Central Pollution Control Board
(Ministry of Environment, Forest and Climate Change)
Govt. of India, Delhi

IMPACT OF LOCKDOWN (25th March to 15th April) ON AIR QUALITY

21st APRIL, 2020

The nationwide Lockdown, in effect since the midnight of 24 March in view of COVID-19 pandemic, has resulted in significant improvement in air quality in the country, as revealed by data analysis and comparison of data for time before enforcement of restrictions. The Lockdown was announced after a 14 hour voluntary curfew, called Janata curfew, was observed on 22 March, after which CPCB had published a report titled "IMPACT OF JANTA CURFEW & LOCKDOWN ON AIR QUALITY" dated 31.03.2020, describing the improvement in air quality in the country. This report is in continuation to the same. The major sectors contributing to air pollution are transport, industries, power plants, construction activities, biomass & refuse burning, road dust resuspension and residential activities. In addition, certain activities such as operation of DG sets, restaurant, landfill fires, etc. also contribute to air pollution. Under the nationwide lockdown, all transport services – road, air and rail were suspended with exceptions for essential services. Educational institutions, industrial establishments and hospitality services were also suspended. As a result, air quality improvement has been noted in many towns and cities across the nation.

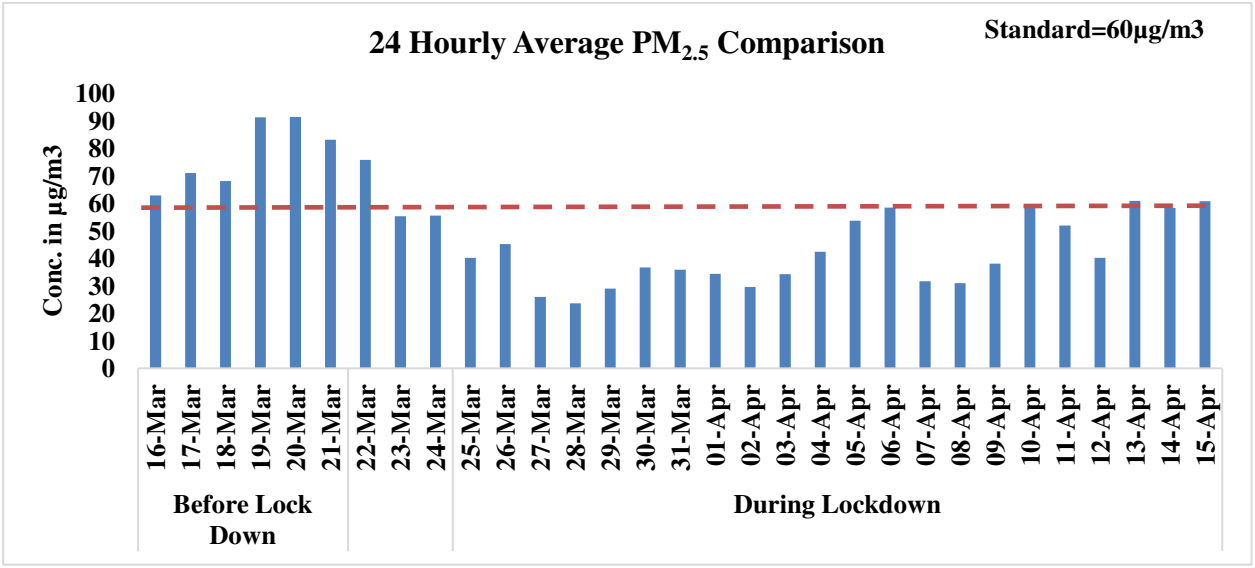
Data generated from continuous ambient air quality monitoring network has been analysed for Delhi with 38 stations and its neighbouring major NCR towns i.e. Faridabad, Gurugram, Noida and Ghaziabad with 4 stations each for the period from 16 March 2020 to 15 April 2020. Air quality trends have been studied in two phases: Pre-lockdown phase (16-21 March 2020) and Lockdown phase (25 March- 15 April 2020). AQI values as per CPCB bulletin have also been analysed to observe the general trend of air quality improvement in the country.

