, proved to be helpful to know the background levels of air pollutants as the pollution from most sectors reduced significantly during this period. The lockdown has also given an opportunity to identify the key drivers of air pollutants across the State which would later help in taking necessary measures to control them.

The lockdown brought a gloomy picture for everyone but, accepting this situation too as an opportunity, the team of Environment Surveillance Centre (ESC), M.P. Pollution Control Board carried out study on ambient air quality in the Madhya Pradesh State to assess and compare the pollution scenario before and during lockdown period for future environment planning.

The purpose of this report is to present the status of air quality during pandemic lockdown in different areas of the State, with respect to criteria pollutants as listed in the GoI Notification G.S.R. 826 E dated 16/11/2009.

The outcome of the study would be helpful to the city planners and the policy makers to understand if there is any need to revise the criteria of background concentration of ambient air parameters and raise the baseline data value for reference studies and would also help them in formulating the future strategy accordingly. The observations and the inferences of this study may be integrated with policy and planning related issues to plan the combat actions against the air pollution in times to come.

July 10, 2020 **Team E.S.C.**

Table of Contents

1. Preamble 3
2. Objective of the Study 4
3. The Study Course 5
   3.1. The State 5
   3.2. Monitoring Protocol 5
   3.3. The Criteria Pollutants 6
   3.4. The Study Duration 7
4. Observations 7
   4.1. Air Quality Index 7
   4.2. The Highest and the Lowest AQI Locations 9
   4.3. Prominent Pollutant 12
   4.4. Air Quality Assessment Using Exceedance Factor 21
   4.5. Comparative Status of Criteria Pollutants 21
   4.6. Ambient Parameters 22
      4.6.1. Particulate Matters – PM_{10} 22
      4.6.2. Particulate Matters – $PM_{2.5}$ 23
      4.6.3. Nitrogen oxide 24
      4.6.4. Sulphur dioxide 25
      4.6.5. Carbon monoxide 35
      4.6.6. Ozone 35
      4.6.7. Ammonia 37
5. Meteorological Observations 38
6. Statistical Analysis 40
   6.1. Standard Deviation Analysis 40
   6.2. Correlation Analysis 44
   6.3. Frequency Distribution Analysis 45
      6.3.1. Frequency Distribution of PM_{10} 45
      6.3.2. Frequency Distribution of $PM_{2.5}$ 48
   6.4. Spread of Data Values and Time Relation 52
      6.4.1. Intra-day Distribution of PM_{10} 52
      6.4.2. Intra-day Distribution of $PM_{2.5}$ 55
   6.5. Percentage Component of $PM_{2.5}$ in PM_{10} 59
7. Salient Features of the Study 60
8. Conclusion 61
9. Reference Sources 62

Table of Figures

Figure 1: State wide AQI Categories During Study Period ---- 8
Figure 2: Frequency of Prominent AQI Pollutants ---- 10
Figure 3: Frequency of AQI Categories During Study Period ---- 10
Figure 4: Percentage of AQI Pollutants ---- 12
Figure 5: Parentage of AQI Categories During Study Period ---- 13
Figure 6: Air Quality Assessment based on Exceedance Factor ---- 26
Figure 7: Surface Data at Day/Night Time during Pre/Post Lockdown ---- 38
Figure 8: Locationwise PM_{10} Statistics ---- 41
Figure 9: Locationwise $PM_{2.5}$ Statistics ---- 41
Figure 10: Location wise SO2 Statistics ---- 42
Figure 11: Location wise NOx Statistics ---- 43
Figure 12: Ozone and NOx Correlation ---- 45
Figure 13: Pre Lockdown Histogram of PM_{10} - Cluster 1 ---- 46
Figure 14: Lockdown Histogram of PM_{10} - Cluster 1 ---- 46
Figure 15: Pre lockdown Histogram of PM_{10} - Cluster 2 ---- 47
Figure 16: During Lockdown Histogram of PM_{10} - Cluster 2 ---- 47
Figure 17: Pre lockdown Histogram of PM_{10} - Cluster 3 ---- 48
Figure 18: During Lockdown Histogram of PM_{10} - Cluster 3 ---- 48
Figure 19: $PM_{2.5}$ During Pre Lockdown - Cluster1 ---- 49
Figure 20: $PM_{2.5}$ During Lockdown - Cluster1 ---- 49
Figure 21: $PM_{2.5}$ During Pre Lockdown – Cluster 2 ---- 50
Figure 22: $PM_{2.5}$ During Lockdown – Cluster 2 ---- 50
Figure 23: $PM_{2.5}$ During Pre lockdown – Cluster 3 ---- 51
Figure 24: $PM_{2.5}$ During Lockdown – Cluster 3 ---- 51
Figure 25: PM_{10} Concentration against Time hour during Pre-Lockdown – Cluster 1 ---- 52
Figure 26: PM_{10} Concentration against Time hour during Lockdown – Cluster 1 ---- 53
Figure 27: PM_{10} Concentration against Time hour during Pre-Lockdown – Cluster 2 ---- 53
Figure 28: PM_{10} Concentration against Time hour during Lockdown – Cluster 2 ---- 54
Figure 29: PM_{10} Concentration against Time hour during Pre-Lockdown – Cluster 3 ---- 54
Figure 30: PM_{10} Concentration against Time hour during Lockdown – Cluster 3 ---- 55
Figure 31: $PM_{2.5}$ Pre Lockdown - Cluster 1 ---- 56
Figure 32: $PM_{2.5}$ During Lockdown - Cluster 1 ---- 56
Figure 33: $PM_{2.5}$ Pre Lockdown - Cluster 2 ---- 57
Figure 34: $PM_{2.5}$During Lockdown - Cluster 2 ---- 57
Figure 35: $PM_{2.5}$ During Pre lockdown - Cluster 3 ---- 58
Figure 36: $PM_{2.5}$ During Lockdown - Cluster 3 ---- 58
Figure 37: $PM_{2.5}$ as percent of PM_{10} ---- 59

Table of Tables

Table 1: District Demography of Monitoring cities 5
Table 2: Details of Monitoring Locations 6
Table 3: AQI during pre-lockdown and Lockdown 9
Table 4: Frequency of Pollutant Parameters During Study Course 11
Table 5: Day wise AQI at Monitoring Location During Pre-lockdown 18
Table 6: Day wise AQI at Monitoring Location During Lockdown 19
Table 7: Change in Air Pollutants Concentration During Lockdown Period 23
Table 8: Station wise Data Summary of Ambient Parameters 27
Table 9: Correlation Analysis of PM_{10} and $PM_{2.5}$ 44
Table 10: Crest and trough time PM_{10} 55
Table 11: Crest and Trough time of $PM_{2.5}$ 59

1. Preamble

The pandemic lockdown across the country due to COVID-19, imposed in consecutive phases from 25.03.2020 to 17.05.2020, brought the country to a standstill with all industrial activities coming to a total halt, cancellation of all means of transport, viz. railways, airways, roadways etc., shutting of all kind of business activities, ban on all types of construction activities and closure of all government and private offices and institutions. Only emergency services were active to handle the terrible crisis. This pandemic has casted a global gloom by causing severe damage to health, economy and general societal well-being.

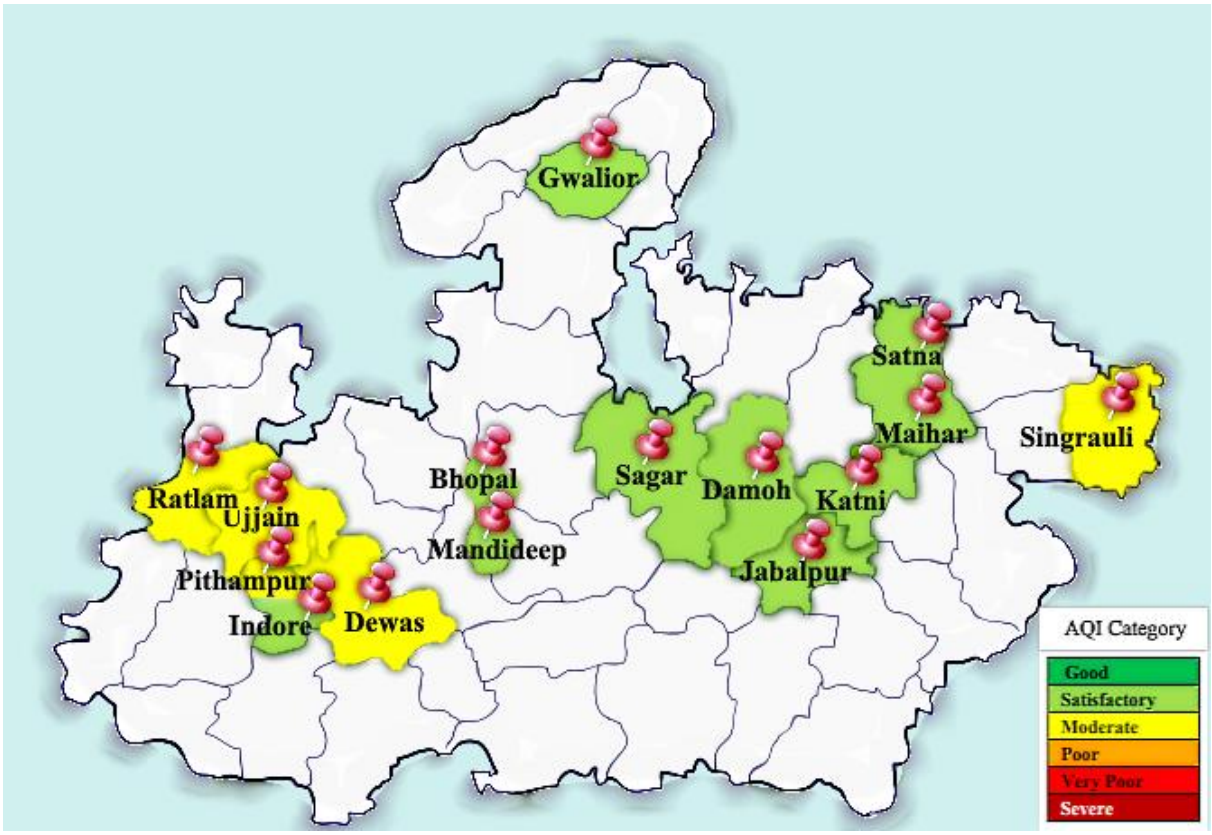
Despite nationwide grim picture due to lockdown there are few positive sides too and, among them, the environment segment appears to have emerged as the most benefitted one. The lockdown has given opportunity to identify the key drivers of air pollutants across the country which would later help the policy makers to take necessary measures to limit them. The lockdown period is also helpful to know the background levels of air pollutants in times when the emissions from most sectors, including transport and industrial sector, have significantly reduced. The lockdown measures resulted in sharp reduction in road traffic, air traffic, commercial and industrial activities. This led to a reduction in emissions of air pollutants, such as nitrogen oxides, sulphur dioxide, carbon dioxide, carbon monoxide, ozone and particulate matters. This is another fact that the decline in air pollutants goes hand in hand with the decrease in economic activity which has a direct impact on the society and the country as a whole.

The lockdown brought a dejected and gloomy picture for everyone but, accepting this situation too as an opportunity, the Environment Surveillance Centre, M.P. Pollution Control Board carried out study on ambient air quality in the State to assess and compare the pollution scenario before and during lockdown period for future environment planning. The monitoring work was carried out at 15 locations in the State thus each monitoring station covering an average population of about 5.5 million people. Total population of the State is ~82 million and the area of the State is 289 sq.km. Considering the large area the number of monitoring locations may not present the actual representative picture of air pollution of entire State but it is close to that. The observations and the inferences of this study may be integrated with policy and planning related issues to plan the combat actions against the air pollution.

2. Objective of the Study

The purpose of this report is to present the status of air quality during pandemic lockdown in different areas of the State, with respect to criteria pollutants as listed in the GoI Notification G.S.R. 826 E dated 16/11/2009, and its comparison with the air quality observed on the same locations during pre-lockdown period. The outcome would be helpful to the city planners and the policy makers in formulating future strategy.

The outcome of the study would also be helpful to understand if there is any need to revise the criteria of background concentration of ambient air parameters and raise the baseline data value for reference studies. The clean air scenario during lockdown is a very short lived and temporary phase the country has observed but it has paved a clear way to plan future strategies and planning so that the country can maintain the same clean air status in future. The cleaner environment during lockdown promises that if the norms of emissions are made stringent, the air quality can be achieved to a high standard.



Map showing Study Locations and AQI during Lockdown in the State

3. The Study Course

3.1. The State

The Madhya Pradesh State, with an area of 3,08,000 km^2, is geographically located in the central part of India within the latitude 23°47'33"N, and longitude 77°94'79''E. As of 2011, the State inhabitates72.6 million people with a population density of 236/km^2, thus becoming the second most populous State in the country. It has 52 districts with presence of 6 Zonal offices, 17 Regional offices, 1 Sub-regional officeand a Central Laboratory of Madhya Pradesh Pollution Control Board. The Demography of monitoring cities of the present study is depicted in Table 1.

S.No.	Monitoring City	Population	Area (sq.km.)	Population Density
01	Bhopal	2,371,061	2772	855
02	Damoh	1,264,219	7306	173
03	Dewas	1,563,715	7020	223
04	Gwalior	2,032,036	5465	446
05	Indore	3,276,697	3898	841
06	Jabalpur	2,463,289	5210	473
07	Katni	1,292,042	4947	261
08	Maihar	2,228,935	7502	297
09	Mandideep	1,331,597	8466	157
10	Pithampur	2,185,793	8153	268
11	Ratlam	1,455,069	4861	299
12	Sagar	2,378,458	10252	232
13	Satna	2,228,935	7502	297
14	Singrauli	1,178,273	5672	208
15	Ujjain	1,986,864	6091	326

Table 1: District Demography of Monitoring cities

3.2. Monitoring Protocol

The present study was carried out for 54 days during entire lockdown period from 25.03.2020 to 17.05.2020 at fifteen locations and the same was compared with study for equal number of days during pre-lockdown from 27.01.2020 to 20.03.2020 on the same locations. Details of locations are shown in Table 2.

S.No.	City	Location	Coordinate
01	Bhopal	T T Nagar	23°14'00.9"N 77°24'02.1"E
02	Damoh	Shrivastav Colony	23°49'03.0"N 79°26'46.5"E
03	Dewas	Bhopal Chauraha	22°58'05.7"N 76°03'50.8"E
04	Gwalior	City Center	26°12'12.4"N 78°11'35.7"E
05	Indore	Chhoti Gwaltoli	22°43'09.7"N 75°52'11.6"E
06	Jabalpur	Marhatal	23°10'07.0"N 79°55'56.1"E
07	Katni	Gole Bazar	23°50'02.8"N 80°23'25.4"E
08	Maihar	Sahilara	24°15'40.7"N 80°43'23.4"E
09	Mandideep	Sector-D Industrial Area	23°06'30.4"N 77°30'41.1"E
10	Pithampur	Sector-2 Industrial Area	22°37'29.1"N 75°40'30.9"E
11	Ratlam	Shasthri Nagar	23°19'54.2"N 75°02'45.5"E
12	Sagar	Deen Dayal Nagar	23°51'50.5"N 78°48'10.4"E
13	Satna	Bandhavgar Colony	24°35'03.6"N 80°51'17.8"E
14	Singrauli	Surya Kiran Bhawan	24°06'32.3"N 82°38'44.1"E
15	Ujjain	Mahakaleshwar Temple	23°10'57.8"N 75°46'05.6"E

Table 2: Details of Monitoring Locations

The monitoring was performed on round-the-clock basis uninterruptedly using continuous ambient air quality monitoring systems (CAAQMS). The near-surface measurement of criteria pollutants was done using online real-time analyzers. The measurement principles and calibration procedure were followed as per the standard norms prescribed by the CPCB. A regular check of zero settings on daily basis and span checks on weekly basis was done for better performance of trace gas analyzers and reliability of data. This data is converted into digital values and transmitted to the Central Server location. The averaged value of a time interval of 15 minute has been recorded for each parameter for analysis purpose.

3.3. The Criteria Pollutants

The criteria pollutants which are responsible for causing serious health and environmental hazards were considered for the present study. The CPCB has set

ambient air quality standards for all the parameters based on human health and environment criteria. A total of eight parameters were monitored during the course, viz. Particulate Matters, i.e. PM_{10}&$PM_{2.5}$, Nitrogen oxide (NO_x), Sulphur dioxide (SO_2), Ozone (O_3), Carbon monoxide (CO), and Ammonia (NH_3).Besides, the meteorological parameters, viz. Wind speed, Temperature were also observed and used for interpretation and correlation with ambient air data.

3.4. The Study Duration

The analysis of observed data and interpretation using meteorological parameters has been presented in this report. A comparison of air quality of 54 days during lock down period, i.e. 25.03.2020 to 17.05.2020, has been made with the air quality of previous 54 days, i.e. pre-lockdown period from 27.01.2020 to 20.03.2020, based on the availability of data.

4. Observations

4.1. Air Quality Index

The AQI is used for effective communication of air quality status to the common people in terms which are easy to understand. It transforms complex air quality data of various pollutants into a single number (index value), nomenclature and colour. The AQI has been categorized into six categories, viz. Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe. Each of these categories is decided on the basis of ambient concentration of air pollutants and their likely health impacts.

An overall improvement was noticed in the ambient air quality at all the stations during the lockdown period. This was obvious due to shutdown of all the activities, specially the movement of vehicles, operation of industries etc which directly influence the air quality. The Air Quality Index (AQI) tool has been used to present the air quality scenario.

Looking to overall AQI share at all the stations during pre-lockdown period the Good category was observed 2%, Satisfactory category was 31.7%, Moderate category 60.4%, Poor category 4% and 1.6% under Very Poor category. An improvement in AQI was noticed during lockdown with 13% observations in Good category, 52.5% in Satisfactory category, 31.8% in Moderate category, 2%

in Poor category and 0.14% in very poor category. No instance was recorded under Severe category during lockdown as seen in Fig.1.

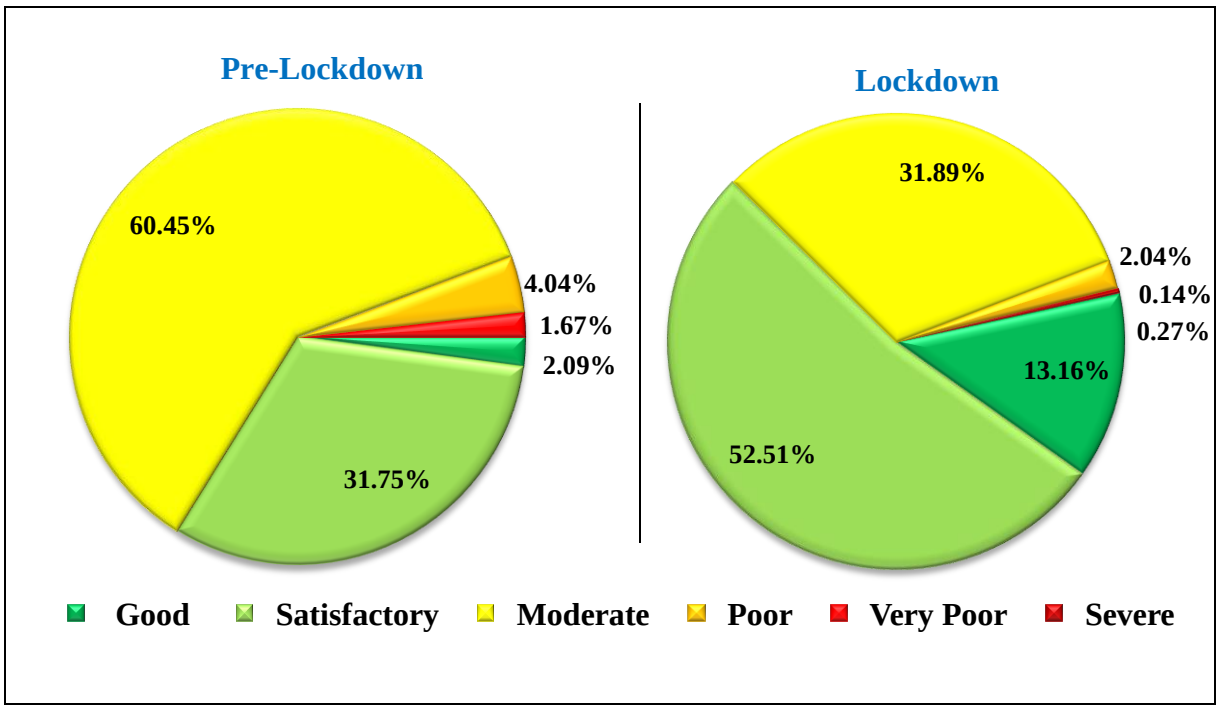


Figure 1: State wide AQI Categories During Study Period

The overall State level AQI during pre-lockdown period was 119 whereas it was 90.1 during lockdown which shows that the AQI dropped from Moderate to Satisfactory category as shown in Fig. 1 and Tab. 3.

Station wise Decline in AQI During Lockdown				
Sr. No.	**Station**	**Pre Lockdown-AQI**	**Lockdown-AQI**	**AQI % Decline**
1	Bhopal	122.1	97.9	19.8
2	Damoh	89.7	55.0	38.7
3	Dewas	111.1	106.5	4.2
4	Gwalior	139.1	94.2	32.3
5	Indore	126.9	98.4	22.4
6	Jabalpur	129.8	84.1	35.2
7	Katni	139.5	96.3	31.0
8	Maihar	60.3	58.3	3.3
9	Mandideep	106.5	52.3	50.9
10	Pithampur	120.1	104.8	12.7
11	Ratlam	120.3	102.8	14.6
12	Sagar	74.5	55.9	24.9
13	Satna	157.9	80.4	49.1
14	Singrauli	173.8	160.3	7.8
15	Ujjain	113.2	103.5	8.6
		119.0	**90.1**	**24.3**

Table 3: AQI during Pre-lockdown and Lockdown

4.2. The Highest and the Lowest AQI Locations

The three stations which recorded the highest AQI during pre-lockdown included Singrauli with 174 followed by Satna with AQI of 158 and Katni with an AQI of 139. The prominent pollutant which contributed to the AQI during this period at Singrauli was noticed to be $PM_{2.5}$ whereas PM_{10} was dominant at Katni and Satna location. During lockdown the top three cities, with respect to AQI, were Singrauli 160 followed by Dewas 106 and Pithampur 105. The prominent pollutant at all the three stations, viz. Singrauli, Dewas and Pithampur, was noticed to be PM_{10}. Similarly the lowest AQI during pre-lockdown was observed at Maihar with 60, Sagar with 74 and Damoh with 90. The lowest AQI during lockdown was 52 at Mandideep, 55 at Damoh and 56 at Sagar. This is shown in Fig. 2, 4 and Tab. 3, 4.

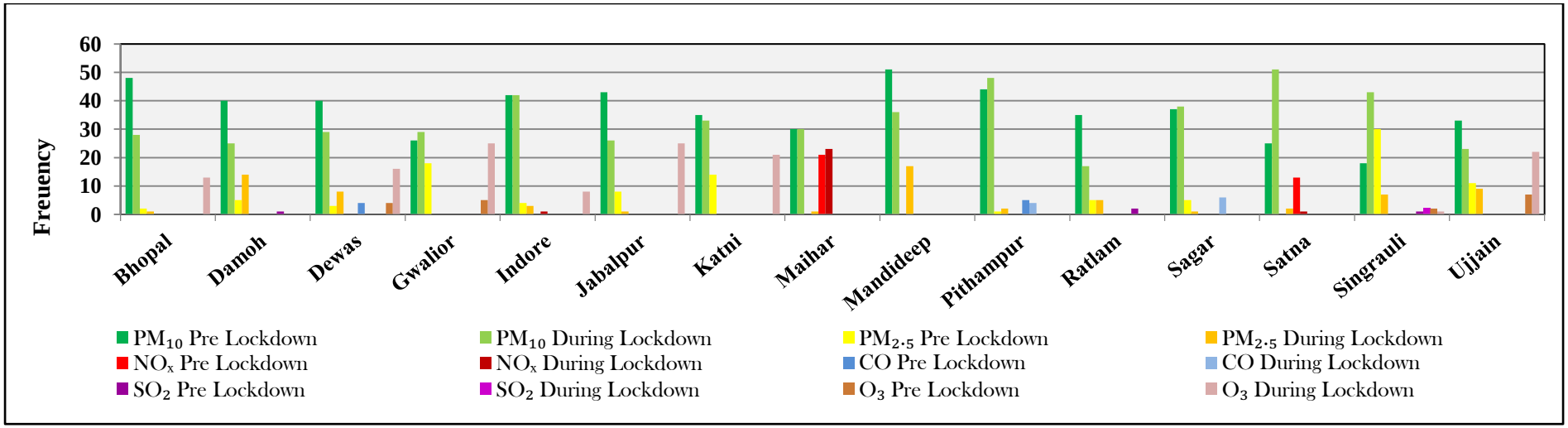


Figure 2: Frequency of Prominent AQI Pollutants

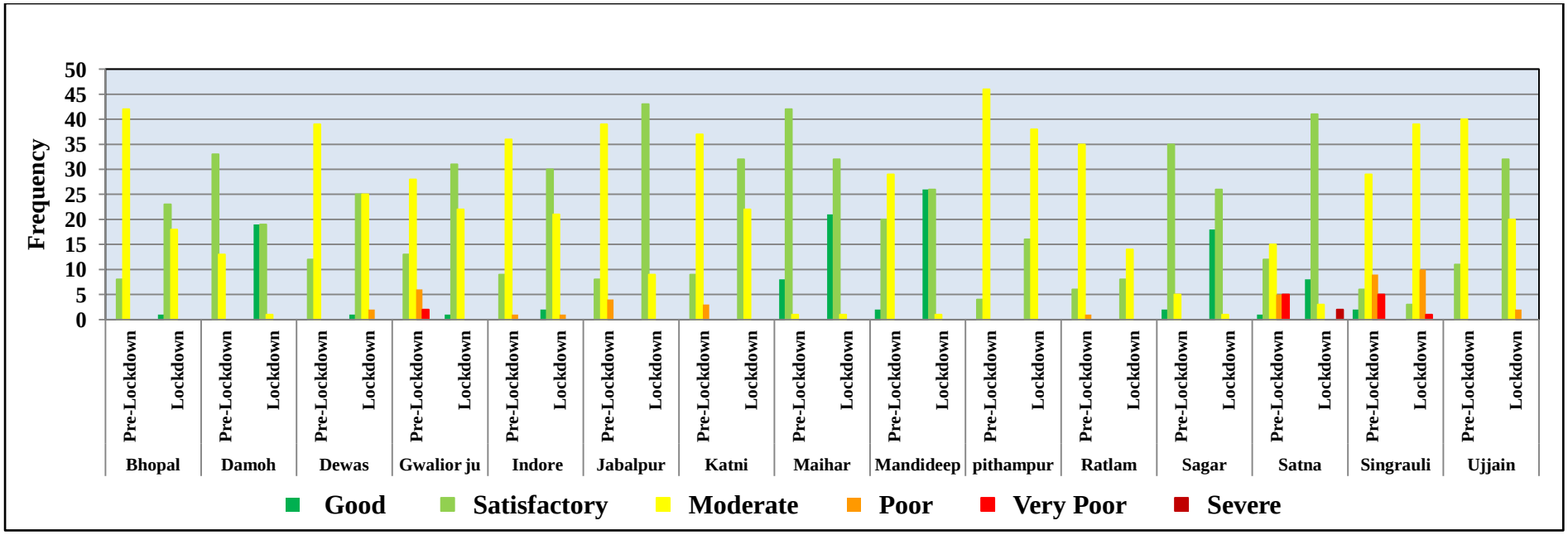


Figure 3: Frequency of AQI Categories During Study Period

Pre Lockdown									
S. No.	**Station**	**PM_{10}**	**$PM_{2.5}$**	**NO_x**	**CO**	**SO_2**	**NH_3**	**O_3**	**Operational days (54)**
1	Bhopal	48	2	-	-	-	-	-	50
2	Damoh	40	5	-	-	1	-	-	46
3	Dewas	40	3	-	4	-	-	4	51
4	Gwalior	26	18	-	-	-	-	5	49
5	Indore	42	4	-	-	-	-	-	46
6	Jabalpur	43	8	-	-	-	-	-	51
7	Katni	35	14	-	-	-	-	-	49
8	Maihar	30	-	21	-	-	-	-	51
9	Mandideep	51	-	-	-	-	-	-	51
10	Pithampur	44	1	-	5	-	-	-	50
11	Ratlam	35	5	-	-	2	-	-	42
12	Sagar	37	5	-	-	-	-	-	42
13	Satna	25	-	13	-	-	-	-	38
14	Singrauli	18	30	-	-	1	-	2	51
15	Ujjain	33	11	-	-	-	-	7	51
State wide		**547**	**106**	**34**	**9**	**4**	**0**	**18**	**718/810**
During Lockdown									
S. No.	**Station**	**PM_{10}**	**$PM_{2.5}$**	**NO_x**	**CO**	**SO_2**	**NH_3**	**O_3**	**Operational days (54)**
1	Bhopal	28	1	-	-	-	-	13	42
2	Damoh	25	14	-	-	-	-	-	39
3	Dewas	29	8	-	-	-	-	16	53
4	Gwalior	29	-	-	-	-	-	25	54
5	Indore	42	3	1	-	-	-	8	54
6	Jabalpur	26	1	-	-	-	-	25	52
7	Katni	33	-	-	-	-	-	21	54
8	Maihar	30	1	23	-	-	-	-	54
9	Mandideep	36	17	-	-	-	-	-	53
10	Pithampur	48	2	-	4	-	-	-	54
11	Ratlam	17	5	-	-	-	-	-	22
12	Sagar	38	1	-	6	-	-	-	45
13	Satna	51	2	1	-	-	-	-	54
14	Singrauli	43	7	-	-	2	-	1	53
15	Ujjain	23	9	-	-	-	-	22	54
State wide		**498**	**71**	**25**	**10**	**2**	**0**	**131**	**737/810**

Table 4: Frequency of Pollutant Parameters During Study Course

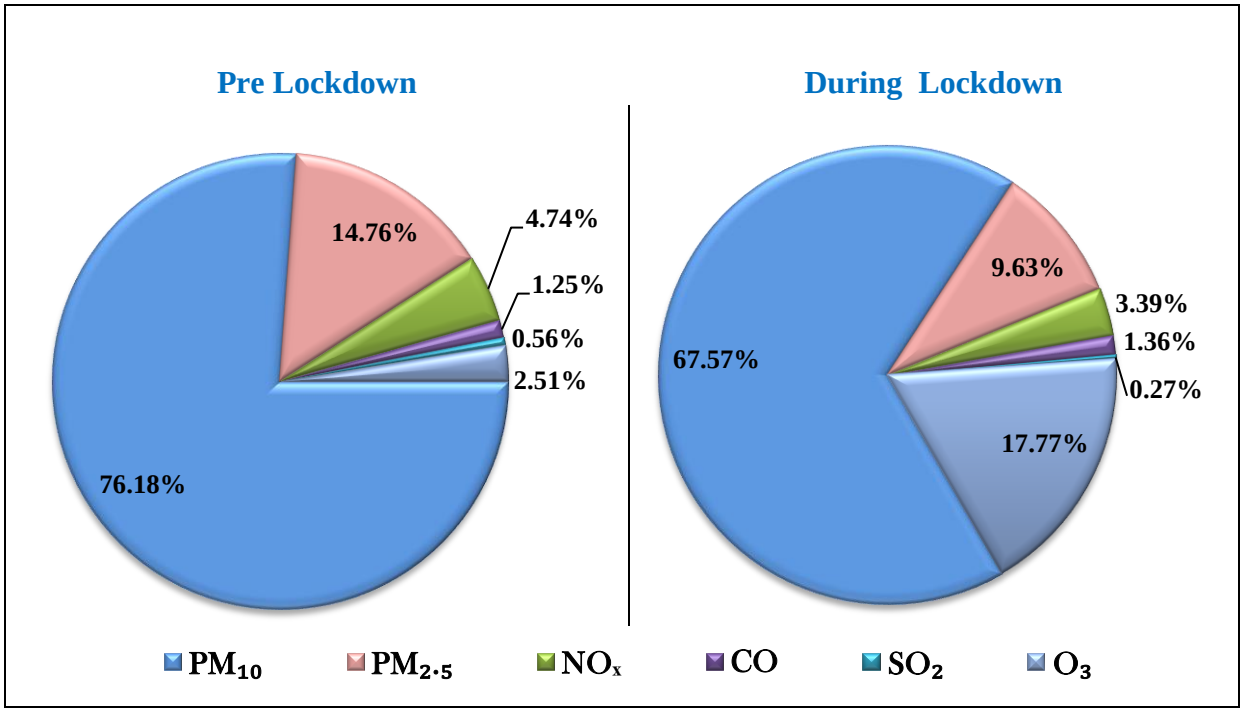


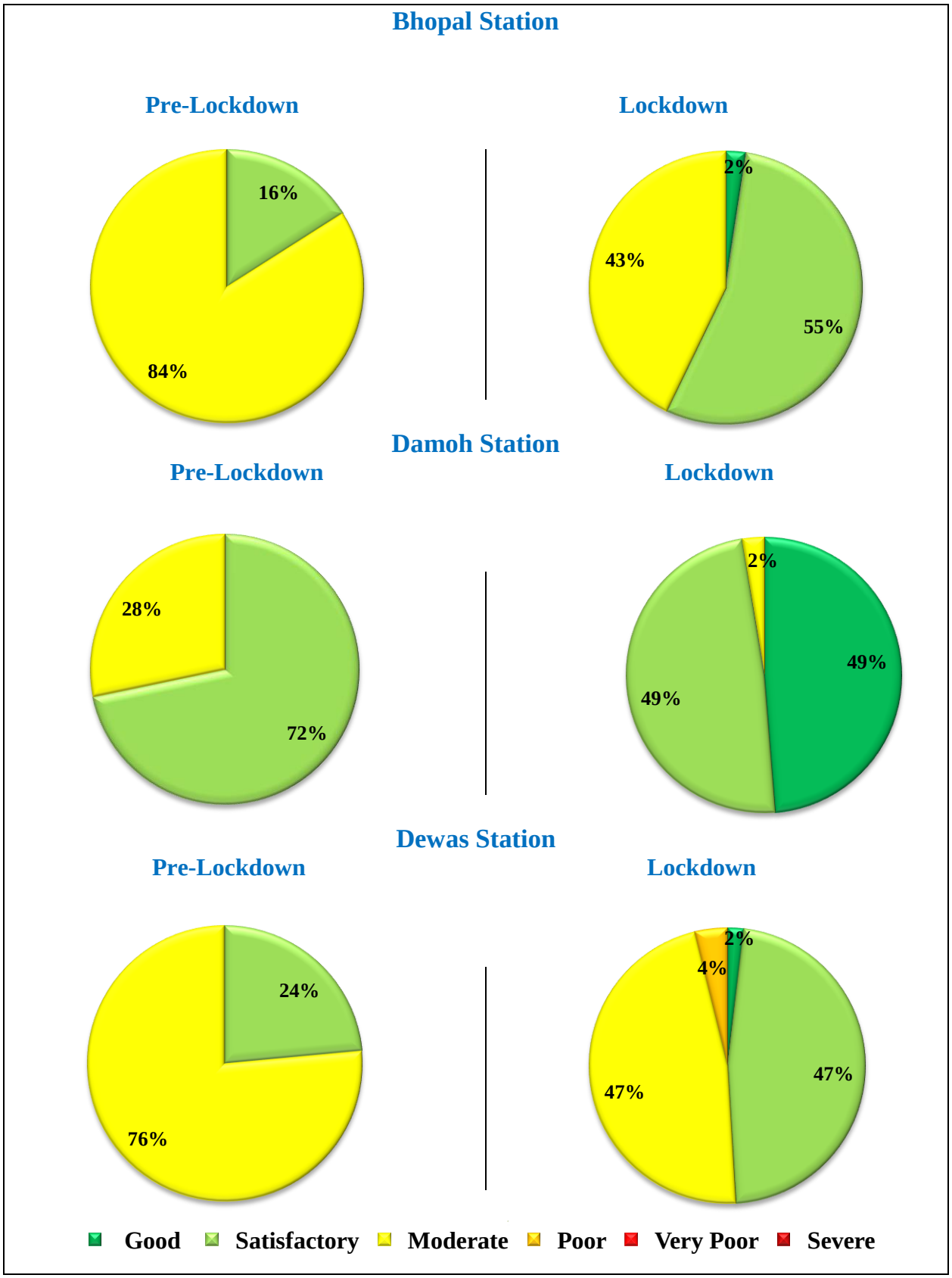
Figure 4: Percentage of AQI Pollutants

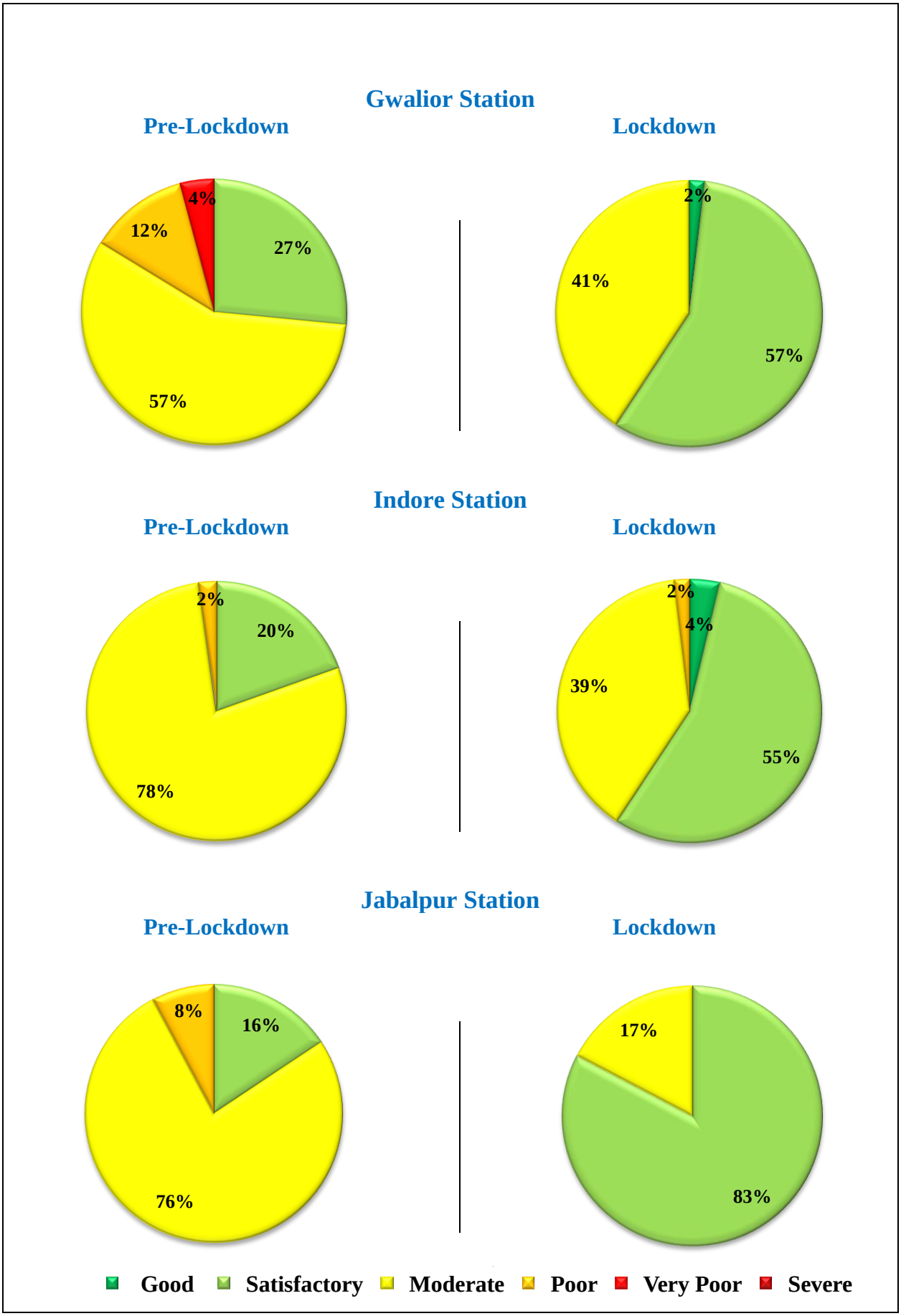
Among the top three stations which observed highest decline in AQI during the entire study span were Mandideep with 50.9% followed by Satna with 49.1% and Jabalpur noticed a drop in AQI by 35.2%. Day-wise AQI details are depicted in Table 5-6 and station-wise and other AQI details are shown in Fig. 1, 3 and 5.

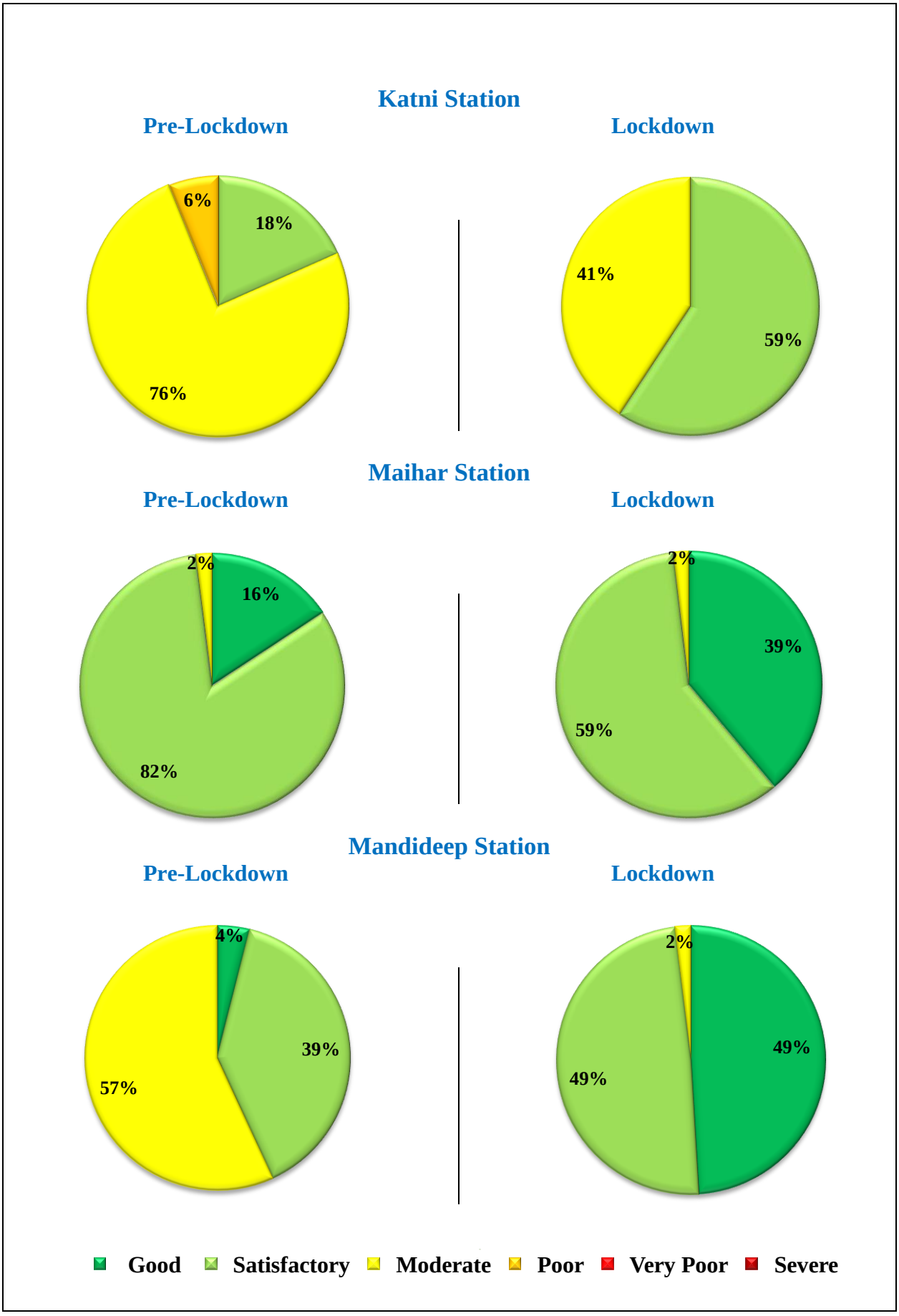
4.3. Prominent Pollutant

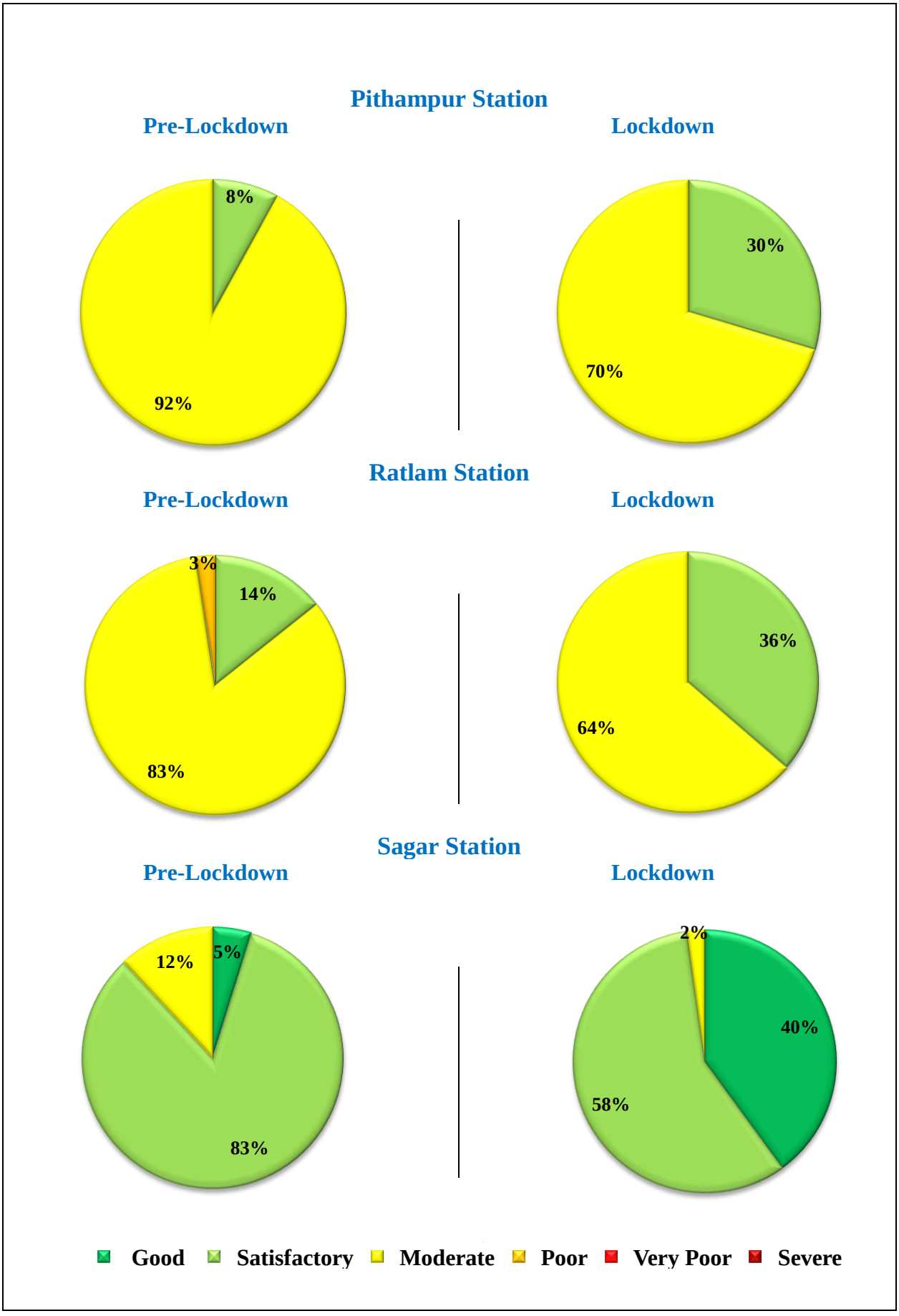
As far as prominent pollutant contributing to the AQI is concerned, the PM_{10} was responsible for 76.1% times during pre-lockdown and 67.6% during lockdown. The contribution of $PM_{2.5}$ as prominent pollutant was noticed 14.8 % during pre-lockdown and 9.6% during lockdown. The NO_x was also observed as dominating parameter for AQI. This contributed 4.7% during pre-lockdown and 3.4% during lockdown period. The Ozone was also noticed as prominent parameter for AQI with 2.5% during pre-lockdown and 17.8% during lockdown time. Sulphur dioxide and Carbon monoxide contributed approx. 1% as prominent pollutant in AQI as shown in Fig. 4.

Figure 5: Percentage of AQI Categories During Study Period




Gwalior Station
Pre-Lockdown
Lockdown
4%
12%
27%
57%
2%
41%
57%
Indore Station
Pre-Lockdown
Lockdown
2%
20%
78%
2%
4%
39%
55%
Jabalpur Station
Pre-Lockdown
Lockdown
8%
16%
76%
17%
83%
Good
Satisfactory
Moderate
Poor
Very Poor
Severe


Katni Station
Pre-Lockdown
Lockdown
6%
18%
76%
41%
59%
Maihar Station
Pre-Lockdown
Lockdown
2%
16%
82%
2%
39%
59%
Mandideep Station
Pre-Lockdown
Lockdown
4%
39%
57%
2%
49%
49%
Good
Satisfactory
Moderate
Poor
Very Poor
Severe


Pithampur Station
Pre-Lockdown
Lockdown
8%
92%
30%
70%
Ratlam Station
Pre-Lockdown
Lockdown
3%
14%
83%
36%
64%
Sagar Station
Pre-Lockdown
Lockdown
12%
5%
83%
2%
40%
58%
Good
Satisfactory
Moderate
Poor
Very Poor
Severe

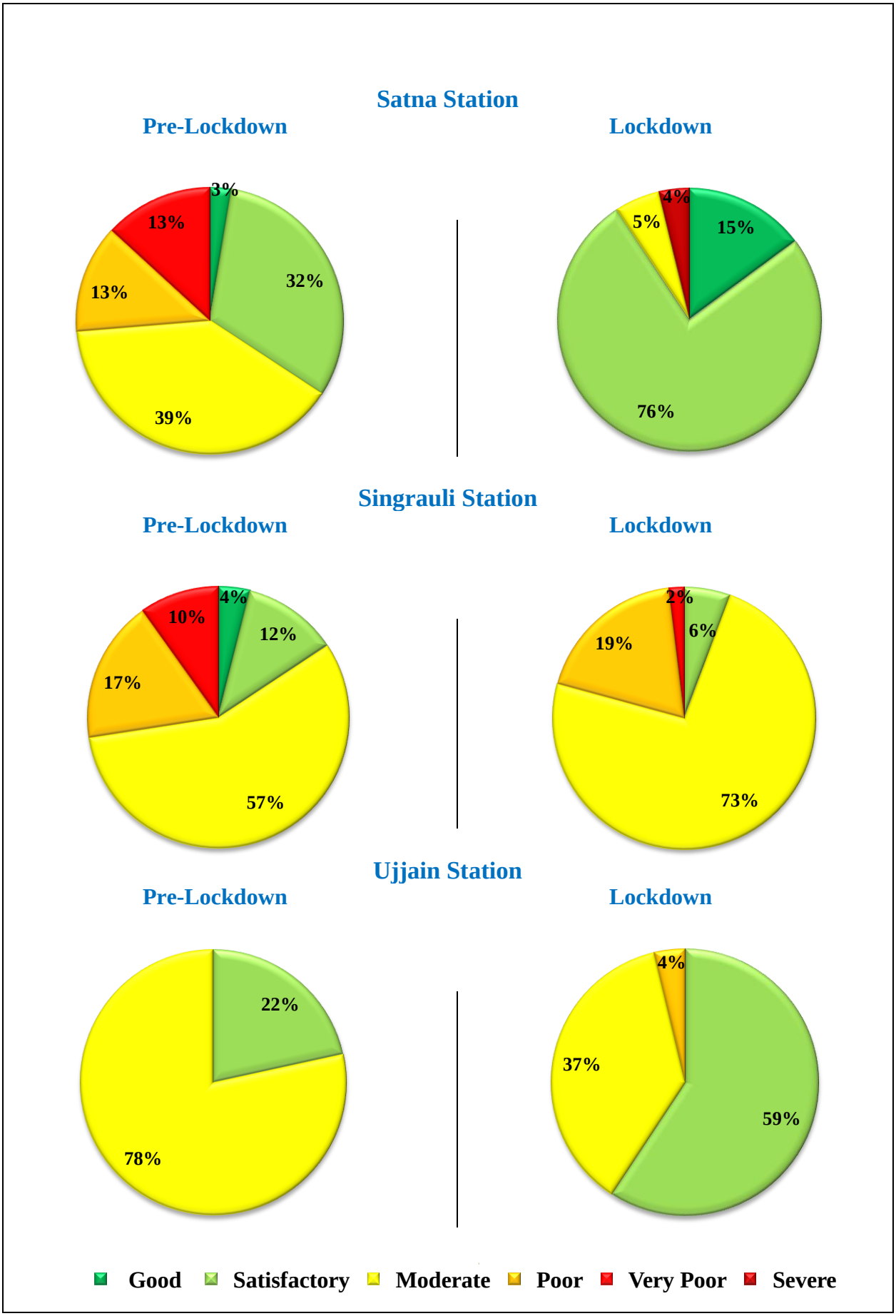

Satna Station
Pre-Lockdown
3%
13%
32%
13%
39%
Lockdown
4%
5%
15%
76%
Singrauli Station
Pre-Lockdown
4%
10%
12%
17%
57%
Lockdown
2%
6%
19%
73%
Ujjain Station
Pre-Lockdown
22%
78%
Lockdown
4%
37%
59%
Good
Satisfactory
Moderate
Poor
Very Poor
Severe

Table 5: Day wise AQI at Monitoring Location During Pre-lockdown

Date	Bhopal	Damoh	Dewas	Gwalior	Indore	Jabalpur	Katni	Maihar	Mandideep	Pithampur	Ratlam	Sagar	Satna	Singrauli	Ujjain
27-01-2020	155	77	101	116	-	111	171	45	132	98	119	79	-	329	107
28-01-2020	129	73	120	113	-	125	114	58	133	134	113	83	-	242	104
29-01-2020	117	80	116	219	123	136	146	70	100	133	117	-	295	283	105
30-01-2020	113	90	99	140	91	115	-	84	82	120	-	-	258	143	85
31-01-2020	-	79	89	-	93	106	-	74	116	110	103	89	172	152	83
01-02-2020	96	-	85	109	84	123	147	64	106	117	97	71	129	188	95
02-02-2020	90	-	75	-	74	125	173	80	91	99	102	-	-	153	83
03-02-2020	105	-	80	204	96	119	121	83	91	102	102	-	128	330	92
04-02-2020	119	83	95	203	132	171	151	102	108	111	124	-	118	303	100
05-02-2020	124	94	104	307	109	251	180	71	104	126	112	63	115	163	105
06-02-2020	113	81	108	262	-	115	121	55	97	126	137	60	76	261	104
07-02-2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
08-02-2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
09-02-2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-02-2020	109	106	103	313	114	149	187	61	91	106	112	75	151	329	107
11-02-2020	103	71	101	227	113	157	189	86	90	123	111	62	119	301	103
12-02-2020	138	-	87	156	124	204	269	68	127	116	117	70	154	237	106
13-02-2020	186	108	93	157	158	162	200	52	154	120	137	102	229	157	161
14-02-2020	149	97	115	126	223	184	162	55	175	116	210	79	342	132	136
15-02-2020	152	101	128	116	124	175	193	62	126	124	142	77	371	141	126
16-02-2020	127	118	104	131	83	140	174	45	131	109	111	94	146	186	105
17-02-2020	123	114	65	168	94	134	169	51	137	102	108	125	384	179	130
18-02-2020	121	109	84	141	134	140	229	49	144	92	109	118	269	214	135
19-02-2020	124	98	109	120	172	106	141	50	142	92	151	106	175	258	135
20-02-2020	130	100	125	111	158	115	123	57	144	126	159	61	-	211	144
21-02-2020	135	78	124	130	135	111	132	64	108	144	152	76	-	200	120
22-02-2020	134	105	117	210	127	135	171	81	112	142	136	77	-	293	114
23-02-2020	164	132	128	197	114	202	243	75	102	129	123	64	281	175	123
24-02-2020	124	100	102	184	108	201	199	59	94	109	139	65	310	95	102
25-02-2020	122	-	116	178	121	114	121	50	119	121	125	78	325	146	133
26-02-2020	156	96	112	144	186	141	142	54	139	125	131	103	-	147	126
27-02-2020	139	116	140	101	153	148	102	51	151	128	152	63	-	145	139
28-02-2020	128	125	102	110	126	147	100	51	131	126	113	58	-	179	137
29-02-2020	154	117	126	97	141	140	120	53	164	-	-	71	-	233	122
01-03-2020	136	105	147	84	176	111	89	52	108	126	-	41	-	177	148
02-03-2020	103	54	130	80	163	80	109	50	87	119	-	36	-	70	119
03-03-2020	118	81	130	93	147	124	100	61	118	134	-	58	-	143	110
04-03-2020	133	79	150	77	130	124	93	54	125	141	-	56	84	168	105
05-03-2020	126	86	138	73	142	132	107	57	122	144	125	73	91	129	115
06-03-2020	135	62	142	80	142	139	106	54	115	139	121	85	84	80	127
07-03-2020	125	100	123	70	128	136	133	59	94	141	118	83	84	92	85
08-03-2020	88	79	80	92	80	109	107	63	51	106	87	-	94	118	93
09-03-2020	80	73	84	114	74	100	128	48	64	108	85	-	105	90	91
10-03-2020	85	72	104	124	136	97	100	62	41	105	96	-	81	161	108
11-03-2020	80	58	113	79	-	56	61	56	47	108	122	-	51	65	87
12-03-2020	90	92	113	97	-	105	114	56	59	108	-	52	68	104	89

13-03-2020	116	61	119	96	122	98	100	56	80	115	-	66	69	48	111
14-03-2020	123	70	133	74	138	93	66	50	88	138	-	71	46	46	126
15-03-2020	133	92	127	113	130	111	86	56	73	127	108	80	64	119	119
16-03-2020	125	102	116	125	110	119	124	55	74	119	98	74	109	121	108
17-03-2020	106	84	117	162	109	115	124	53	83	129	99	81	115	130	113
18-03-2020	99	93	110	151	129	107	149	55	67	119	105	71	127	155	107
19-03-2020	114	63	108	139	130	96	132	55	93	123	114	69	116	156	123
20-03-2020	109	70	129	104	141	68	116	65	104	130	110	62	66	188	124
Summary Value															
Good	0	0	0	0	0	0	0	8	2	0	0	2	1	2	0
Satisfactory	8	33	12	13	9	8	9	42	20	4	6	35	12	6	11
Moderate	42	13	39	28	36	39	37	1	29	46	35	5	15	29	40
Poor	0	0	0	6	1	4	3	0	0	0	1	0	5	9	0
Very-Poor	0	0	0	2	0	0	0	0	0	0	0	0	5	5	0
Severe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Summary Percentage															
Good	0%	0%	0%	0%	0%	0%	0%	15%	4%	0%	0%	4%	2%	4%	0%
Satisfactory	15%	61%	22%	24%	17%	15%	17%	78%	37%	7%	11%	65%	22%	11%	20%
Moderate	78%	24%	72%	52%	67%	72%	69%	2%	54%	85%	65%	9%	28%	54%	74%
Poor	0%	0%	0%	11%	2%	7%	6%	0%	0%	0%	2%	0%	9%	17%	0%
Very-Poor	0%	0%	0%	4%	0%	0%	0%	0%	0%	0%	0%	0%	9%	9%	0%
Severe	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Good Satisfactory Moderate Poor Very Poor Severe

Table 6: Days wise AQI at Monitoring Location During Lockdown

Date	Bhopal	Damoh	Dewas	Gwalior	Indore	Jabalpur	Katni	Maihar	Mandideep	Pithampur	Ratlam	Sagar	Satna	Singrauli	Ujjain
25-03-2020	68	65	100	100	76	77	86	71	46	83	79	57	70	142	74
26-03-2020	66	33	77	70	53	57	62	73	26	53	-	28	42	124	86
27-03-2020	41	-	33	49	34	60	66	78	24	57	-	31	54	247	59
28-03-2020	-	-	-	57	39	51	51	56	23	55	-	23	32	108	60
29-03-2020	-	-	80	67	53	57	65	61	27	57	-	26	44	104	72
30-03-2020	-	-	63	73	64	66	67	68	32	58	-	32	51	127	68
31-03-2020	-	-	82	67	70	70	76	75	34	69	74	38	46	114	68
01-04-2020	-	-	86	77	81	71	64	65	40	90	80	44	53	174	85
02-04-2020	-	-	84	62	85	103	92	40	39	95	-	49	62	173	84
03-04-2020	-	-	69	66	63	67	67	34	32	79	-	44	49	143	75
04-04-2020	-	-	72	67	73	72	80	71	37	81	-	43	55	200	73
05-04-2020	-	78	72	73	74	71	87	84	37	88	-	38	57	221	87
06-04-2020	-	71	83	89	91	-	91	61	52	115	-	48	63	172	104
07-04-2020	-	115	108	107	97	-	86	44	44	106	107	66	68	218	108
08-04-2020	104	40	111	119	105	86	81	40	-	117	-	63	60	159	102
09-04-2020	106	38	123	102	126	88	90	38	53	125	-	68	59	136	119
10-04-2020	101	35	123	88	124	110	111	54	67	121	-	61	61	186	144
11-04-2020	97	43	127	97	219	90	139	44	76	152	-	54	76	227	179

12-04-2020	-	49	171	122	177	111	127	55	78	146	-	71	78	201	130
13-04-2020	94	40	141	113	169	108	122	49	60	131	-	66	82	228	127
14-04-2020	115	38	177	107	145	89	132	46	64	131	-	76	91	237	240
15-04-2020	94	39	216	121	147	70	108	40	63	134	-	52	73	175	202
16-04-2020	111	49	201	114	105	81	123	42	69	110	90	52	64	156	102
17-04-2020	122	58	159	126	107	132	134	62	75	110	97	-	115	200	89
18-04-2020	107	44	198	132	124	118	116	48	65	112	87	-	112	306	117
19-04-2020	120	48	110	122	100	87	110	43	62	107	104	-	84	147	103
20-04-2020	120	59	108	80	84	89	151	77	85	103	97	-	118	164	158
21-04-2020	110	38	106	64	118	113	108	77	63	124	-	-	67	124	151
22-04-2020	101	-	111	75	132	104	94	97	63	119	-	-	81	163	199
23-04-2020	109	-	96	96	106	90	112	99	81	111	-	-	403	135	181
24-04-2020	114	-	85	71	87	91	91	102	82	103	101	-	545	264	102
25-04-2020	116	-	115	91	107	83	89	97	55	121	130	-	86	109	123
26-04-2020	127	49	98	96	103	80	86	80	85	116	126	51	32	81	114
27-04-2020	82	38	75	99	97	79	89	64	39	109	-	53	31	100	88
28-04-2020	86	46	66	112	76	65	89	76	52	75	-	36	47	104	93
29-04-2020	174	64	89	113	96	73	86	83	101	101	-	71	56	152	93
30-04-2020	96	54	106	93	107	79	90	55	79	112	-	61	64	174	107
01-05-2020	107	66	97	123	95	77	81	53	59	117	-	69	61	121	90
02-05-2020	86	80	78	109	76	102	100	54	53	105	-	96	58	128	95
03-05-2020	84	-	105	98	102	100	106	57	45	119	-	82	63	137	96
04-05-2020	120	82	117	78	102	98	107	44	62	119	-	62	62	131	102
05-05-2020	88	42	105	97	79	79	85	24	37	116	113	52	55	88	74
06-05-2020	88	72	107	90	108	76	79	34	53	138	135	80	60	-	96
07-05-2020	76	47	78	87	98	74	74	42	44	93	112	43	64	124	80
08-05-2020	93	71	96	101	103	82	107	59	58	119	107	68	68	120	90
09-05-2020	96	58	110	110	89	74	103	38	46	112	103	103	66	129	84
10-05-2020	83	60	154	107	92	81	120	51	30	111	106	71	71	179	95
11-05-2020	98	-	115	90	115	88	93	31	23	61	-	26	59	126	79
12-05-2020	85	54	88	92	91	80	85	34	46	99	104	79	64	113	66
13-05-2020	87	58	83	82	91	83	88	49	40	112	93	80	71	120	82
14-05-2020	83	54	81	103	81	78	109	62	40	101	105	67	73	196	65
15-05-2020	81	43	107	118	92	79	113	49	48	117	-	47	72	236	80
16-05-2020	87	67	99	116	93	91	101	54	41	127	-	45	68	132	81
17-05-2020	88	60	101	111	93	95	129	66	39	119	111	44	74	223	69

Summary Value

Good	1	19	1	1	2	0	0	21	26	0	0	18	8	0	0
Satisfactory	23	19	25	31	30	43	32	32	26	16	8	26	41	3	32
Moderate	18	1	25	22	21	9	22	1	1	38	14	1	3	39	20
Poor	0	0	2	0	1	0	0	0	0	0	0	0	0	10	2
Very-Poor	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Severe	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0

Summary Percentage

Good	2%	35%	2%	2%	4%	0%	0%	39%	48%	0%	0%	33%	15%	0%	0%
Satisfactory	43%	35%	46%	57%	56%	80%	59%	59%	48%	30%	15%	48%	76%	6%	59%
Moderate	33%	2%	46%	41%	39%	17%	41%	2%	2%	70%	26%	2%	6%	72%	37%
Poor	0%	0%	4%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	19%	4%
Very-Poor	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%
Severe	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	0%	0%

Good Satisfactory Moderate Poor Very Poor Severe

4.4. Air Quality Assessment Using Exceedance Factor

In order to understand and present the pollution level, the air quality can be categorized into four broad criteria based on the exceedance factor (EF) which is determined by drawing the ratio of annual mean concentration of a pollutant and its respective standard. Accordingly, the air pollution can be categorized into following four categories :

i. Critical pollution (C) : EF ≥ 1.5;
ii. High pollution (H) : 1.0 ≤ EF < 1.5;
iii Moderate pollution (M) : 0.5 ≤ EF < 1.0; and
iv Low pollution (L) : EF < 0.5

Based on the data of criteria pollutant the exceedance factors have been calculated and shown fig. 6. It is evident from the figure that pollution level for SO_2 , NO_x,CO, NH_3 and ozone is low during pre-lockdown as well as lockdown period. The pollution level in case of $PM_{2.5}$ is moderate during both the monitoring periods. The pollution level of PM_{10} was high during pre-lockdown and in moderate level during lockdown time.

4.5. Comparative Status of Criteria Pollutants

An overall reduction in concentration of particulate matter, i.e. 28 % in PM_{10} and 27 % in $PM_{2.5}$, was observed during the lockdown period. Similarly in gaseous results a total reduction of 45 % in NO_x, 16% in SO_2, 31% in CO, 32% in NH_3 was observed cumulatively on all the monitoring stations. Contrary to other criteria pollutants the Ozone observed an overall increase of 22%cumulatively on all the monitoring stations. The decline in $PM_{2.5}$, NO_x, SO_2 and CO could be due to drastic reduction in vehicles on the road. The low value of PM_{10} might have been resulted primely due to traffic restrictions and less mobility on the roads and no construction activity.

The main contribution during this period was due to plying of emergency service vehicles, dust blowing due to surface winds, refuse burning etc. The decline in values of NH_3 and CO might have been due to reduction in refuse burning/municipal waste combustion and decline in the decomposition of organic waste due to reduction in overall quantity. The Singrauli station noticed lowest improvement amongst all the stations during lockdown with only 7.8% decline in AQI which could be due to influence of uninterrupted operation of major industries in this area. Details are shown in Table 7.

4.6. Ambient Parameters

4.6.1. Particulate Matters – PM_{10}

The trend shows that the concentration of PM_{10} was higher at all the locations in pre-lockdown period, as compared to lockdown period, without any exception. The value was observed between 16.0 $\mu g/m^3$ at Satna station to 308 $\mu g/m^3$ at Singrauli station among all the study locations during pre-lockdown. The value of PM_{10} was found to be in the range of 11.0 at Sagar to 297.5 $\mu g/m^3$ at Singrauli during lockdown period with 28% decline in overall concentration. The highest decline in concentration in PM_{10}value was observed to be 55% at Mandideep station followed by 44% at Jabalpur, 42% at Satna, 36% at Katni, 33% at Damoh and 32% at Gwalior. The other stations recorded less reduction during lockdown period. Exceptionally the Singrauli station recorded 2% increase in PM_{10} concentration during lockdown period. It was noticed that 62.2% of the total PM_{10} observations exceeded the prescribed norms during pre-lockdown. During lockdown the PM_{10} exceeded the prescribed daily norms 31.1% times. Refer table 7 and 8.

The highest 87 % of the total observations of PM_{10} at Katni were found to exceed the prescribed norms during pre-lockdown period. The Jabalpur station exceeded 83.3% and Singrauli station exceeded 81.5% of the total PM_{10} observations. Among the total monitored values of PM_{10} at Bhopal 79.6% results exceeded the prescribed norms whereas Indore observed 75.9% values of PM_{10} exceeding the norms. The lowest exceedance of PM_{10} was noticed at Maihar station with only 1.8% of the observations crossing the norms followed by Sagar which observed only 12.9% times the PM_{10} exceeded the limit. Similarly during lockdown period, the Singrauli station observed the highest 94.4% results of the total PM_{10} to exceed the norms. 70.4% of the total PM_{10} observations at Pithampur were above prescribed limits. There was no exceedance of PM_{10} value at Maihar and Mandideep location during the lockdown.

This PM_{10} parameter was 76.1% times prominent pollutant with 547 counts among total AQI observations during pre-lockdown period. During lockdown this parameter remained dominant for 67.6% times with 498 counts in all the AQI observations. Details are shown in table 4, 7 and 8.

S.No	Station	PM_{10}	$PM_{2.5}$	NO_x	CO	SO_2	NH_3	O_3
1	Bhopal	-30%	-23%	-69%	-39%	-27%	-7%	8%
2	Damoh	-33%	-43%	0%	0%	21%	-	-
3	Dewas	-18%	-6%	-33%	-18%	40%	-33%	34%
4	Gwalior JU	-32%	-52%	-71%	1%	-22%	-17%	6%
5	Indore	-30%	-38%	-41%	-50%	-37%	-42%	49%
6	Jabalpur	-44%	-42%	-61%	-49%	-24%	-17%	62%
7	Katni	-36%	-50%	-66%	-31%	-47%	-28%	47%
8	Maihar	-26%	-34%	-3%	3%	-1%	-	-
9	Mandideep	-55%	-19%	-64%	-29%	-19%	-54%	8%
10	Pithampur	-15%	-28%	-40%	-40%	-41%	-46%	-8%
11	Ratlam	-23%	13%	-60%	-	-68%	-	-
12	Sagar	-27%	-14%	-55%	-21%	22%	-	-
13	Satna	-42%	-27%	-39%	-53%	-45%	-	-
14	Singrauli	2%	-20%	-22%	-23%	21%	-6%	31%
15	Ujjain	-19%	-17%	-60%	-29%	-19%	-39%	-5%
	State wide	-28%	-27%	-45%	-31%	-16%	-32%	22%

Table 7: Change in Air Pollutants Concentration During Lockdown Period

4.6.2. Particulate Matters – $PM_{2.5}$

The trend shows that the concentration of $PM_{2.5}$ was higher at all the locations in pre-lockdown period, as compared to lockdown period, except at Ratlam station which noticed higher $PM_{2.5}$ concentration during lockdown period. The value was observed between 6.73 $\mu g/m^3$ at Satna station to 158.94 $\mu g/m^3$ at Singrauli station among all the study locations during pre-lockdown. The value of $PM_{2.5}$ was found to be in the range of 5.78 at Satna to 109.71 $\mu g/m^3$ at Singrauli during lockdown period with 27 % decline in overall concentration. The highest decline in concentration in PM12.5 value was observed to be 52% at Gwalior station followed by 50% at Katni, 43% at Damoh, 42% at Jabalpur, 38% at Indore and 34% at Maihar. The other stations recorded less reduction during lockdown period, exceptionally the Ratlam station which recorded 13% increase in $PM_{2.5}$ concentration during lockdown period. It was noticed that 21.1% of the total $PM_{2.5}$ observations exceeded the prescribed norms during pre-lockdown. During lockdown the $PM_{2.5}$ exceeded the prescribed daily norms 11.73% times. Details are shown in table 7 and 8.

The highest 70.4 % of the total observations of $PM_{2.5}$ at Singrauli were found to exceed the prescribed norms during pre-lockdown period. The Katni station exceeded 48.15% and Gwalior station exceeded 46.3% of the total

$PM_{2.5}$observations. There was no instance at Maihar, Satna and Sagar locations exceeding the $PM_{2.5}$ concentration beyond the prescribed norms during pre-lockdown period. Similarly during lockdown period, the Ratlam station observed the highest 59.26% results of the total $PM_{2.5}$ to exceed the norms. At Singrauli 51.85% of the total $PM_{2.5}$ observations were found above the prescribed limits. There was no exceedance of $PM_{2.5}$ value at Damoh, Gwalior, Katni, Maihar, Sagar and Satna location during the lockdown.

This $PM_{2.5}$ parameter was 14.76% times prominent pollutant with 106 counts among the total AQI observations during pre-lockdown period. During lockdown this parameter remained dominant for 9.63% times with 71 counts in all the AQI observations. Details are shown in table 4, 7 and 8.

4.6.3. Nitrogen oxide

The comparative observation of Nitrogen oxide level in the ambient air during the study course reveals that this parameter showed a marked difference during pre-lockdown and lockdown period. As expected the level of nitrogen oxide was comparatively much lower during lockdown time which could possibly due to decline in vehicular density on the roads due to traffic restrictions. The industries and the other commercial activities, hotels, restaurants etc, which contribute to the NO_x level in ambient air, were also either shutdown or were operating on reduced load. Total 0.99% of the NO_x values exceeded the prescribed standards during pre-lockdown and 0.12% during lockdown period.

The NO_x value was observed between 5.5 $\mu g/m^3$ at Gwalior to 131.3 $\mu g/m^3$ at Indore location among all the monitoring locations during pre-lockdown. The concentration of NO_x was observed to be in the range of 1.48 $\mu g/m^3$ at Maihar to 81.55 $\mu g/m^3$ at the same location during lockdown period. A decline of 45% was observed in NO_x level during lockdown as compared to pre-lockdown level.
The highest decline in level of NO_x was noticed to be 71% at Gwalior location followed by 69% decline at Bhopal, 66% at Katni, 64% at Mandideep and 61% at Jabalpur. The Damoh station did not see any reduction in the NO_x level during lockdown. The lowest drop of 3% in NO_x level was noticed at Maihar station followed by 22 % Singrauli station.

A highest exceedance percentage of 12.96% of the total NO_x observations was noticed at Indore station during pre-lockdown period. The Jabalpur station exceeded 1.85% of the total NO_x observations beyond prescribed limit. No other

station recorded exceedance of NO_x beyond the norms during pre-lockdown period. Similarly, during lockdown condition, 1.85% results of the total NO_x observations at Maihar were found above the limit. No other station was seen to exceed the NO_x level beyond the prescribed limit during lockdown.

The NO_x parameter was 4.7% times prominent pollutant in 718 total AQI observations during pre-lockdown period. During lockdown this parameter was dominant for 3.4% times in 737 AQI observations. Details are shown in table 4, 7 and 8 and figure 2 and 4.

4.6.4. Sulphur dioxide

The impact of lockdown restriction on SO_2 level in the ambient air was clearly visible during the entire study course. The level of SO_2 was comparatively low at all the locations during the lockdown period. However few exceptions were noticed at Damoh, Dewas, Sagar and Singrauli station where SO_2 level during lockdown was slightly higher than the pre-lockdown time. Total 0.99% of the SO_2 values exceeded the prescribed standards during pre-lockdown and 0.62% during lockdown period.

The SO_2 value was observed between 1.43 $\mu g/m^3$ at Sagar to 125.16 $\mu g/m^3$ at Katni location among all the monitoring locations during pre-lockdown. The concentration of SO_2 was observed to be in the range of 0.17 $\mu g/m^3$ at Ratlam to 124.76 $\mu g/m^3$ at Singrauli station during lockdown period. A decline of 16% was observed in SO_2 concentration during lockdown as compared to pre-lockdown period.

The highest decline in levelof SO_2 was noticed to be 68% at Ratlam location followed by 47% decline at Katni, 45% at Satna and 41% at Pithampur. The lowest drop of 1% in SO_2 level was noticed at Maihar station followed by 19 % at Mandideep and Ujjain stations. A reverse trend was noticed at Dewas station with an increment in SO_2 concentration by 40% followed by 22% at sagar and 21 % at Damoh and Singrauli.

The highest exceedance percentage of 11.11% of SO_2 was noticed at Singrauli station during pre-lockdown period. This was followed by Katni and Ratlam station exceeding 1.85% of the total SO_2 observations beyond the prescribed limit. No other station recorded exceedance of SO_2 beyond the norms during pre-lockdown period. Similarly, during lockdown condition, 9.26% results of the total SO_2

observations at Singrauli were found above the limit. No other station was seen to exceed the SO_2 level beyond the prescribed limit during lockdown.

The SO_2 parameter was 0.56% times prominent pollutant in 718 total AQI observations during pre-lockdown period. During lockdown this parameter was dominant for 0.27% times in 737 AQI observations. Details are shown in table 4, 7 and 8 and figure 2 and 4.

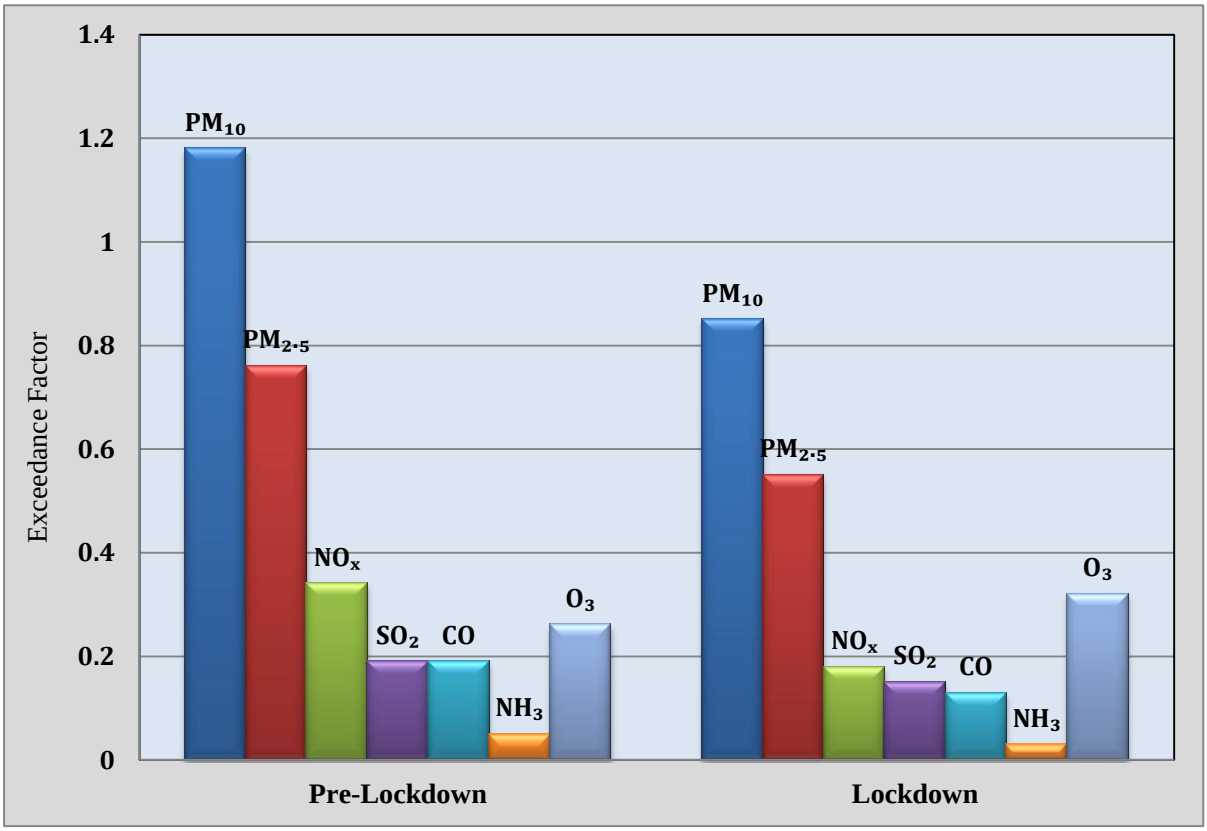


Figure 6: Air Quality Assessment based on Exceedance Factor

Table 8: Station wise Data Summary of Ambient Parameters

Value	PM_{10} (µg/m_3)		$PM_{2.5}$ (µg/m_3)		NO_x (µg/m_3)		CO (mg/m_3)		SO_2 (µg/m_3)		NH_3 (µg/m_3)		Ozone (µg/m_3)	
	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown
Bhopal														
Min	79.23	29.73	21.4	10.42	8.71	3.99	0.39	0.29	6.66	6.49	6.87	9.57	44.97	33.54
	09-03-20	28-03-20	13-03-20	11-05-20	11-03-20	03-05-20	12-03-20	11-05-20	06-02-20	07-05-20	13-03-20	09-05-20	16-02-20	28-03-20
Max	228	138.08	86.34	82.33	49.81	10.69	1.6	0.81	46.35	20.83	29.25	24.03	84.54	98.27
	07-02-20	26-04-20	13-02-20	29-04-20	26-02-20	07-04-20	13-02-20	16-04-20	20-02-20	15-05-20	23-02-20	26-03-20	20-02-20	11-05-20
Above Limit	43	20	8	2	0	0	0	0	0	0	0	0	0	0
	79.63%	37.04%	14.81%	3.70%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Within Limit	10	25	45	43	53	45	53	45	52	45	53	45	53	45
	18.52%	46.30%	83.33%	79.63%	98.15%	83.33%	98.15%	83.33%	96.30%	83.33%	98.15%	83.33%	98.15%	83.33%
No Data	1	9	1	9	1	9	1	9	2	9	1	9	1	9
	1.85%	16.67%	1.85%	16.67%	1.85%	16.67%	1.85%	16.67%	3.70%	16.67%	1.85%	16.67%	1.85%	16.67%
Damoh														
Min	54.13	32.38	13.64	8.37	24.47	25.2	0.2	0.24	10.04	7.01	-	-	-	-
	02-03-20	26-03-20	13-03-20	26-04-20	20-03-20	01-04-20	20-03-20	01-04-20	05-02-20	11-05-20	-	-	-	-
Max	166.57	123.19	69.78	35.44	25.72	25.61	0.31	0.35	55.51	23.38	-	-	-	-
	12-02-20	07-04-20	23-02-20	20-04-20	01-02-20	11-04-20	04-02-20	11-05-20	20-03-20	05-05-20	-	-	-	-
Above Limit	19	1	3	0	0	0	0	0	0	0	-	-	-	-
	35.19%	1.85%	5.56%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-	-	-	-
Within Limit	33	30	49	44	52	48	52	48	52	48	-	-	-	-
	61.11%	55.56%	90.74%	81.48%	96.30%	88.89%	96.30%	88.89%	96.30%	88.89%	-	-	-	-
No Data	2	23	2	10	2	6	2	6	2	6	54	54	54	54
	3.70%	42.59%	3.70%	18.52%	3.70%	11.11%	3.70%	11.11%	3.70%	11.11%	100.00%	100.00%	100.00%	100.00%

Value	PM_{10} (µg/m_3)		$PM_{2.5}$ (µg/m_3)		NO_x (µg/m_3)		CO (mg/m_3)		SO_2 (µg/m_3)		NH_3 (µg/m_3)		Ozone (µg/m_3)	
	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown
Dewas														
Min	62.54	24.24	18.23	14.38	8.59	3.98	0.48	0.42	3.46	5.17	8.58	12.48	10	32.97
	18-02-20	27-03-20	17-02-20	27-03-20	09-02-20	07-05-20	12-02-20	09-05-20	29-01-20	13-05-20	14-03-20	03-04-20	07-02-20	27-03-20
Max	175.15	142.72	74.18	92.86	23.96	15.8	10.91	1.84	24.1	33.64	43.9	27.43	122.72	136.73
	04-03-20	15-04-20	01-03-20	15-04-20	03-03-20	15-04-20	26-02-20	15-04-20	07-02-20	19-04-20	07-02-20	27-03-20	14-03-20	10-05-20
Above Limit	36	21	4	11	0	0	6	0	0	0	0	0	8	7
	66.67%	38.89%	7.41%	20.37%	0.00%	0.00%	11.11%	0.00%	0.00%	0.00%	0.00%	0.00%	14.81%	12.96%
Within Limit	17	33	49	43	53	54	43	54	53	54	53	54	45	47
	31.48%	61.11%	90.74%	79.63%	98.15%	100.00%	79.63%	100.00%	98.15%	100.00%	98.15%	100.00%	83.33%	87.04%
No Data	1	0	1	0	1	0	5	0	1	0	1	0	1	0
	1.85%	0.00%	1.85%	0.00%	1.85%	0.00%	9.26%	0.00%	1.85%	0.00%	1.85%	0.00%	1.85%	0.00%
Gwalior														
Min	37.72	25.42	20.55	10.79	5.5	3.16	0.31	0.21	14.53	9.48	12.34	11.54	18.87	49.47
	01-03-20	27-04-20	01-03-20	27-04-20	11-03-20	27-03-20	15-02-20	26-03-20	01-03-20	02-04-20	13-03-20	03-04-20	10-02-20	27-03-20
Max	236.65	147.75	136.92	49.75	55.57	12.86	0.95	0.77	33.95	25.47	34	21.96	109.44	115.63
	10-02-20	18-04-20	10-02-20	23-04-20	09-02-20	08-05-20	17-03-20	09-05-20	28-01-20	10-05-20	28-01-20	11-05-20	09-02-20	01-05-20
Above Limit	38	20	25	0	0	0	0	0	0	0	0	0	6	5
	70.37%	37.04%	46.30%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	11.11%	9.26%
Within Limit	15	33	28	53	47	53	53	53	53	53	47	53	47	48
	27.78%	61.11%	51.85%	98.15%	87.04%	98.15%	98.15%	98.15%	98.15%	98.15%	87.04%	98.15%	87.04%	88.89%
No Data	1	1	1	1	7	1	1	1	1	1	7	1	1	1
	1.85%	1.85%	1.85%	1.85%	12.96%	1.85%	1.85%	1.85%	1.85%	1.85%	12.96%	1.85%	1.85%	1.85%

Value	PM_{10} (µg/m_3)		$PM_{2.5}$ (µg/m_3)		NO_x (µg/m_3)		CO (mg/m_3)		SO_2 (µg/m_3)		NH_3 (µg/m_3)		Ozone (µg/m_3)	
	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown
Indore														
Min	73.92	27.17	18.5	11.5	34.8	19.91	0.38	0.21	6.4	2.77	12.26	5.12	22.85	28.51
	11-03-20	27-03-20	08-03-20	03-04-20	02-02-20	11-05-20	11-03-20	03-04-20	12-03-20	27-04-20	17-02-20	16-04-20	27-02-20	01-05-20
Max	228.25	172.36	98.04	95.49	131.33	56.04	1.43	0.97	27.13	14.61	36.71	28.38	39.26	110.54
	26-02-20	15-04-20	14-02-20	11-04-20	14-02-20	14-04-20	28-01-20	11-04-20	04-02-20	15-04-20	23-02-20	27-03-20	16-03-20	11-05-20
Above Limit	41	20	10	5	7	0	0	0	0	0	0	0	0	2
	75.93%	37.04%	18.52%	9.26%	12.96%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.70%
Within Limit	11	34	42	49	44	54	52	54	52	54	52	54	52	52
	20.37%	62.96%	77.78%	90.74%	81.48%	100.00%	96.30%	100.00%	96.30%	100.00%	96.30%	100.00%	96.30%	96.30%
No Data	2	0	2	0	3	0	2	0	2	0	2	0	2	0
	3.70%	0.00%	3.70%	0.00%	5.56%	0.00%	3.70%	0.00%	3.70%	0.00%	3.70%	0.00%	3.70%	0.00%
Jabalpur														
Min	55.42	34.67	27	15.42	15.21	9.38	0.41	0.29	3.38	3.97	6.95	6.2	19.06	43.01
	11-03-20	27-04-20	13-03-20	27-04-20	11-03-20	08-04-20	11-03-20	27-03-20	24-02-20	06-05-20	07-03-20	09-05-20	05-02-20	28-03-20
Max	225.33	127.58	105.08	69.21	83.37	24.31	1.36	0.75	18.11	10.51	21.72	13.86	74.78	94.74
	14-02-20	17-04-20	05-02-20	17-04-20	16-02-20	06-05-20	14-02-20	24-04-20	21-02-20	03-05-20	23-02-20	29-04-20	18-03-20	17-05-20
Above Limit	45	10	17	1	1	0	0	0	0	0	0	0	0	0
	83.33%	18.52%	31.48%	1.85%	1.85%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Within Limit	8	44	36	53	52	54	52	54	52	54	53	54	53	54
	14.81%	81.48%	66.67%	98.15%	96.30%	100.00%	96.30%	100.00%	96.30%	100.00%	98.15%	100.00%	98.15%	100.00%
No Data	1	0	1	0	1	0	2	0	2	0	1	0	1	0
	1.85%	0.00%	1.85%	0.00%	1.85%	0.00%	3.70%	0.00%	3.70%	0.00%	1.85%	0.00%	1.85%	0.00%

Value	PM_{10} (µg/m_3)		$PM_{2.5}$ (µg/m_3)		NO_x (µg/m_3)		CO (mg/m_3)		SO_2 (µg/m_3)		NH_3 (µg/m_3)		Ozone (µg/m_3)	
	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown
Katni														
Min	61	32.42	26.04	8.09	17.1	8.3	0.4	0.25	2.45	3.31	27.54	10.36	32.77	46.61
	11-03-20	27-04-20	14-03-20	05-05-20	11-03-20	04-05-20	04-03-20	28-03-20	25-02-20	13-04-20	11-03-20	03-05-20	20-03-20	11-04-20
Max	266.55	176.58	110.33	57.04	66.95	14.35	1.49	0.87	125.16	37.06	89.27	62.95	76.63	104.39
	18-02-20	20-04-20	12-02-20	11-04-20	18-02-20	14-04-20	18-03-20	15-05-20	18-02-20	10-05-20	19-03-20	25-03-20	28-02-20	04-05-20
Above Limit	47	19	26	0	0	0	0	0	1	0	0	0	0	2
	87.04%	35.19%	48.15%	0.00%	0.00%	0.00%	0.00%	0.00%	1.85%	0.00%	0.00%	0.00%	0.00%	3.70%
Within Limit	6	35	27	54	53	54	52	54	51	54	53	54	53	52
	11.11%	64.81%	50.00%	100.00%	98.15%	100.00%	96.30%	100.00%	94.44%	100.00%	98.15%	100.00%	98.15%	96.30%
No Data	1	0	1	0	1	0	2	0	2	0	1	0	1	0
	1.85%	0.00%	1.85%	0.00%	1.85%	0.00%	3.70%	0.00%	3.70%	0.00%	1.85%	0.00%	1.85%	0.00%
Maihar														
Min	35.04	23.19	13.97	11.15	13.28	1.48	0.14	0.14	6.99	6.99	-	-	-	-
	09-03-20	29-03-20	16-02-20	28-03-20	30-01-20	04-05-20	09-03-20	17-04-20	21-02-20	10-05-20	-	-	-	-
Max	103.02	76.68	49.71	30.45	52.23	81.55	0.65	0.59	8.22	7.58	-	-	-	-
	04-02-20	20-04-20	04-02-20	16-05-20	20-03-20	24-04-20	10-02-20	17-05-20	20-03-20	27-03-20	-	-	-	-
Above Limit	1	0	0	0	0	1	0	0	0	0	-	-	-	-
	1.85%	0.00%	0.00%	0.00%	0.00%	1.85%	0.00%	0.00%	0.00%	0.00%	-	-	-	-
Within Limit	51	54	52	54	52	53	52	54	52	54	-	-	-	-
	94.44%	100.00%	96.30%	100.00%	96.30%	98.15%	96.30%	100.00%	96.30%	100.00%	-	-	-	-
No Data	2	0	2	0	2	0	2	0	2	0	54	54	54	54
	3.70%	0.00%	3.70%	0.00%	3.70%	0.00%	3.70%	0.00%	3.70%	0.00%	100.00%	100.00%	100.00%	100.00%

Value	PM_{10} (µg/m_3)		$PM_{2.5}$ (µg/m_3)		NO_x (µg/m_3)		CO (mg/m_3)		SO_2 (µg/m_3)		NH_3 (µg/m_3)		Ozone (µg/m_3)	
	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown
Mandideep														
Min	41.42	20.21	16.92	12.46	7.43	4.4	0.43	0.35	6.76	6.27	11.61	5.32	15.91	16.55
	10-03-20	11-05-20	11-03-20	28-03-20	10-03-20	05-05-20	12-03-20	11-05-20	13-03-20	05-04-20	31-01-20	17-05-20	19-02-20	27-03-20
Max	212.5	90.33	60.25	60.38	47.23	14.76	1.29	1.11	18.25	13.61	45.65	31.26	18.92	21.09
	14-02-20	29-04-20	14-02-20	29-04-20	31-01-20	23-04-20	13-02-20	29-04-20	02-02-20	15-05-20	10-02-20	26-03-20	18-03-20	27-04-20
Above Limit	30	0	1	1	0	0	0	0	0	0	0	0	0	0
	55.56%	0.00%	1.85%	1.85%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Within Limit	23	54	52	53	45	54	52	54	53	54	45	54	53	54
	42.59%	100.00%	96.30%	98.15%	83.33%	100.00%	96.30%	100.00%	98.15%	100.00%	83.33%	100.00%	98.15%	100.00%
No Data	1	0	1	0	9	0	2	0	1	0	9	0	1	0
	1.85%	0.00%	1.85%	0.00%	16.67%	0.00%	3.70%	0.00%	1.85%	0.00%	16.67%	0.00%	1.85%	0.00%
Pithampur														
Min	86.15	30.21	24.58	16.62	5.67	4.91	0.57	0.44	4.14	4.81	17.24	7.28	8.63	5.93
	09-02-20	27-03-20	18-02-20	27-03-20	14-03-20	25-03-20	26-02-20	01-05-20	09-02-20	25-03-20	13-03-20	17-05-20	06-03-20	27-03-20
Max	165.67	166.33	68.64	75.26	15.92	9.23	2.64	1.6	43.88	17.71	38.86	37.89	17.7	17.91
	21-02-20	12-04-20	23-02-20	11-04-20	27-02-20	06-04-20	09-03-20	11-04-20	27-02-20	17-04-20	23-02-20	27-03-20	20-02-20	11-05-20
Above Limit	45	38	8	4	0	0	11	0	0	0	0	0	0	0
	83.33%	70.37%	14.81%	7.41%	0.00%	0.00%	20.37%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Within Limit	8	16	45	50	53	54	39	54	52	54	53	54	53	54
	14.81%	29.63%	83.33%	92.59%	98.15%	100.00%	72.22%	100.00%	96.30%	100.00%	98.15%	100.00%	98.15%	100.00%
No Data	1	0	1	0	1	0	4	0	2	0	1	0	1	0
	1.85%	0.00%	1.85%	0.00%	1.85%	0.00%	7.41%	0.00%	3.70%	0.00%	1.85%	0.00%	1.85%	0.00%

Value	PM_{10} (µg/m_3)		$PM_{2.5}$ (µg/m_3)		NO_x (µg/m_3)		CO (mg/m_3)		SO_2 (µg/m_3)		NH_3 (µg/m_3)		Ozone (µg/m_3)	
	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown
Ratlam														
Min	76.35	52.02	30.87	13.02	7.62	7.84	-	-	2.49	0.17	-	-	-	-
	29-02-20	28-03-20	15-03-20	16-05-20	02-02-20	11-05-20	-	-	28-01-20	03-05-20	-	-	-	-
Max	226.25	152.28	93	88.45	77.54	30.77	-	-	104.99	12.42	-	-	-	-
	14-02-20	06-05-20	14-02-20	23-04-20	14-02-20	16-05-20	-	-	20-03-20	17-05-20	-	-	-	-
Above Limit	38	25	14	32	0	0	-	-	1	0	-	-	-	-
	70.37%	46.30%	25.93%	59.26%	0.00%	0.00%	-	-	1.85%	0.00%	-	-	-	-
Within Limit	11	28	35	21	49	53	-	-	42	52	-	-	-	-
	20.37%	51.85%	64.81%	38.89%	90.74%	98.15%	-	-	77.78%	96.30%	-	-	-	-
No Data	5	1	5	1	5	1	54	54	11	2	54	54	54	54
	9.26%	1.85%	9.26%	1.85%	9.26%	1.85%	100.00%	100.00%	20.37%	3.70%	100.00%	100.00%	100.00%	100.00%
Sagar														
Min	29.13	11.01	16.87	11.94	15.65	8.94	0.34	0.35	1.43	1.65	-	-	-	-
	02-03-20	28-03-20	29-01-20	29-03-20	20-03-20	27-04-20	15-03-20	14-05-20	03-03-20	25-04-20	-	-	-	-
Max	138	109.42	42.41	47.68	53.22	16.83	1.28	1.22	3.34	3.84	-	-	-	-
	17-02-20	25-04-20	29-02-20	25-04-20	18-02-20	13-04-20	18-02-20	16-04-20	04-02-20	08-05-20	-	-	-	-
Above Limit	7	2	0	0	0	0	0	0	0	0	-	-	-	-
	12.96%	3.70%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-	-	-	-
Within Limit	43	44	50	46	50	46	50	46	50	46	-	-	-	-
	79.63%	81.48%	92.59%	85.19%	92.59%	85.19%	92.59%	85.19%	92.59%	85.19%	-	-	-	-
No Data	4	8	4	8	4	8	4	8	4	8	54	54	54	54
	7.41%	14.81%	7.41%	14.81%	7.41%	14.81%	7.41%	14.81%	7.41%	14.81%	100.00%	100.00%	100.00%	100.00%

Value	PM_{10} (µg/m_3)		$PM_{2.5}$ (µg/m_3)		NO_x (µg/m_3)		CO (mg/m_3)		SO_2 (µg/m_3)		NH_3 (µg/m_3)		Ozone (µg/m_3)	
	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown
Satna														
Min	16	26.31	6.73	5.78	7.71	6.66	0.22	0.1	6.83	5.93	-	-	-	-
	07-02-20	27-04-20	09-02-20	29-03-20	19-03-20	06-05-20	14-03-20	26-04-20	06-03-20	27-04-20	-	-	-	-
Max	265.85	127	46.66	38.6	34.98	27.38	1.57	0.43	30.1	10.49	-	-	-	-
	26-02-20	20-04-20	28-01-20	20-04-20	04-03-20	28-04-20	21-02-20	24-04-20	04-03-20	28-04-20	-	-	-	-
Above Limit	31	3	0	0	0	0	0	0	0	0	-	-	-	-
	57.41%	5.56%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-	-	-	-
Within Limit	16	51	46	54	16	54	46	54	46	54	-	-	-	-
	29.63%	94.44%	85.19%	100.00%	29.63%	100.00%	85.19%	100.00%	85.19%	100.00%	-	-	-	-
No Data	7	0	8	0	38	0	8	0	8	0	54	54	54	54
	12.96%	0.00%	14.81%	0.00%	70.37%	0.00%	14.81%	0.00%	14.81%	0.00%	100.00%	100.00%	100.00%	100.00%
Singrauli														
Min	29.17	52.96	20.96	16.63	10.55	6.81	0.28	0.28	21.88	25.9	7.44	8.79	11.1	34.26
	14-03-20	05-05-20	14-03-20	05-05-20	14-03-20	05-05-20	27-02-20	07-05-20	26-02-20	16-05-20	13-03-20	30-03-20	07-02-20	30-04-20
Max	308.08	297.52	158.94	109.71	70.81	51.73	1.71	1.05	112.28	124.76	19.32	13.9	80.79	102.37
	27-01-20	27-03-20	03-02-20	24-04-20	27-01-20	30-04-20	20-02-20	11-05-20	10-02-20	14-05-20	22-02-20	17-04-20	14-02-20	21-04-20
Above Limit	44	51	38	28	0	0	0	0	6	5	0	0	0	1
	81.48%	94.44%	70.37%	51.85%	0.00%	0.00%	0.00%	0.00%	11.11%	9.26%	0.00%	0.00%	0.00%	1.85%
Within Limit	8	3	15	26	53	54	52	54	46	49	53	54	53	53
	14.81%	5.56%	27.78%	48.15%	98.15%	100.00%	96.30%	100.00%	85.19%	90.74%	98.15%	100.00%	98.15%	98.15%
No Data	2	0	1	0	1	0	2	0	2	0	1	0	1	0
	3.70%	0.00%	1.85%	0.00%	1.85%	0.00%	3.70%	0.00%	3.70%	0.00%	1.85%	0.00%	1.85%	0.00%

Value	PM_{10} (µg/m_3)		$PM_{2.5}$ (µg/m_3)		NO_x (µg/m_3)		CO (mg/m_3)		SO_2 (µg/m_3)		NH_3 (µg/m_3)		Ozone (µg/m_3)	
	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown	Pre-Lockdown	During Lockdown
Ujjain														
Min	44.42	25.86	17.83	15.09	8.36	3.34	0.54	0.37	5.41	3.88	9.66	4.3	45.78	50.87
	08-03-20	27-03-20	08-03-20	11-05-20	23-02-20	02-05-20	06-03-20	03-05-20	30-01-20	11-05-20	13-03-20	17-05-20	18-02-20	23-04-20
Max	162.51	184.5	77.63	101.56	40.33	10.76	1.88	1.3	15.48	14.08	34.74	28.35	109.39	95.4
	13-02-20	14-04-20	13-02-20	14-04-20	18-02-20	14-04-20	17-02-20	06-04-20	16-02-20	14-04-20	20-02-20	25-03-20	22-02-20	10-05-20
Above Limit	39	22	17	11	0	0	0	0	0	0	0	0	6	0
	72.22%	40.74%	31.48%	20.37%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	11.11%	0.00%
Within Limit	14	32	36	43	53	54	53	54	53	54	53	54	47	54
	25.93%	59.26%	66.67%	79.63%	98.15%	100.00%	98.15%	100.00%	98.15%	100.00%	98.15%	100.00%	87.04%	100.00%
No Data	1	0	1	0	1	0	1	0	1	0	1	0	1	0
	1.85%	0.00%	1.85%	0.00%	1.85%	0.00%	1.85%	0.00%	1.85%	0.00%	1.85%	0.00%	1.85%	0.00%
State-wide														
Min	16	11.01	6.73	5.78	5.5	1.48	0.14	0.1	1.43	0.17	6.87	4.3	8.63	5.93
	07-02-20	28-03-20	09-02-20	29-03-20	11-03-20	04-05-20	09-03-20	26-04-20	03-03-20	03-05-20	13-03-20	17-05-20	06-03-20	27-03-20
	Satna	Sagar	Satna	Satna	Gwalior	Maihar	Maihar	Satna	Sagar	Ratlam	Bhopal	Ujjain	Pithampur	Pithampur
Max	308.08	297.52	158.94	109.71	131.33	81.55	10.91	1.84	125.16	124.76	89.27	62.95	122.72	136.73
	27-01-20	27-03-20	03-02-20	24-04-20	14-02-20	24-04-20	26-02-20	15-04-20	18-02-20	14-05-20	19-03-20	25-03-20	14-03-20	10-05-20
	Singrauli	Singrauli	Singrauli	Singrauli	Indore	Maihar	Dewas	Dewas	Katni	Singrauli	Katni	Katni	Dewas	Dewas
Exceed Max	87.04%	94.44%	70.37%	59.26%	12.96%	1.85%	20.37%	0.00%	11.11%	9.26%	0.00%	0.00%	14.81%	12.96%
	Katni	Singrauli	Singrauli	Ratlam	Indore	Maihar	Pithampur		Singrauli	Singrauli			Dewas	Dewas
Above Limit	504	252	171	95	8	1	17	0	8	5	0	0	20	17
	62.22%	31.11%	21.11%	11.73%	0.99%	0.12%	2.10%	0.00%	0.99%	0.62%	0.00%	0.00%	2.47%	2.10%
Within Limit	274	516	607	686	725	784	701	732	759	779	515	530	509	513
	33.83%	63.70%	74.94%	84.69%	89.51%	96.79%	92.72%	96.83%	93.70%	96.17%	95.37%	98.15%	94.26%	95.00%
No Data	32	42	32	29	77	25	92	78	43	26	295	280	281	280
	3.95%	5.19%	3.95%	3.58%	9.51%	3.09%	11.36%	9.63%	5.31%	3.21%	36.42%	34.57%	34.69%	34.57%

4.6.5. Carbon monoxide

The ambient air analysis showed a similar trend for CO as that of other gaseous parameters. The level of CO was comparatively low at all the locations during the lockdown period except at Gwalior and Maihar stations where marginally elevated concentration was noticed during lockdown as compared to the pre-lockdown time. Total 2.10% of the CO values exceeded the prescribed standards during pre-lockdown, however there was no instance of CO exceeding the prescribed limit during lockdown period.

The CO value was observed between 0.14 $\mu g/m^3$ at Maihar to 10.91 $\mu g/m^3$ at Dewas location among all the monitoring locations during pre-lockdown. The concentration of CO was observed to be in the range of 0.1 $\mu g/m^3$ at Satna to 1.8 $\mu g/m^3$ at Dewas station during lockdown period. A decline of 31% was observed in cumulative CO concentration during lockdown as compared to pre-lockdown period.

The highest decline in level of CO was noticed to be 53% at Satna location followed by 50% decline at Indore, 49% at Jabalpur and 40% at Pithampur. Damoh station did not observe any change in CO concentration during lockdown time. The lowest drop of 18% in CO level was noticed at Dewas station followed by 21 % at Sagar station. A marginal reverse trend was noticed at Gwalior station with an increment in CO concentration by 1% followed by 3% at Maihar.

The highest exceedance percentage of 20.37% of CO was noticed at Pithampur station during pre-lockdown period. This was followed by Dewas station exceeding 11.11% of the total CO observations beyond the prescribed limit. No other stations recorded exceedance of CO beyond the norms during pre-lockdown period. During lockdown condition none of the monitoring locations observed exceedance of CO limit beyond the norms.

The CO parameter was 1.25% times prominent pollutant in 718 total AQI observations during pre-lockdown period. During lockdown this parameter was dominant for 1.36% times in 737 AQI observations. Details are shown in tab. 4, 7, 8 and fig. 2, 4.

4.6.6. Ozone

The analysis of ambient air data for ozone level during the study exhibited that the average concentration was 48.07 $\mu g/m^3$ in pre-lockdown period whereas the average value during lockdown was found to be 58.67 $\mu g/m^3$. Unlike other

parameters the ozone exhibited altogether different scenario with elevated concentration during lockdown period as compared to the pre-lockdown time. Total 2.47% of the ozone values exceeded the prescribed standards during pre-lockdown and 2.10% during lockdown period.

The ozone value was observed between 8.63 $\mu g/m^3$ at Pithampur to 122.72 $\mu g/m^3$ at Dewas location among all the monitoring locations during pre-lockdown. The ozone level during lockdown period was observed to be in the range of 5.93 $\mu g/m^3$ at Pithampur to 136.73 $\mu g/m^3$ at Dewas station. The average concentration of ozone was higher during lockdown time. An increase in ozone level by 22% was noticed during lockdown as compared to pre-lockdown period.

The marginal decline of 8% in ozone level was noticed at Pithampur location followed by 5% decline at Ujjain. Rest all the stations observed higher values of ozone during lockdown period with highest elevation of 62% at Jabalpur followed by 49% at Indore and 47% at Katni.

The highest exceedance percentage of 14.81% of ozone was noticed at Dewas station during pre-lockdown period. This was followed by Gwalior and Ujjain stations each exceeding 11.11% of the total ozone observations beyond the prescribed limit. No other stations recorded exceedance of ozone beyond the norms during pre-lockdown period. During lockdown the Dewas station observed 12.96% exceedance beyond the prescribed norms followed by 9.26% at Gwalior, 3.70% at Indore and Katni each. The rest of the stations did not observe exceedance of ozone level above standard limits.

The Ozone parameter was 2.51% times prominent pollutant in 718 total AQI observations during pre-lockdown period. During lockdown this parameter was dominant for 17.77% times in 737 total AQI observations. Details are shown in tab. 4, 7, 8 and fig. 2, 4.

The ozone level was also noticed unexpectedly high at few monitoring locations which could be due to the lower amount of NO in the ambient air owing to restrictions on vehicular movement. The NO is generated from vehicular exhaust emission and consumes ozone during atmospheric reaction. In addition to this, during lockdown period, the temperature was comparatively high due to summer season and the increase in temperature might have enhanced the ozone formation.

4.6.7. Ammonia

The major sources of ammonia in the urban areas are said to be due to decomposition of organic/municipal wastes, industrial processes, agriculture fields due to application of ammonia based fertilizers, vehicular exhaust emission etc.

The analysis of ambient air data for NH_3 level during the study exhibited that the average concentration was 22.56 $\mu g/m^3$ in pre-lockdown period whereas the average value during lockdown was found to be 15.39 $\mu g/m^3$. The level of NH_3 was comparatively low at all the locations during the lockdown period with highest decline of 54% at Mandideep followed by 46% decline at Pithampur and 42% decline at Indore. The lowest decline was observed to be 6% at Singrauli and 7% at Bhopal. No instance of NH_3 exceeding the prescribed standards was noticed during pre-lockdown and lockdown period.

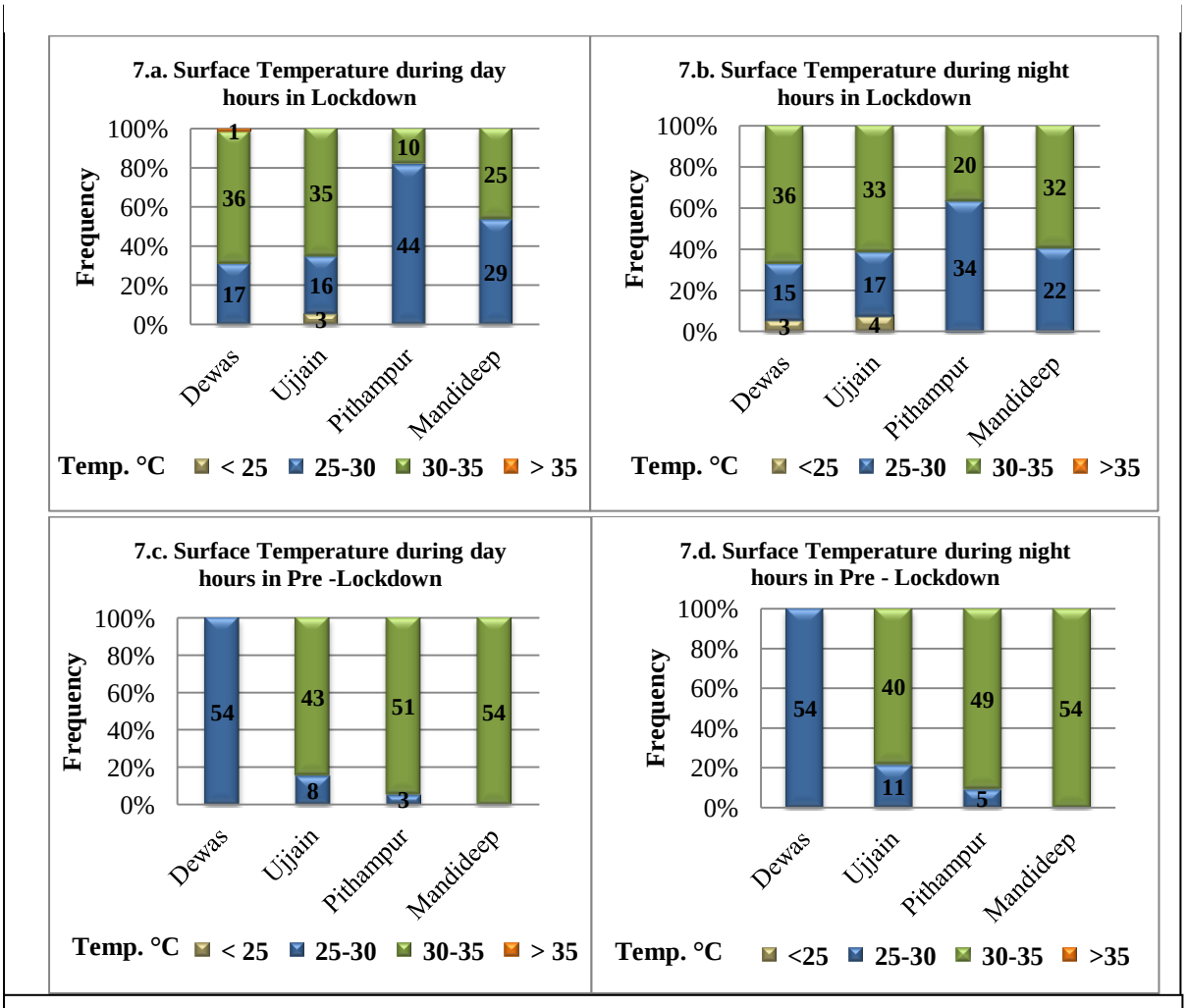
The NH_3 value was observed between 6.87 $\mu g/m^3$ at Bhopal to 89.27 $\mu g/m^3$ at Katni location among all the monitoring locations during pre-lockdown. The concentration of NH_3 was observed to be in the range of 4.3 $\mu g/m^3$ at Ujjain to 62.95 $\mu g/m^3$ at Katni station during lockdown period. The average concentration of ammonia was higher during pre-lockdown time as compared to lockdown time. A decline in ammonia level by 32% was noticed during lockdown as compared to pre-lockdown period.

None of the stations were found to exceed the concentration of ammonia during the study course nor did it contribute as dominant pollutant to the AQI. Details are shown in tab. 4, 7 and 8 and fig. 2, 4.

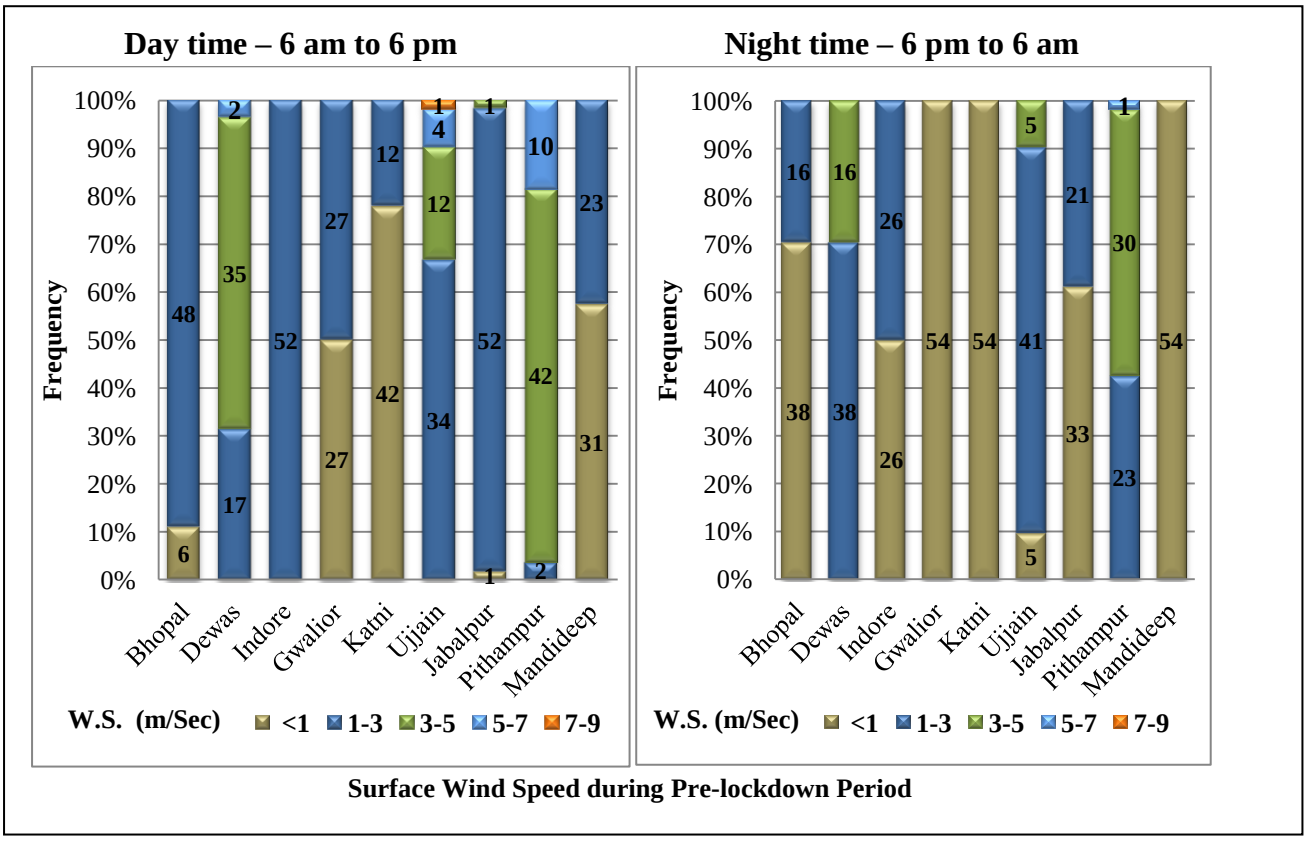
5. Meteorological Observations

The meteorological parameters, viz. temperature, wind speed, wind direction, humidity, in urban areas play an important factor in affecting ambient air quality. The temperature and wind speed were measured during the study to see their influence on ambient air parameters. The wind speed was observed at 10 locations and temperature was monitored at four of the monitoring locations. The significance of meteorological parameters is due to the fact that they may affect the dispersion process, removal of particulates etc. The rainfall may also have impact on air pollutants by removal of gaseous and particulate concentration from the ambient air. The formation of ozone and its decomposition is highly influenced by the ambient temperature conditions and wind speed. The meteorological parameters were recorded separately for day and night hours during pre-lockdown as well as during lockdown period. The day time observations were between 6 am to 6 pm whereas the observations between 6 pm to 6 am were considered as night time observations. There was no specific trend showing relationship between meteorological and ambient air pollutant parameters rather it showed a mixed effect. The meteorological data is shown in Fig. 7 below.

Figure 7: Surface Data at Day/Night Time during Pre/ Post Lockdown



Surface Temperature at Day/Night Time during Pre/Post Lockdown



Surface Wind Speed during Pre-lockdown Period

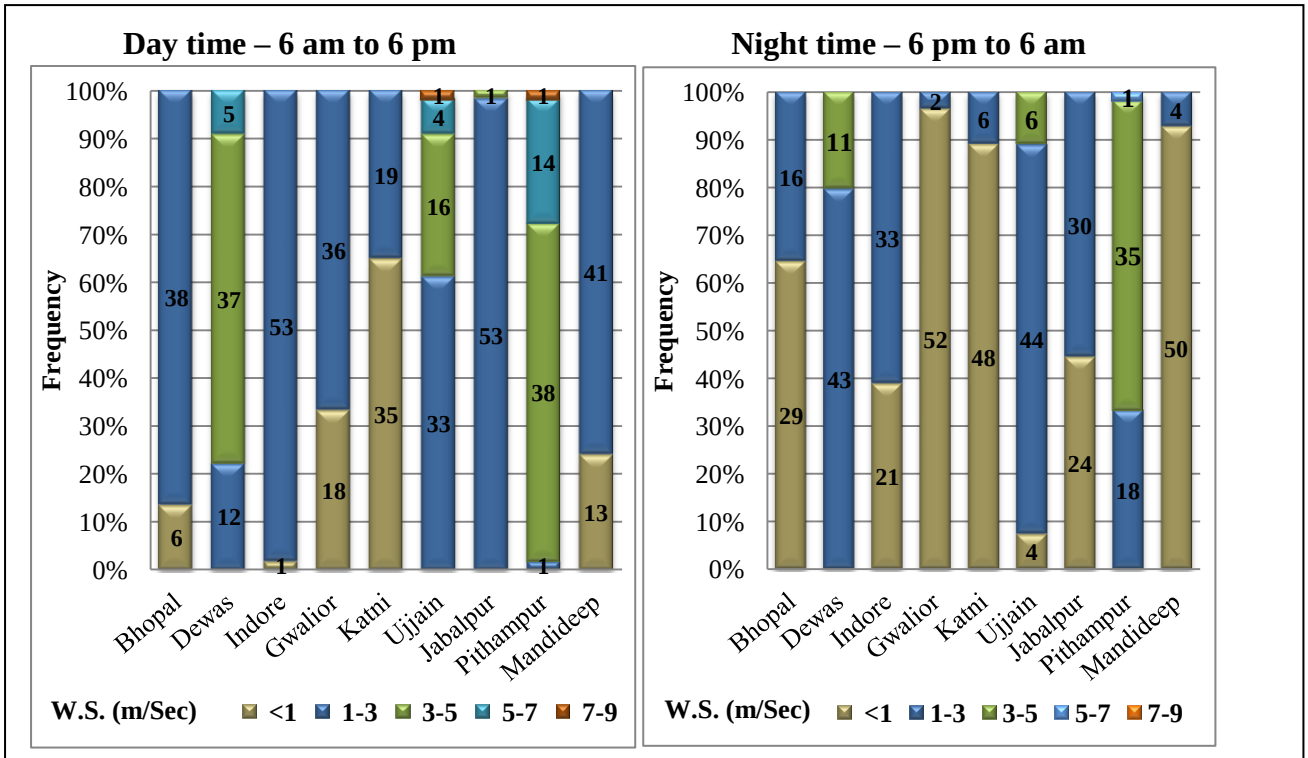


Fig. 7g Fig. 7h

Surface Wind Speed during Lockdown Period

6. Statistical Analysis

6.1. Standard Deviation Analysis

The statistical analysis of the air quality data was also performed during pre-lockdown and lockdown period. The standard deviation which shows variance from the average or mean value was studied for ambient parameters. The consolidated standard deviation (SD) in PM_{10} was found to be 76.10 during pre-lockdown and 60.34 during lockdown. The highest deviation of just over 116 was noticed at Singrauli location during both the phases of study which indicates that the values are spread out over a wide range at this location. The Maihar location observed the lowest standard deviation in PM_{10} value with 27.94 during pre-lockdown and 21.10 during lockdown period indicating that the concentration values were comparatively close and were not spread out as that noticed at Singrauli location, Fig. 8.

Likewise the consolidated standard deviation (SD) in $PM_{2.5}$ was found to be 35.30 during pre-lockdown and 28.95 during lockdown. The SD of $PM_{2.5}$ value was also similar to that of PM_{10} with wider range noticed at Singrauli during both the phases of study. The data range of $PM_{2.5}$ was narrowest at Sagar during pre-lockdown and at Maihar during lockdown period. Details of other locations can be referred in Fig. 9 .

On an aggregated level across all the 15 locations, the average PM_{10} has come down from 119.26 to 86.42 ($\mu g/m^3$) with a reduction of 27.5%. The Singrauli location showed a minor increase of 1.8% during lockdown period. This implies continuing industrial activity during the lockdown phase. The Mandideep station exhibited significant improvements in the PM_{10} levels with a reduction of 55.3% signifying steep reduction in industrial activities. On an average the standard deviation at all the locations is quiet high which warrants an indepth time wise analysis across the day and the same has also been done. The Fig. 8 depicts PM_{10} average and standard deviation values at different monitoring locations. There is a distinct reduction in the average PM_{10} levels across all the monitoring locations except at Singrauli.

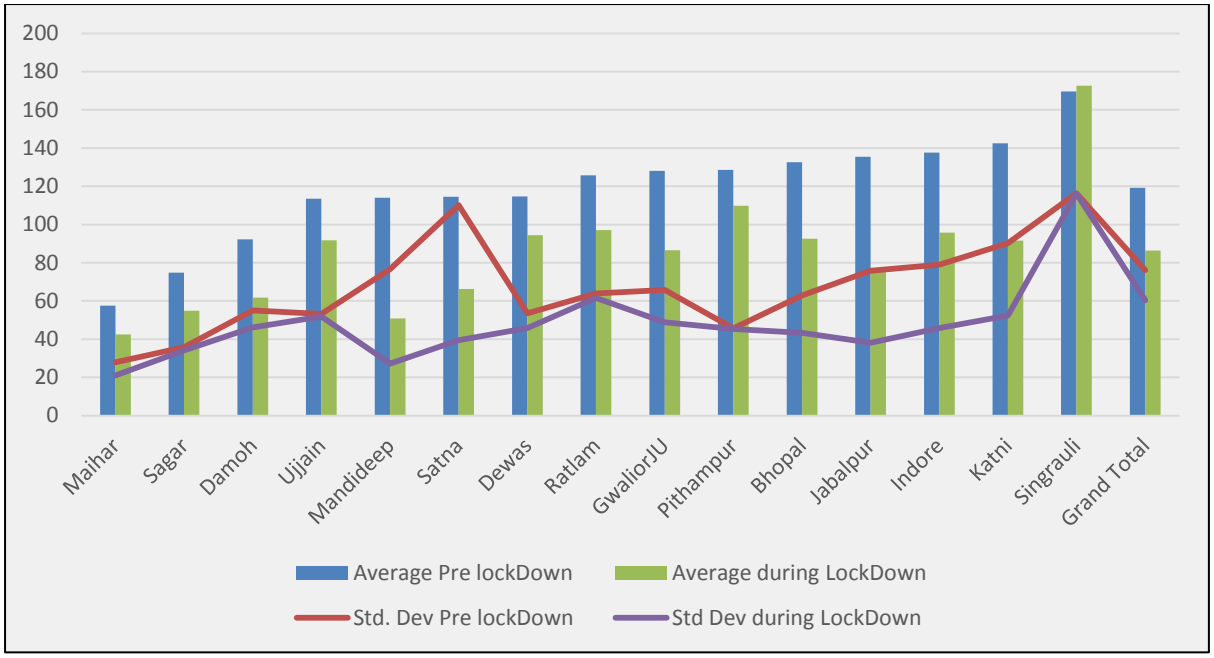


Figure 8: Locationwise PM10 Statistics

On an aggregated level across all the 15 locations, the average $PM_{2.5}$ has come down from 46.4 to 33.2 $\mu g/m^3$ with a reduction of 28.5%. On an average the standard deviation at all the locations is quiet high which warrants an indepth time wise analysis across the day and the same has also been done. The Fig. 9 depicts $PM_{2.5}$ average and standard deviation values at different monitoring locations. There is a distinct reduction in the average $PM_{2.5}$ levels across all the monitoring locations except at Singrauli.

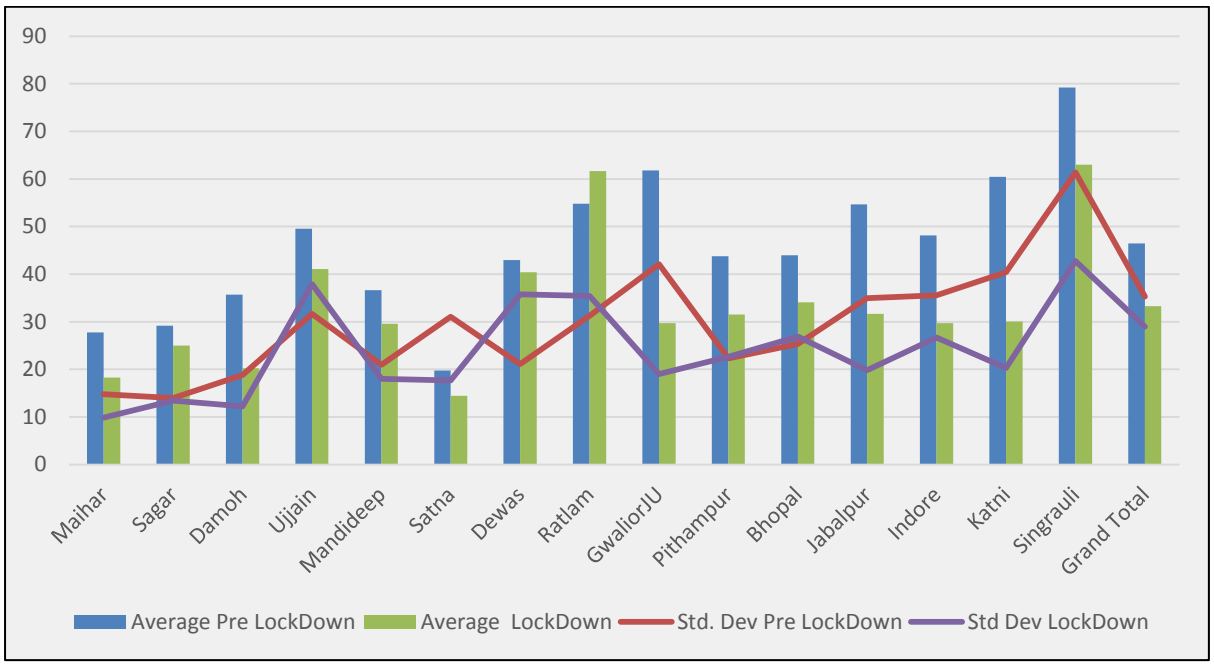


Figure 9: Location wise $PM_{2.5}$ Statistics

Among the gaseous parameters, as far as level of SO_2 is concerned, no significant change was noticed at any station and the variation in values was also negligible. The concentration did not exceed the prescribed norms at any of the monitoring locations. The level of SO_2 was, although it was within the prescribed norms, higher at Singrauli location as compared to the other locations due to presence of thermal power plants in that area. The average value of SO_2 during pre-lockdown and lockdown was noticed to be 15.06 $\mu g/m^3$ and 12.69 $\mu g/m^3$. The consolidated standard deviation (SD) in SO_2 was found to be 20.58 during pre-lockdown and 17.82 during lockdown.

The highest deviation was noticed at Singrauli location during both the phases of study which indicates that the values are spread out over a wide range at this location. The observed SD value during pre-lockdown was 44.32 whereas it was 44.91 during lockdown period. The Maihar station noticed the lowest standard deviation with a value of close to 0.4 during both the phases indicating that the concentration values were comparatively quite close and were not spread out as that noticed at Singrauli station. The SO_2 level and the standard deviation values are depicted in fig. 10.

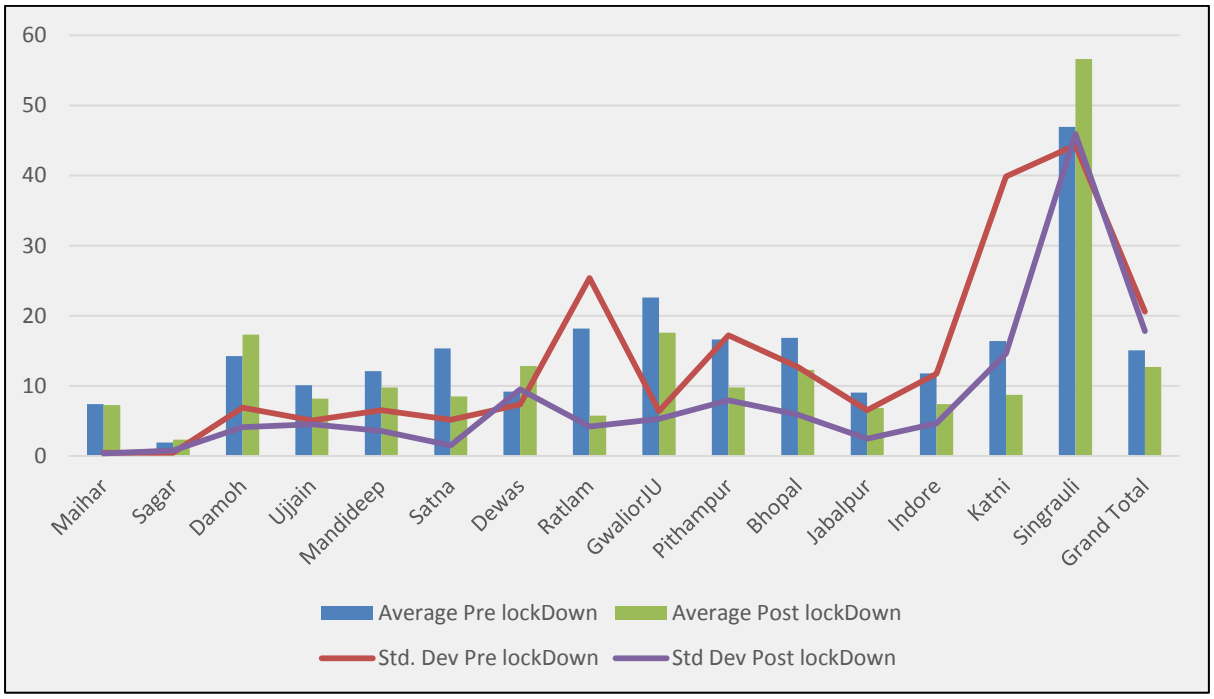


Figure 10: Location wise SO2 Statistics

As far as level of NO_x is concerned, no significant change was noticed at any station. The concentration did not exceed the prescribed norms at any point of time at any of the monitoring locations. The level of NO_x was noticed to be higher at Indore location as compared to the other locations. The average value of NO_x during pre-lockdown and lockdown was noticed to be 27.67 $\mu g/m^3$ and 15.06 $\mu g/m^3$. The consolidated standard deviation (SD) in NO_x was found to be 26.33 during pre-lockdown and 14.84 during lockdown.

The highest deviation of 46 was noticed at Indore location during both the phases of study which indicates that the values are spread out over a wide range at this location. The Damoh location observed the lowest standard deviation in NO_x value with 0.79 during pre-lockdown and 0.49 during lockdown period indicating that the concentration values were comparatively quite close and were not spread out as that noticed at Indore station. The NO_x level and the standard deviation values are depicted in Fig. 11.

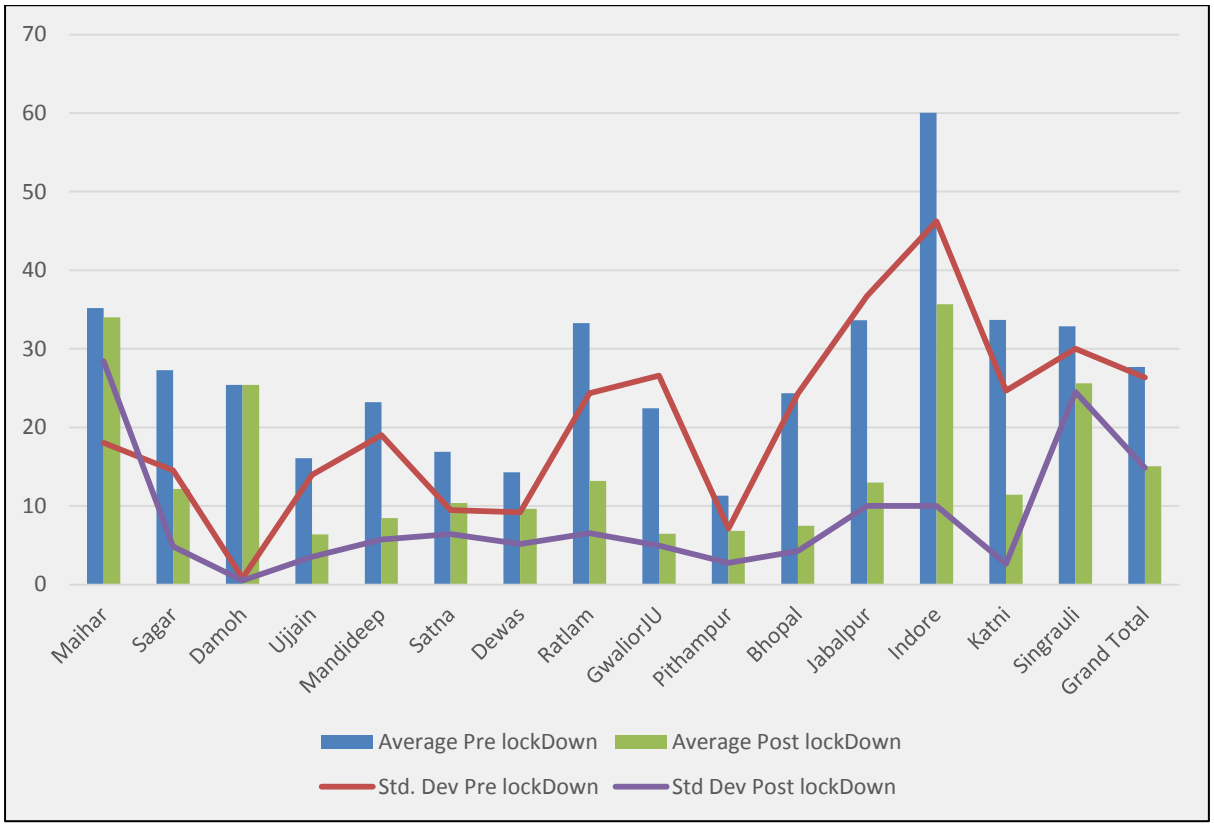


Figure 11: Location wise NOx Statistics

Similarly, in case of ozone, the average value during pre-lockdown was 47.94 $\mu g/m^3$ and lockdown it was 58.07 $\mu g/m^3$. The consolidated standard deviation (SD) in ozone was found to be ~38.5 during pre-lockdown and lockdown phase. The highest deviation was noticed at Gwalior location during both the phases of study with 53.42 during pre-lockdown and 40.22 during lockdown indicating that the values are spread

out over a wide range at this location. The Mandideep station noticed the lowest standard deviation with a value of 3.8 during pre-lockdown and 5.3 during lockdown. A similar analysis was done for other parameters too, i.e. carbon monoxide and ammonia.

6.2. Correlation Analysis

A study was also done to find the correlation between two ambient parameters, i.e. $PM_{10}$and $PM_{2.5}$. While studying the correlation between the parameters it was observed that the degree of correlation was perfect positive at Mandideep with a coefficient value of >0.9 during pre-lockdown as well as during lockdown. This was followed by perfect positive correlation at Katni with coefficient value of >0.8 and Jabalpur with a coefficient value close to ~0.8. The coefficient value was >0.5 at almost all the stations during pre-lockdown period, except at Satna, which shows strong or high degree of correlation. The Damoh station showed high degree of correlation during pre-lockdown but during lockdown it exhibited low correlation. The Satna station showed low degree of correlation during both the phases of study with a coefficient value of <0.2. The details of PM_{10} vs $PM_{2.5}$ Correlation during pre-lockdown and lockdown period are shown in tab. 9.

Station	Pre Lockdown Correlation	Correlation during Lockdown
Satna	0.12	0.149
Ratlam	0.525	0.651
Sagar	0.551	0.686
Damoh	0.614	0.291
Pithampur	0.658	0.623
Singrauli	0.72	0.56
Maihar	0.741	0.793
Dewas	0.743	0.808
Bhopal	0.755	0.698
Ujjain	0.784	0.821
Jabalpur	0.815	0.797
Katni	0.815	0.807
Gwalior	0.819	0.653
Indore	0.869	0.774
Mandideep	0.951	0.937

Table 9: Correlation Analysis of $PM_{2.5}$ and PM_{10}

From the correlation table above, it can be inferred that for all monitoring locations, there is a positive correlation between PM_{10} and $PM_{2.5}$ parameters.

The NO_x and ozone, however, showed a strong negative correlation as depicted in Fig. 12.

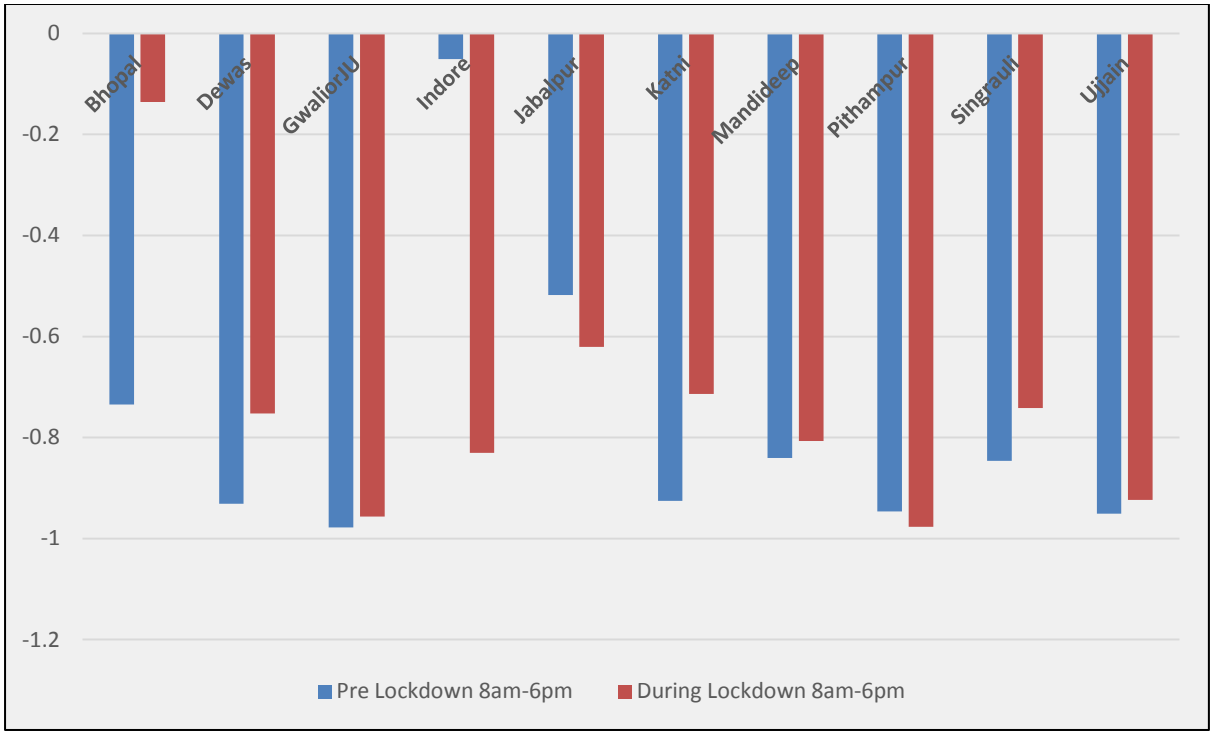


Figure 12: Ozone and NOx Correlation

6.3. Frequency Distribution Analysis

The Frequency distribution or Data range analysis, which measures spread of values, was also performed for the monitoring data results obtained during the study course. This analysis gives a clear picture of the concentration range which remained dominant and the one which was the least. A set of range was created for different parameters depending on data.

6.3.1. Frequency Distribution of PM_{10}

A total of eight sets were created for PM_{10}, minimum range being 0 to 75 and >525 the highest one. A total of 69627 observations for PM_{10} were recorded across the State during pre-lockdown period. It was noticed that the range of 75 to 150 $\mu g/m^3$ was the most dominant with ~50% of the observed values of PM_{10} falling under this category. Next to it was the range between 0 to 75 $\mu g/m^3$ which was 27.1% of the total observations of PM_{10}, i.e. 27.1% times the PM_{10} value was recorded in the range of 0 to 75. The concentration of PM_{10} in the range of 150 to

225 µg/m^3 was noticed 15.6% of the total observations. The results in other set of range were minimal. The PM_{10} concentration >525 µg/m^3 was 0.5% of the total observations. The Histograms showing Frequency vs. Concentration value is depicted below in Fig. 13 to 18.

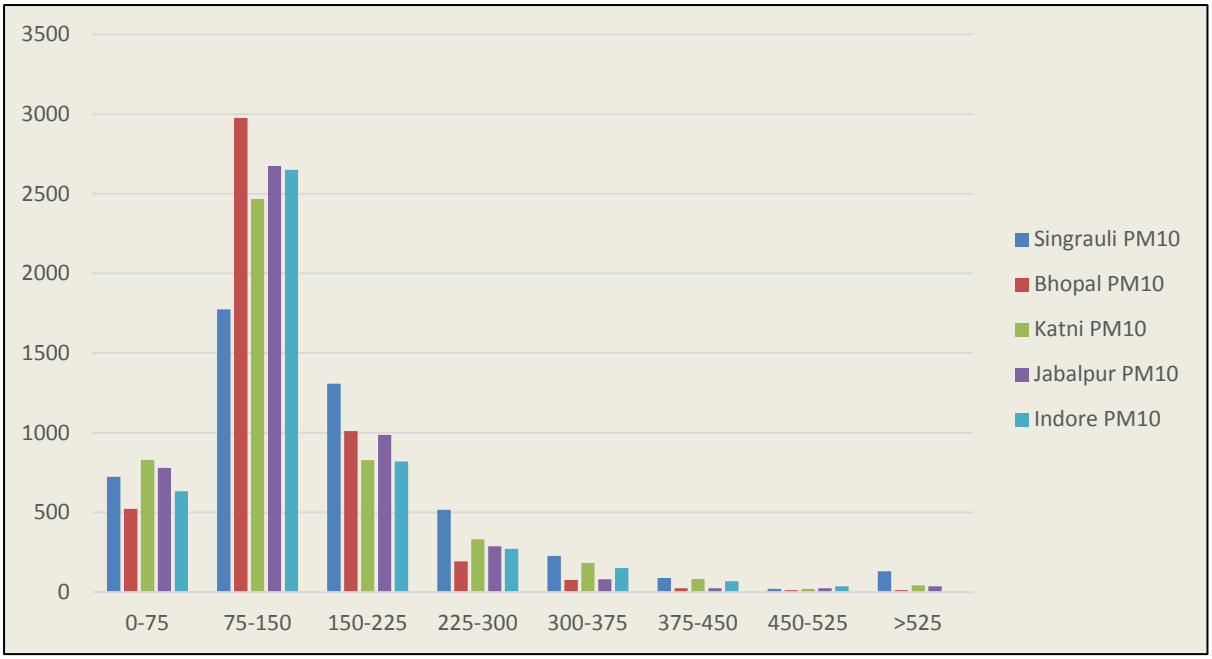


Figure 13: Pre Lockdown Histogram of PM_{10} - Cluster 1

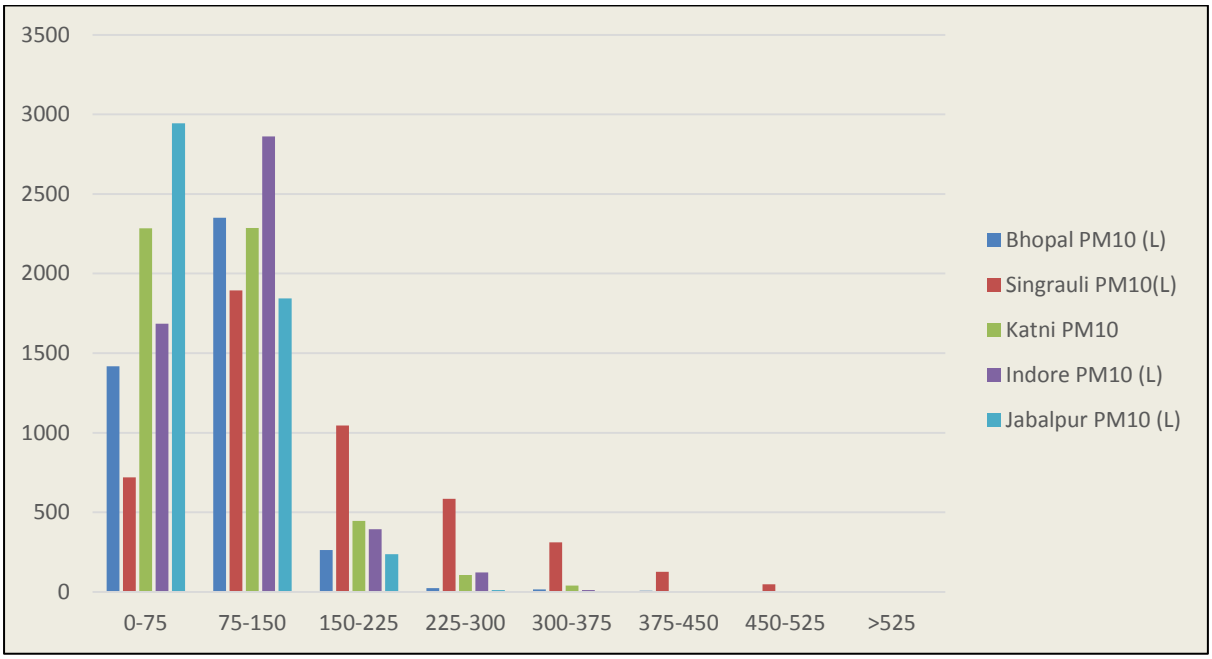


Figure 14: Lockdown Histogram of PM_{10} - Cluster 1

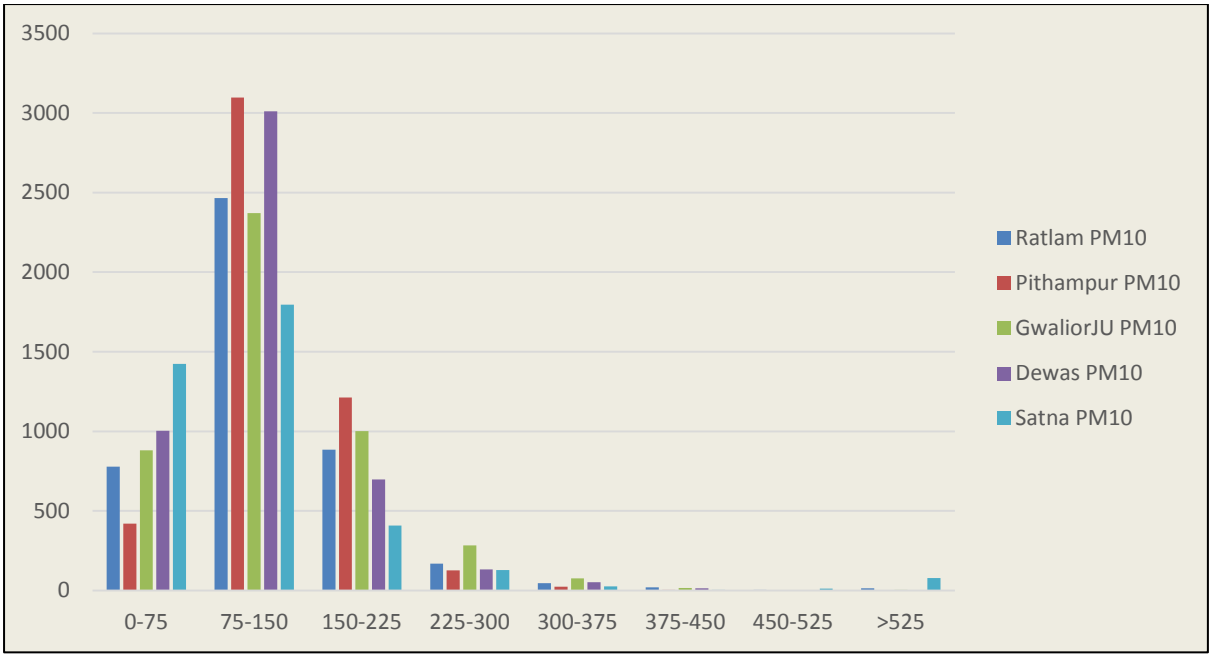


Figure 15: Pre lockdown Histogram of PM_{10} - Cluster 2

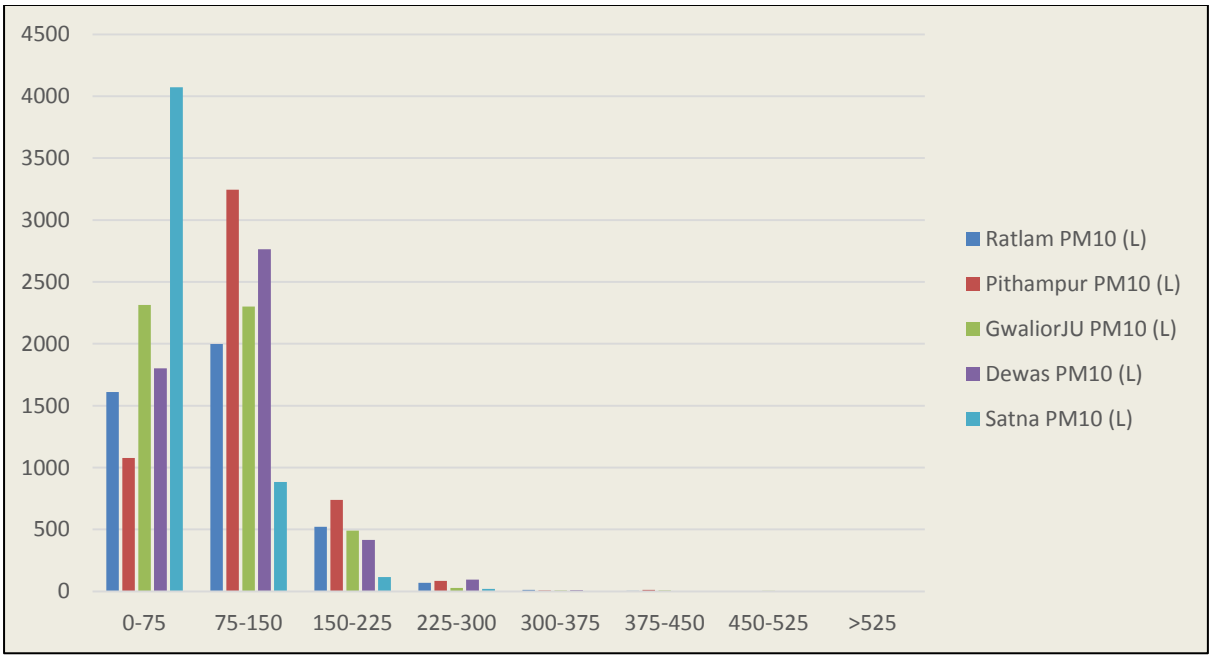


Figure 16: During Lockdown Histogram of PM_{10} - Cluster 2

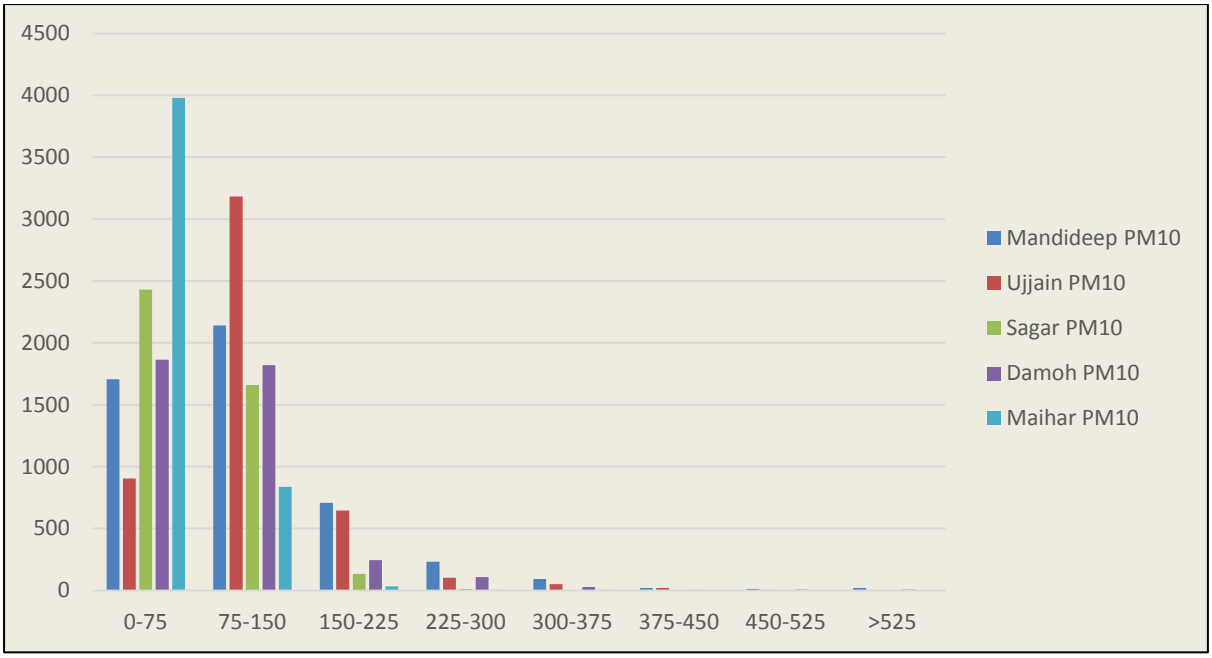


Figure 17: Pre lockdown Histogram of PM_{10} - Cluster 3

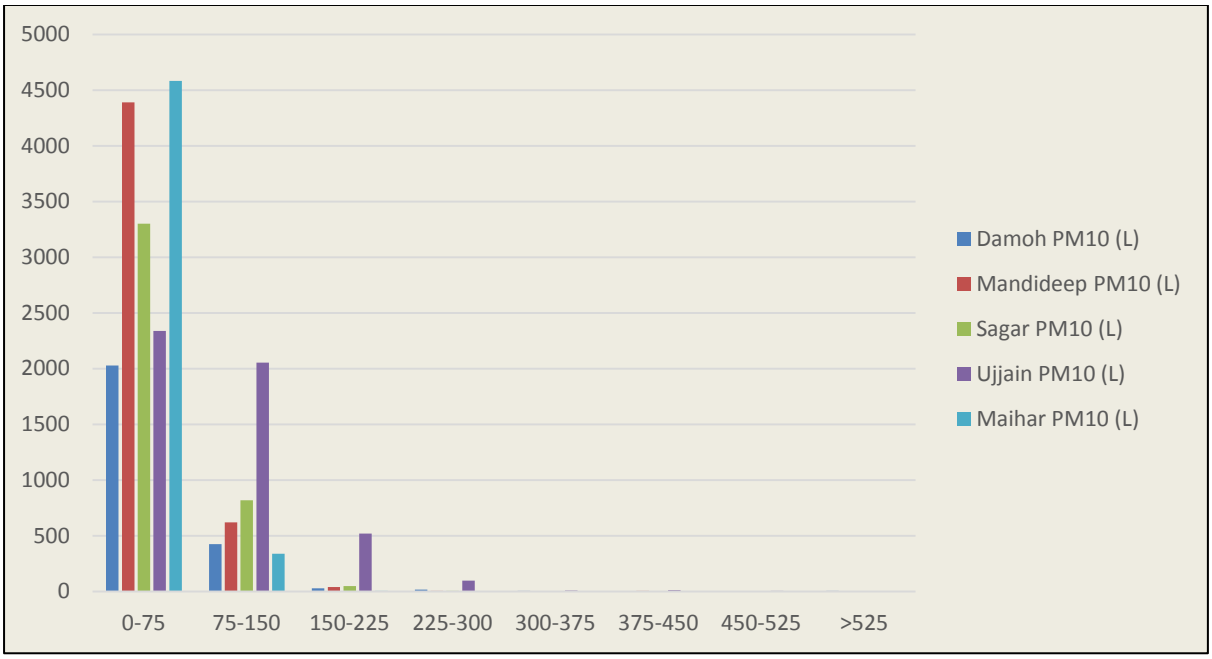


Figure 18: During Lockdown Histogram of PM_{10} - Cluster 3

6.3.2. Frequency Distribution of $PM_{2.5}$

A total of seven sets were created for $PM_{2.5}$, minimum range being 0 to 45 and >270 the highest one, for the analysis. During the pre-lockdown period it was observed that among total 68843 observations 61% values fell in the range of 0 to 45µg/m^3 and 29.6 % values fell in the range of 45 to 90 µg/m^3. The details of other percentage range falling under different sets of data can be referred in Fig. 19 to 24 .

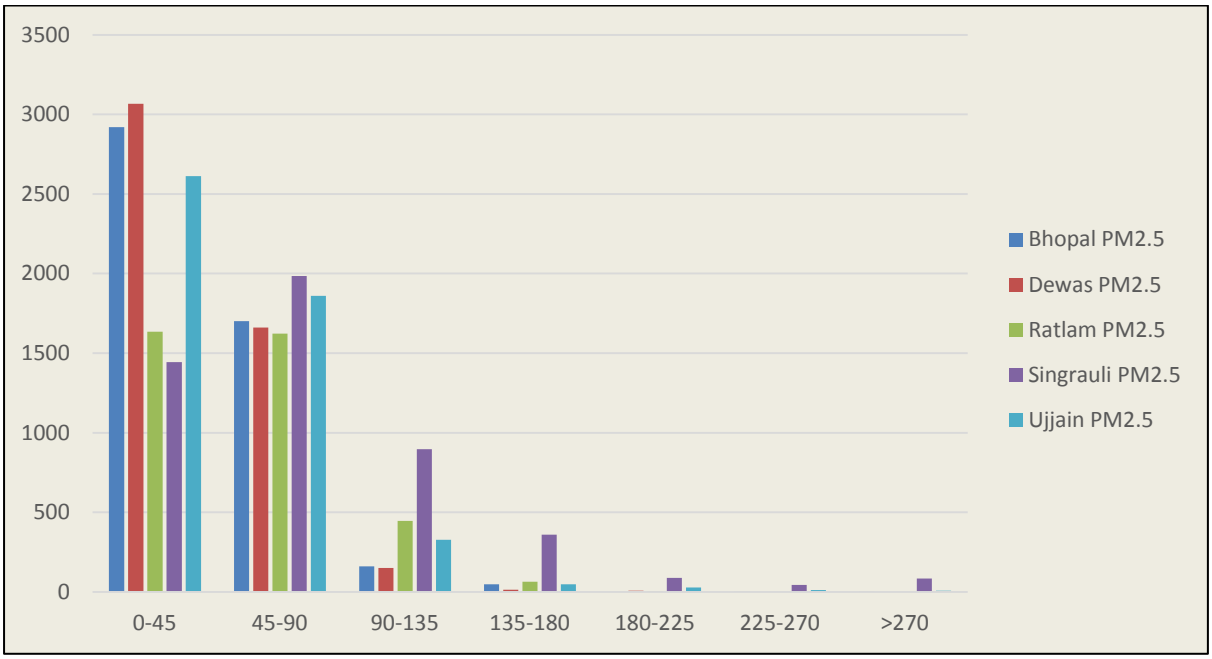


Figure 19: $PM_{2.5}$ During Pre Lockdown – Cluster 1

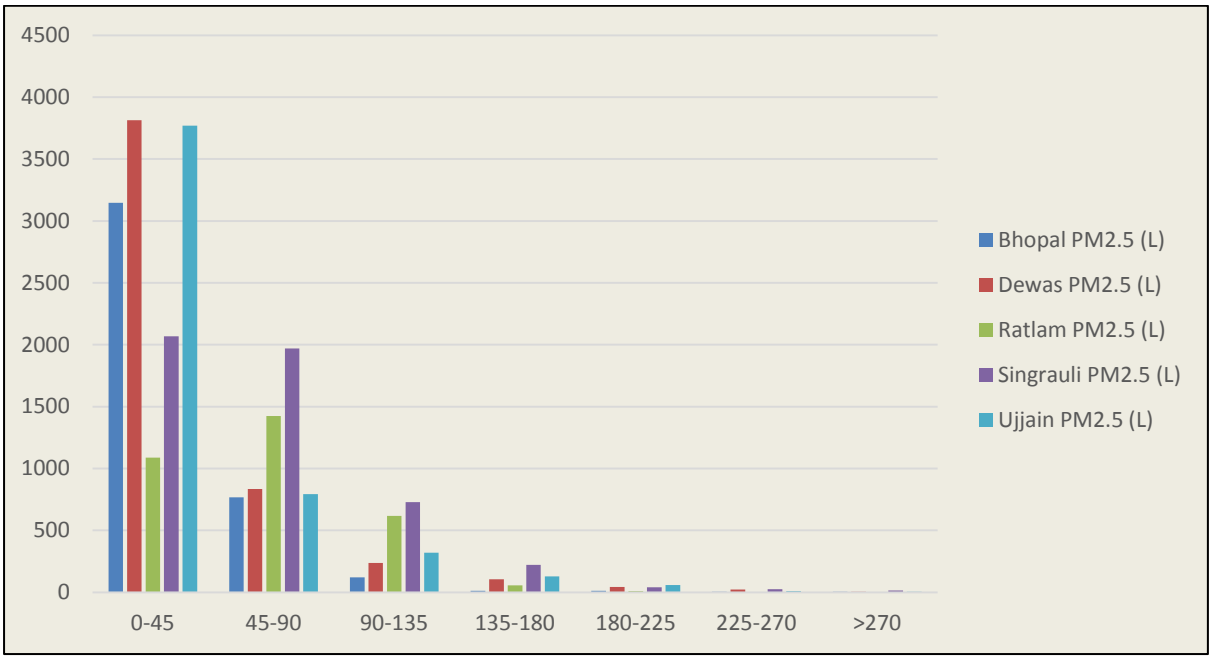


Figure 20: $PM_{2.5}$ During Lockdown – Cluster 1

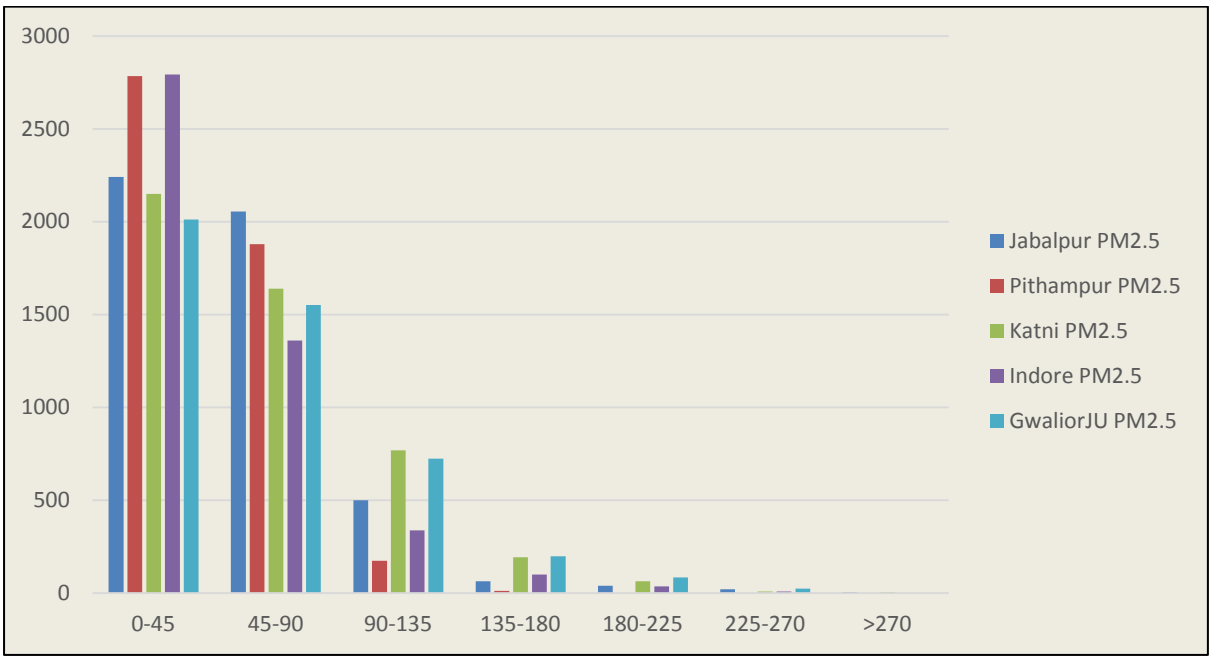


Figure 21: $PM_{2.5}$ During Pre Lockdown – Cluster 2

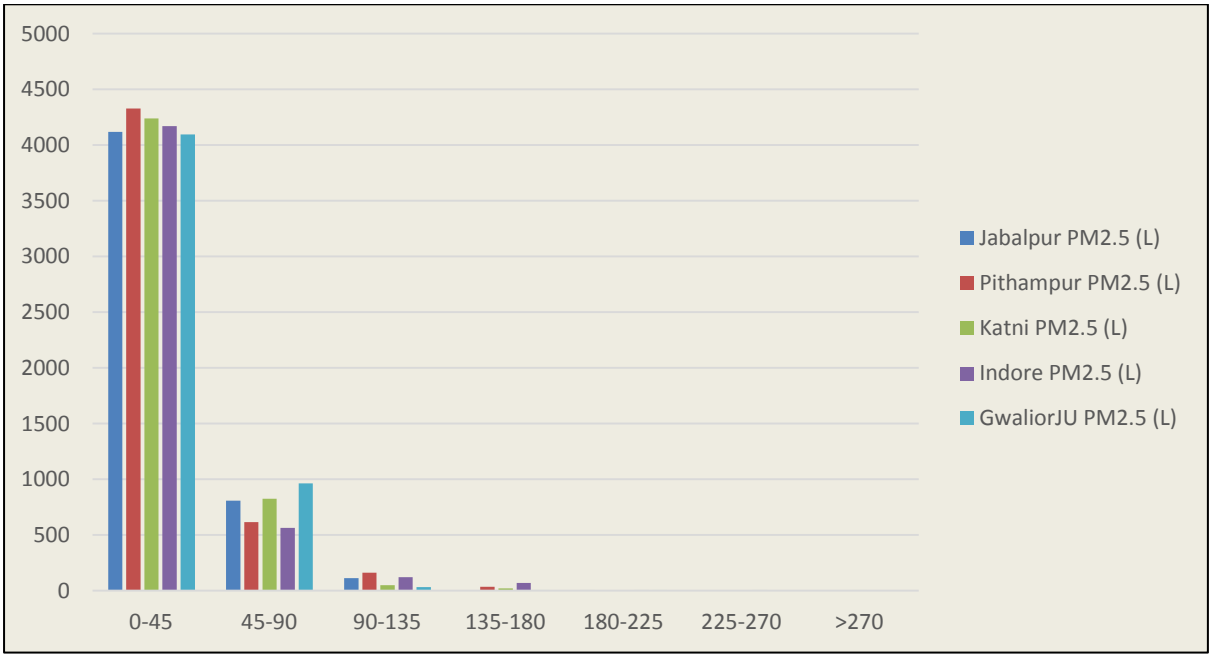


Figure 22: $PM_{2.5}$ During Lockdown – Cluster 2

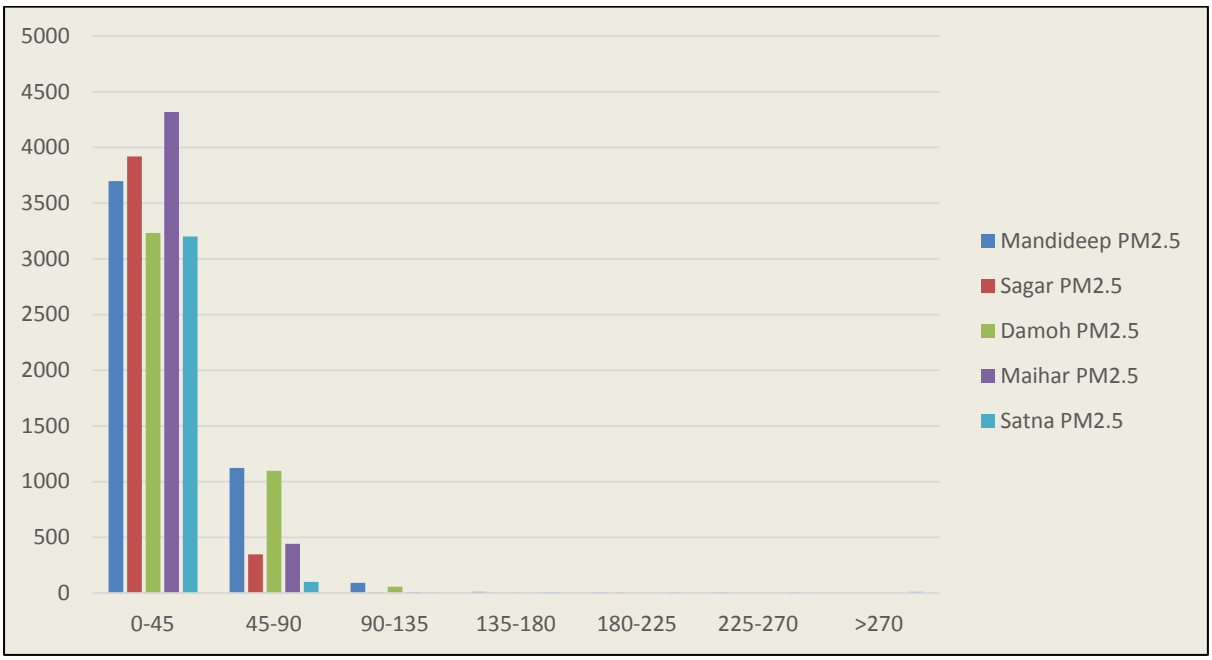


Figure 23: $PM_{2.5}$ During Pre lockdown – Cluster 3

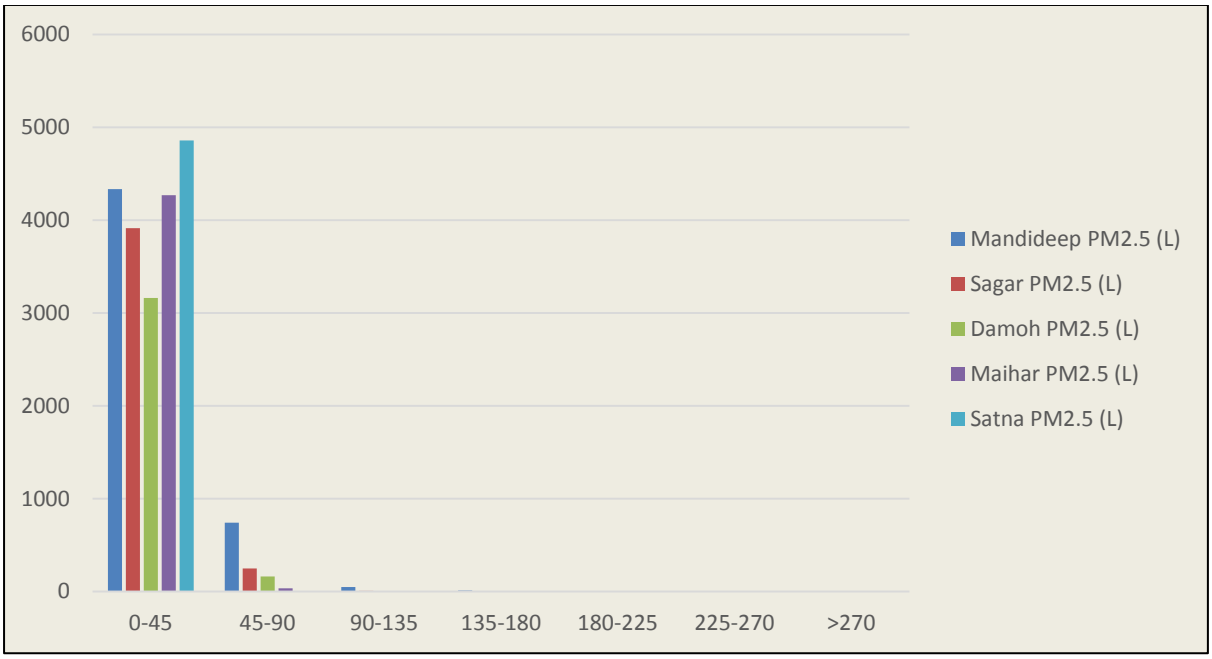


Figure 24: $PM_{2.5}$ During Lockdown – Cluster 3

6.4. Spread of Data Values and Time Relation

Another Intra-day distribution analysis of State-wide data was performed to find out the spread of data values with time relation. This gives information about the particular time slot of day when the value of parameters was observed to be maximum or minimum at any station. The study reveals that the particulate pollution level was higher during 8 pm to 1 am and 8 am to 10 am and it was comparatively low during rest of the hours during the entire study period.

6.4.1. Intra-day Distribution of PM_{10}

For the data analysis purpose the monitoring locations have been put into three buckets. Each bucket is clustered based on proximity of their average PM_{10} values to each other. The following three sets of graphs for 15 locations, Fig. 25 to 30, each showing values of five locations, for each hour of the day. This also helps us visualize the standard deviation of PM_{10} explained above. In all the clusters, there is a distinct pattern showing PM_{10} level peaks twice a day and attains trough too twice daily at time slots stated above.

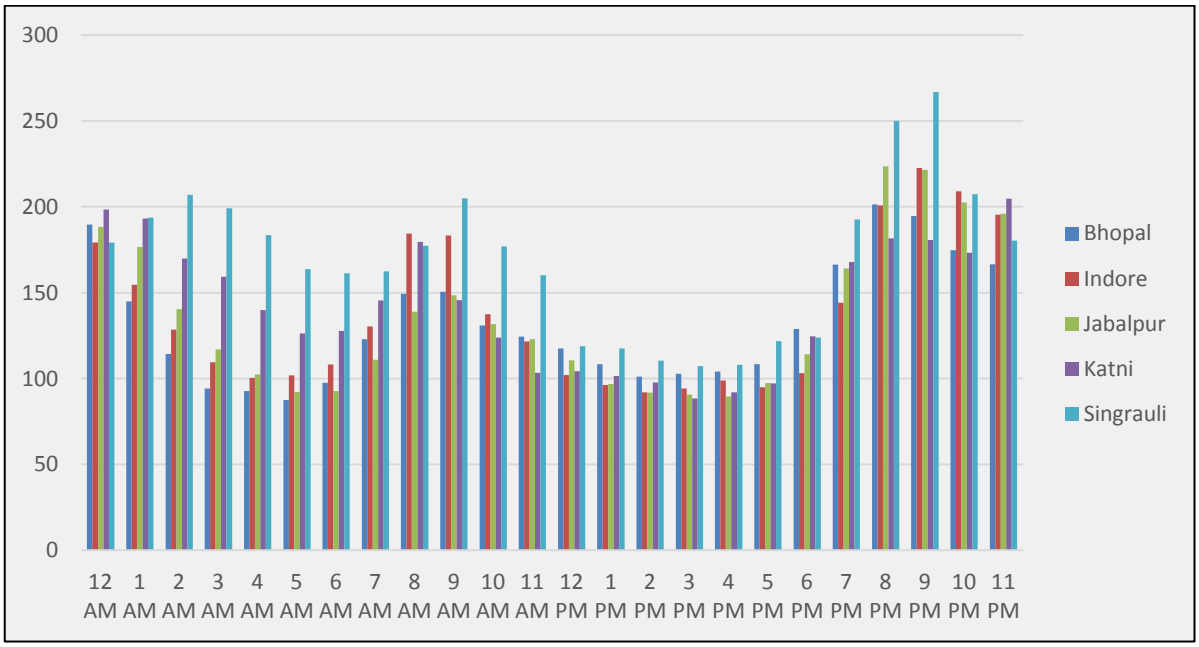


Figure 25: PM_{10} Concentration against Time hour during Pre-Lockdown – Cluster 1

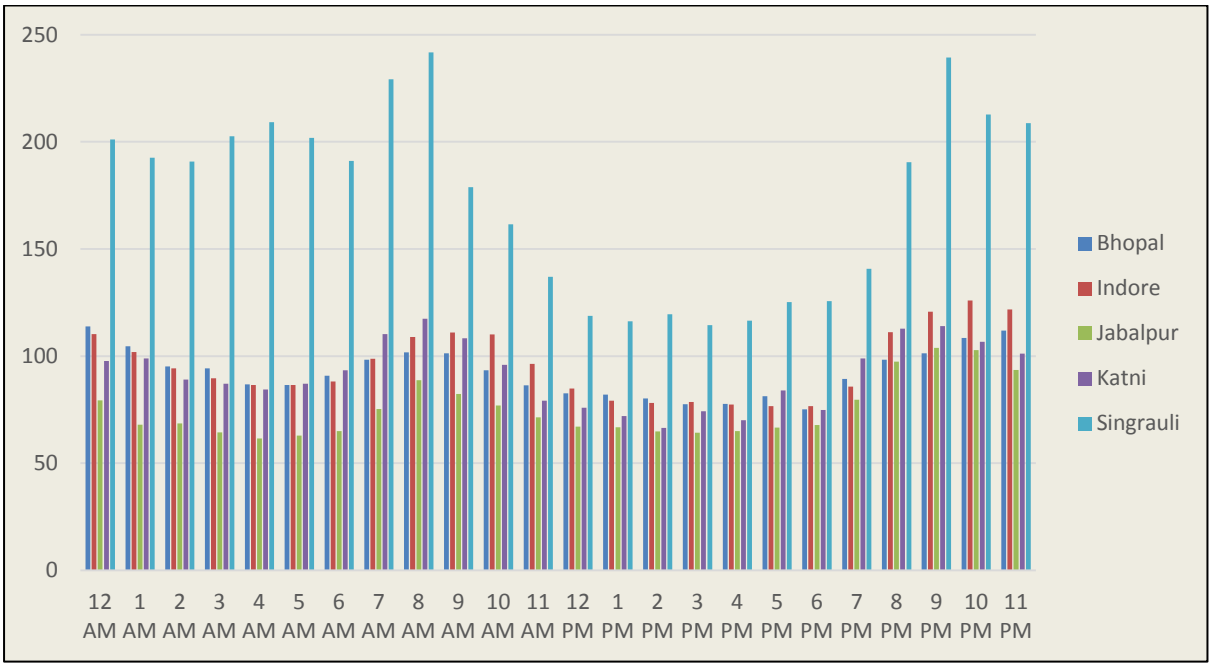


Figure 26: PM_{10} Concentration against Time hour during Lockdown – Cluster 1

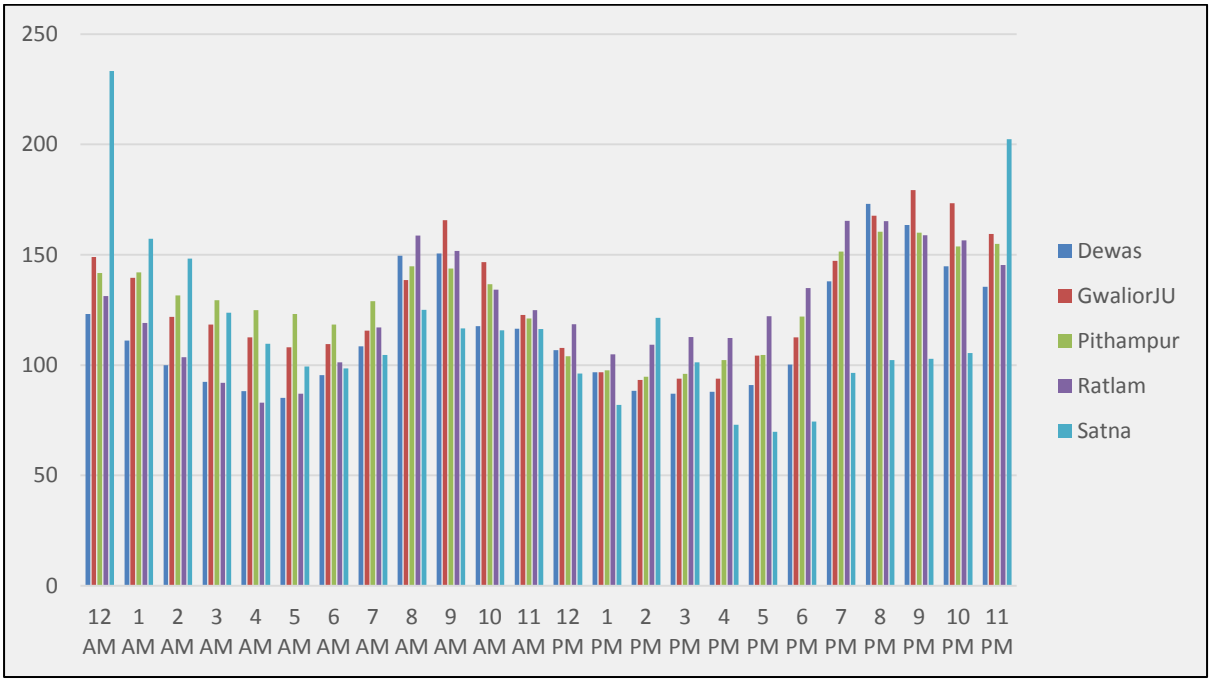


Figure 27: PM_{10} Concentration against Time hour during Pre-Lockdown – Cluster 2

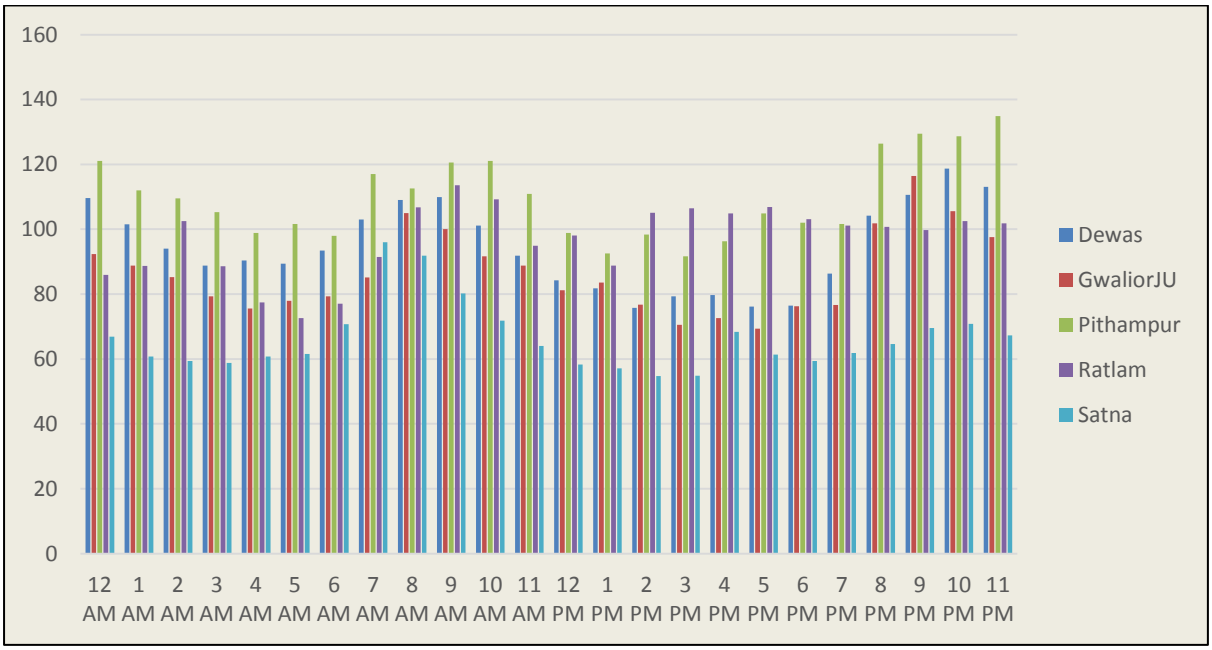


Figure 28: PM_{10} Concentration against Time hour during Lockdown – Cluster 2

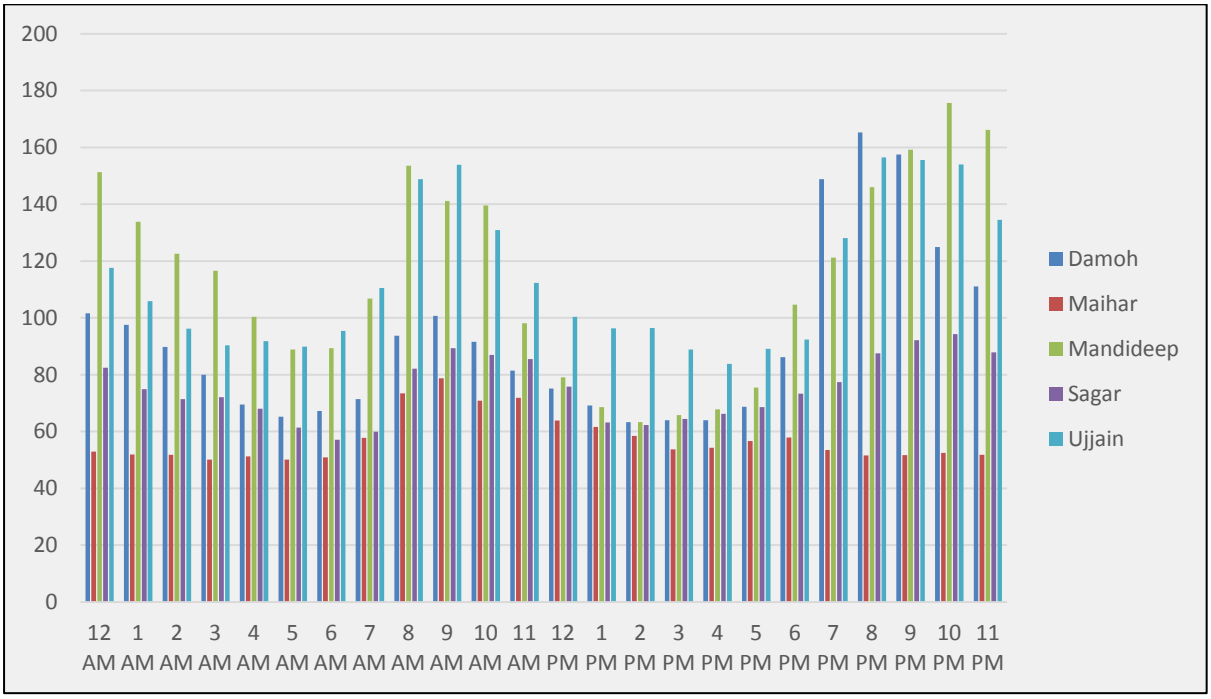


Figure 29: PM_{10} Concentration against Time hour during Pre-Lockdown – Cluster 3

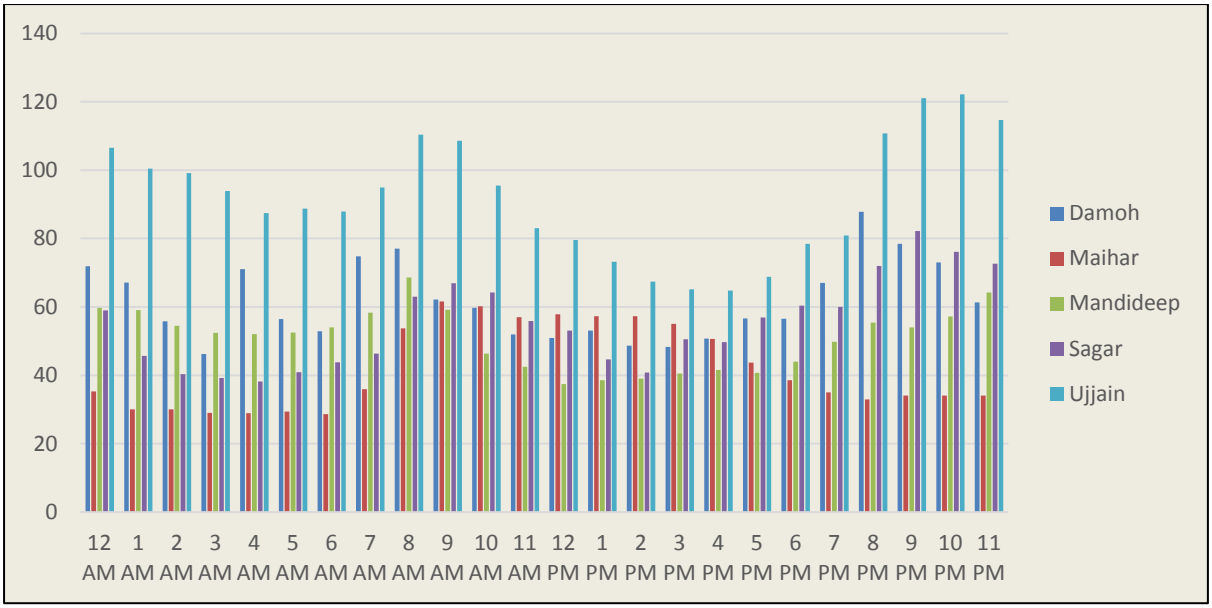


Figure 30: PM_{10} Concentration against Time hour during Lockdown – Cluster 3

The crest and trough time of PM_{10}noticed during the study period is tabulated below:

Particular	Period	Time	Details
Crest Time	Pre Lockdown	~ 9 am and 9pm	Possible vehicular emissions for office commute/ local parameters.
Trough Time	Pre Lockdown	~ 4amand 3:30pm	Lean industrial and vehicular activity time.
Crest Time	During Lockdown	~ 9 am and 9pm	Possible vehicular emissions for office commute/ other local parameters.
Trough Time	During Lockdown	~ 3:30pm	Lean industrial and vehicular activity time.

Table 10: Crest and trough time PM_{10}

6.4.2. Intra-day Distribution of $PM_{2.5}$

Like $PM_{10}$the monitoring locations have been put into three buckets for data analysis purpose. Each bucket is clustered based on proximity of their average $PM_{2.5}$ values to each other. The following three sets of graphs for 15 locations, Fig. 31 to 36, each showing values of five locations, for each hour of the day. This also helps us visualize the standard deviation of $PM_{2.5}$ explained above. Similar to PM_{10} there is a distinct pattern showing $PM_{2.5}$ level peaks twice a day and attains trough too twice daily at time slots in all the clusters.

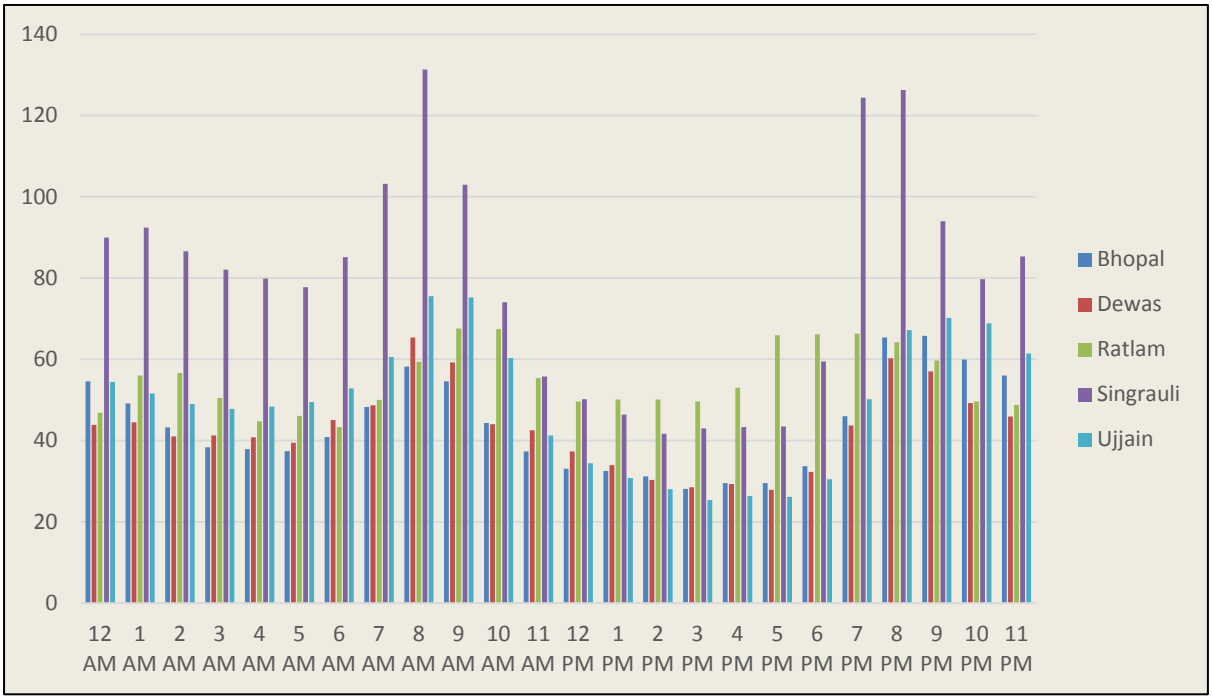


Figure 31: $PM_{2.5}$ Pre Lockdown - Cluster 1

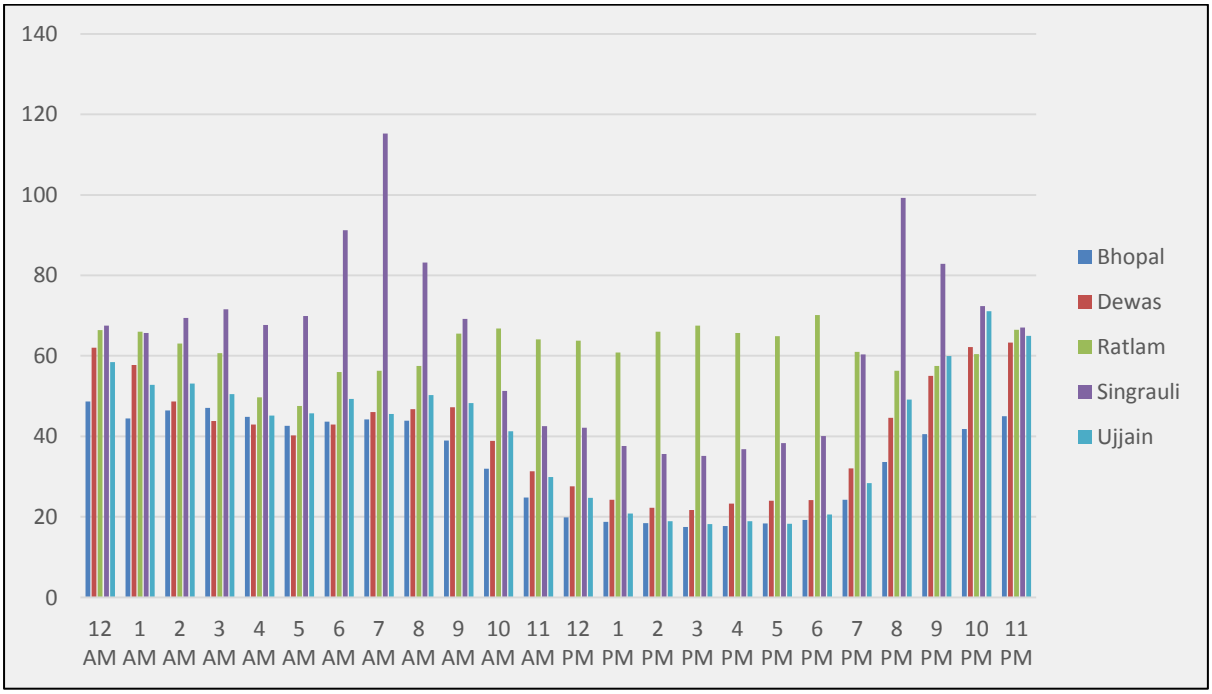


Figure 32: $PM_{2.5}$ During Lockdown - Cluster 1

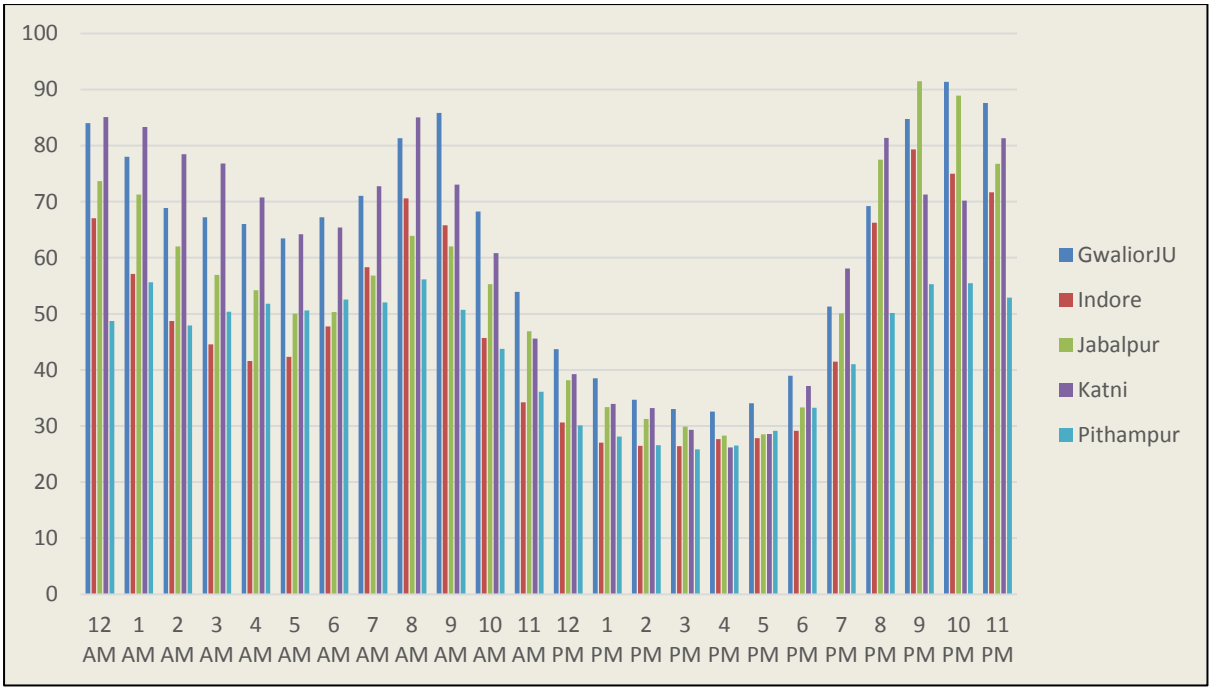


Figure 33: $PM_{2.5}$ Pre Lockdown - Cluster 2

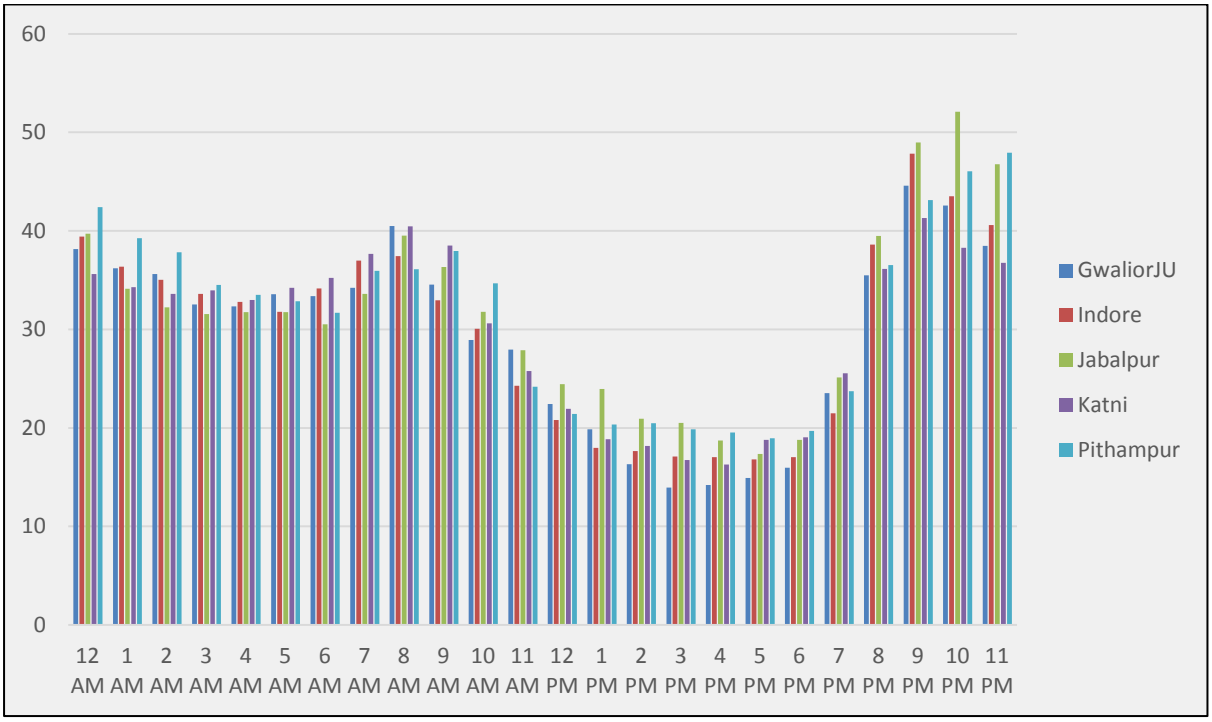


Figure 34: $PM_{2.5}$ During Lockdown - Cluster 2

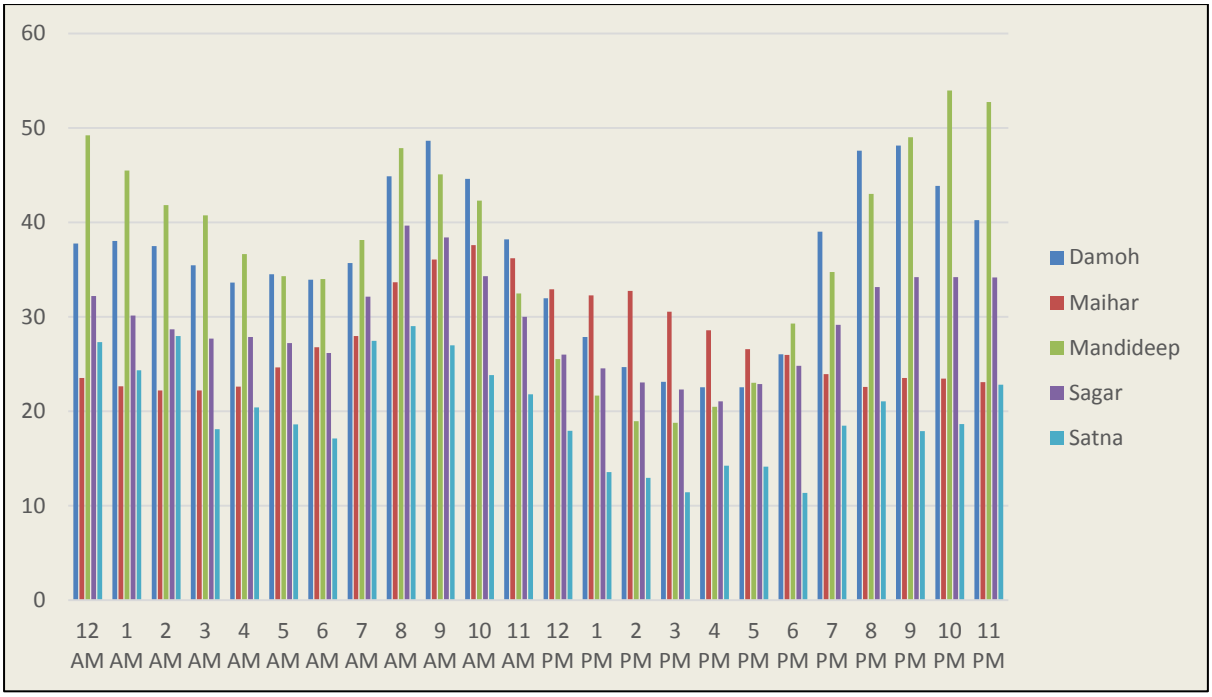


Figure 35: $PM_{2.5}$ During Pre lockdown - Cluster 3

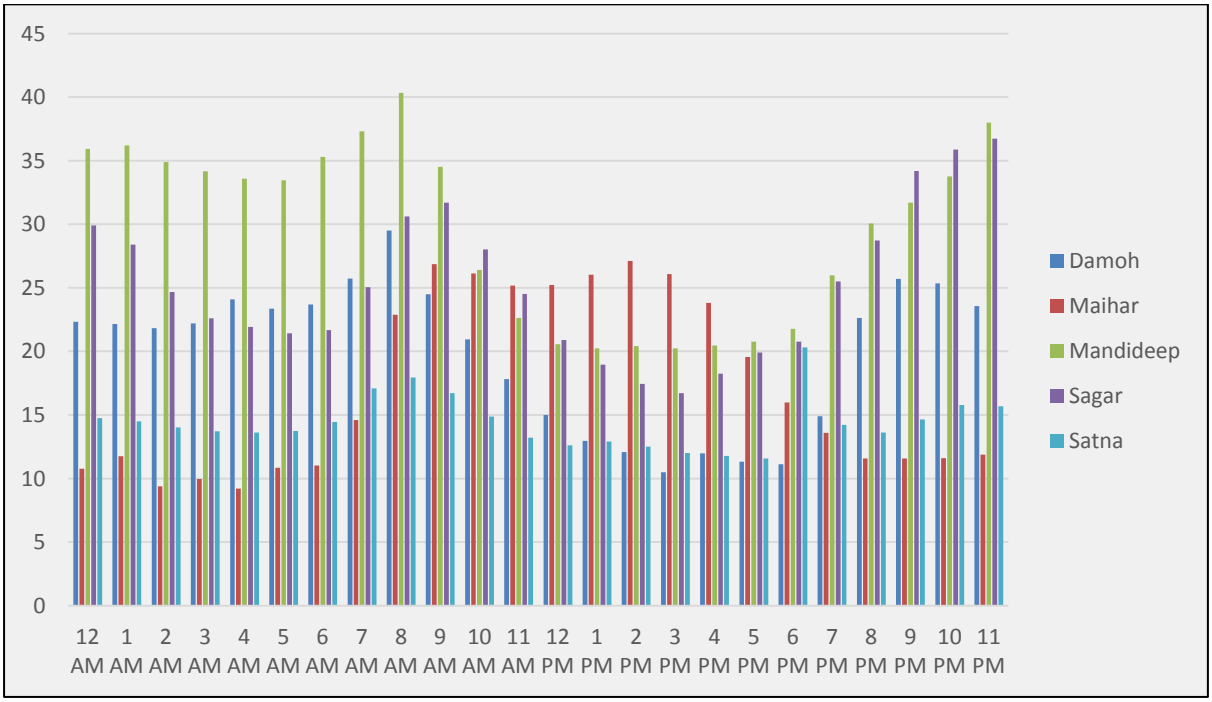


Figure 36: $PM_{2.5}$ During Lockdown - Cluster 3

The observed crest and trough time of $PM_{2.5}$ is tabulated below:

Particular	Period	Time	Details
Crest Time	Pre Lockdown	~ 9 am and 9pm	Possible vehicular emissions for office commute/ other local parameters.
Trough Time	Pre Lockdown	~ 4am and 3:30pm	Lean industrial and vehicular activity time.
Crest Time	During Lockdown	~ 9 am and 9pm	Possible vehicular emissions for office commute/ other local parameters.
Trough Time	During Lockdown	~ 3:30pm	

Table 11: Crest and Trough time of $PM_{2.5}$

6.5. Percentage Component of $PM_{2.5}$ in PM_{10}

A further observation on percentage component of $PM_{2.5}$ in PM_{10} was made during both the phases. During pre-lockdown the $PM_{2.5}$ contributed 38.42% of the PM_{10} concentration. It was noticed that the $PM_{2.5}$, as percentage of PM_{10}, during pre-lockdown varied from 17.2% to 48.3%, minimum being at Satna station and maximum at Maihar station. Similarly during lockdown the overall PM_{10} contained 39.64 part of $PM_{2.5}$. The percentage of $PM_{2.5}$ in PM_{10} varied from 21.8% to 63.5%, minimum being at Satna station and maximum at Ratlam station. Station-wise details can be referred in Fig. 37.

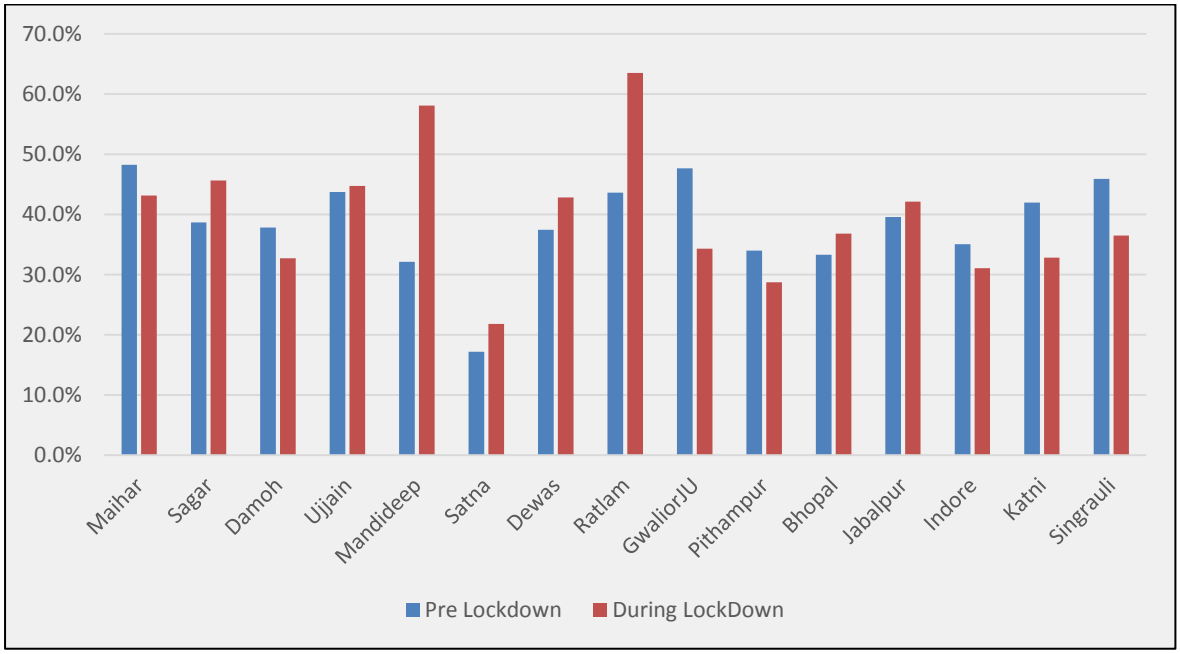


Figure 37: PM 2.5 as percent of PM_{10}

7. Salient Features of the Study

i. The Singrauli location was noticed to be the worst amongst all the locations during both the phases of study, i.e. pre-lockdown and lockdown.
ii. There was an unprecedented improvement in the ambient air quality during lockdown with Air Quality Index at most of the locations falling under 'Good' and 'Satisfactory' range.
iii. The aggregated State-wide AQI fell from Moderate category to satisfactory category.
iv. The overall AQI % showed 13% in 'Good' category, 52.5% in satisfactory category, 31.8% in moderate category 2 % in poor category and 0.14% in very poor category. There was no instance of AQI reaching 'Severe' range at any of the locations.
v. During lockdown all the monitoring locations have seen an improvement in the air quality with maximum decline of 50.9% AQI at Mandideep station followed by Satna with decline of AQI by 49.1% and Damoh station with 38.7% recording the top three improved locations.
vi. The Singrauli station was found to notice lowest improvement amongst all the stations during lockdown with only 7.8% decline in AQI.
vii. PM_{10} parameter was noticed to be the most prominent pollutant at all the locations during lockdown period with a contribution of 67.57% of all the AQIs. During pre-lockdown the contribution of PM_{10} as prominent pollutant was 76.18%.
viii. The ozone contributed 17.77% times as prominent pollutant during lockdown as against 2.51% during pre-lockdown.
ix. Ammonia did not contribute to the AQI at any location during both the phases of study.
x. The NO_x parameter was found to have the overall highest reduction with 45%.
xi. SO_2 parameter was found to have the overall minimum reduction with 16%.
xii. The reduction in PM_{10} was noticed to be 28% and $PM_{2.5}$ 27% during lockdown.
xiii. The maximum reduction of 55% in PM_{10} was noticed at Mandideep station. The $PM_{2.5}$ saw the maximum reduction of 52% at Gwalior station, NO_x71% at Gwalior station, SO_2 68% at Ratlam station, CO 53% at Satna station, NH_3 54% at Mandideep station and O_3 62% at Jabalpur station.
xiv. The PM_{10} exceeded the prescribed ambient air standards 62.22% times cumulatively during pre-lockdown. During lockdown it was 31.11%.
xv. The $PM_{2.5}$ exceeded the prescribed ambient air standards 21.11% times cumulatively during pre-lockdown. During lockdown it was 11.73%.
xvi. The Ammonia did not exceed the prescribed standards at any instance during both the phases of study.

xvii. During pre-lockdown period the PM_{10} exceeded the most 87.04% times at Katni station whereas during lockdown it exceeded the most 94.44% at Singrauli.

xviii. During pre-lockdown period the $PM_{2.5}$ exceeded the most 70.37% times at Singrauli station whereas during lockdown it exceeded the most 59.26% at Ratlam station.

8. Conclusion

An overall improvement in the air quality was noticed during lockdown period as the regional contribution was largely absent due to non operation of industrial and other establishments. The contributing sources were only local, viz. Emergency transport activities, refuse burning of garbage, road dust resuspension due to transport of vehicles and blowing of surface winds etc. The variation in ambient air quality at various locations was due to varies contribution by local sources. The reduction in air pollution largely attributed to the restriction of industrial, commercial, building constructions and vehicular activities.

Despite restrictions on all the activities the AQI did not come below 50, i.e. 'Good' category, at any of the monitoring locations, although it almost touched this category at few locations with AQI value between 50 and 55. The ozone level was also noticed unexpectedly high at few locations for the reasons stated in the report.

The AQI may be in the 'Good' or 'Satisfactory' category but the elevated level of ozone, which is considered as secondary pollutant, raises concern because it can affect the health conditions. There is, thus, need to plan a strategy to reduce the secondary pollutants too. The study also points that the shift from use of conventional fossil fuels to renewable or clean energy fuels can also make a distinct change in the pollution scenario.

A key point from the above study is about the background concentration of ambient air parameters and baseline data for future reference. The AQI did not achieve 'Good' category despite non-operation of all the pollution emitting sources during lockdown period. Considering this fact there is need to give a thought to the existing criteria of AQI and also if there is any need to raise the limit of background ambient data for future studies.

Although it appears not practical to see this lockdown as a prospective measure to be adopted to control the extreme air quality situations in some pollution prone cities of the country but this can be kept as a reserved option to apply if the situation in the society worsens due to extreme air pollution.

9. Reference Sources

i. https://urbanemissions.info/india-apna/

ii. http://www.indiaenvironmentportal.org.in/content/467253/impact-of-janta-curfew-lockdown-on-air-quality/

iii. https://www.teriin.org/library/files/Pollution-level-in-India.pdf

iv. https://en.wikipedia.org/wiki/List_of_districts_of_Madhya_Pradesh_by_area

v. https://www.census2011.co.in/census/state/districtlist/madhya+pradesh.html

vi. https://aqicn.org/city/india/dewas/bhopal-chauraha/

vii. https://aqicn.org/city/india/mandideep/sector-d-industrial-area/

viii. https://urbanemissions.info/india-apna/

ix. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7266738/

x. https://www.mpinfo.org/MPinfoStatic/English/factfile/mp.asp

xi. https://www.census2011.co.in/census/state/districtlist/madhya+pradesh.html

xii. https://www.latlong.net/place/madhya-pradesh-india-21644.html