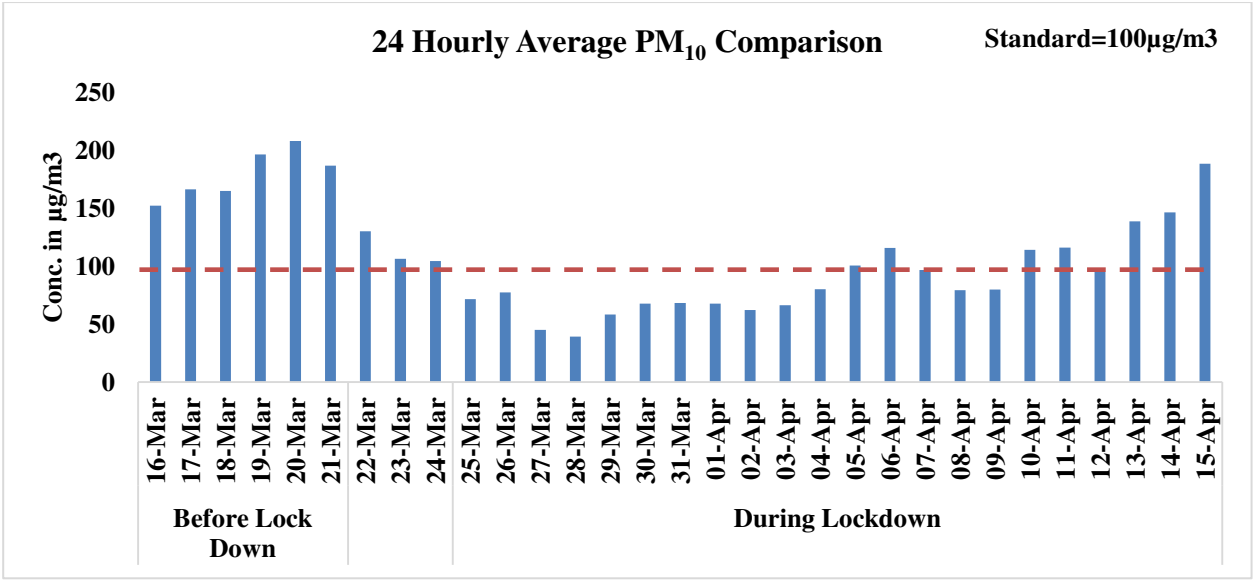
EFFECT OF LOCKDOWN IN DELHI

During the lockdown period, as a result of combination of reduced vehicles on the road, functioning of only essential commercial units and prevailing weather conditions, significant reduction in $PM_{2.5}$, PM_{10} and NO_2 levels were observed. Overall, 46% reduction in $PM_{2.5}$ and 50% reduction in PM_{10} was observed during the lockdown period. Similar level of reduction in PM_{10} & $PM_{2.5}$ primarily indicate reduction in combustion and industrial sources which are common to both fractions of Particulate matter. Since 81% of Delhi's NOx comes from the transport sector (as per TERI Emission Inventory, 2018), restrictions on vehicular activity led to a 56% reduction in NO_2 levels and over 37% reduction in CO levels during the lockdown period, compared pre- lockdown period. Since there are restrictions in place on the transport sector and over industrial operations, the two major sources of Benzene emissions, 47% reduction in Benzene levels has been observed. However, only 19% reduction was seen in SO_2 levels which may be due to the fact that over

70% of Delhi's SO_2 originates from power plants located around Delhi (as per TERI Emission Inventory, 2018) and power plants were operational during lockdown period. Other sources of SO_2 include restaurants and some industries, which might be operational during the lockdown period along with biomass/refuse burning in some areas in and around Delhi. However, most of these eateries and industries in Delhi have shifted from coal to other less polluting energy sources and thus, power plants appear to be the most likely source of Delhi's SO_2. 24 Hourly Average $PM_{2.5}$ and PM_{10} were within National Ambient Air Quality Standards (NAAQS) for 20 and 15 days respectively in 22 days of the lockdown period, while NO_2 levels were 75% less than their 24 hourly standard during the lockdown period. PM_{10}, $PM_{2.5}$, NO_2 and SO2, 24 hourly average levels dropped as low as 24 µg/m^3, 39 µg/m^3 , 15 µg/m^3 and 10 µg/m^3 respectively during the lockdown period.

A 27% increase in $PM_{2.5}$ and a 65% increase in PM_{10} compared to the first two weeks of the lockdown (25 March to 6 April) was observed in the second week of April (7 April to 15 April). However, $PM_{2.5}$ and PM_{10} levels were still lower by 39% and 35% respectively than pre-lockdown concentrations. This may primarily be attributed to change in meteorological conditions. Due to the onset of summers, temperature has started to increase with a minimum and maximum temperature of 12.6 ºC and 27 ºC on 16th March 2020 to 24 ºC and 40ºC on 15th April 2020, leading to dry and dusty conditions. Moreover, it was reported that a mild dust storm from western part of the country and the gulf regions hit Delhi on 14- 15th April, thus rapidly increasing the PM_{10} levels in Delhi and NCR




24 Hourly Average PM10 Comparison
Standard=100µg/m3
Conc. in µg/m3
250
200
150
100
50
0
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
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06-Apr
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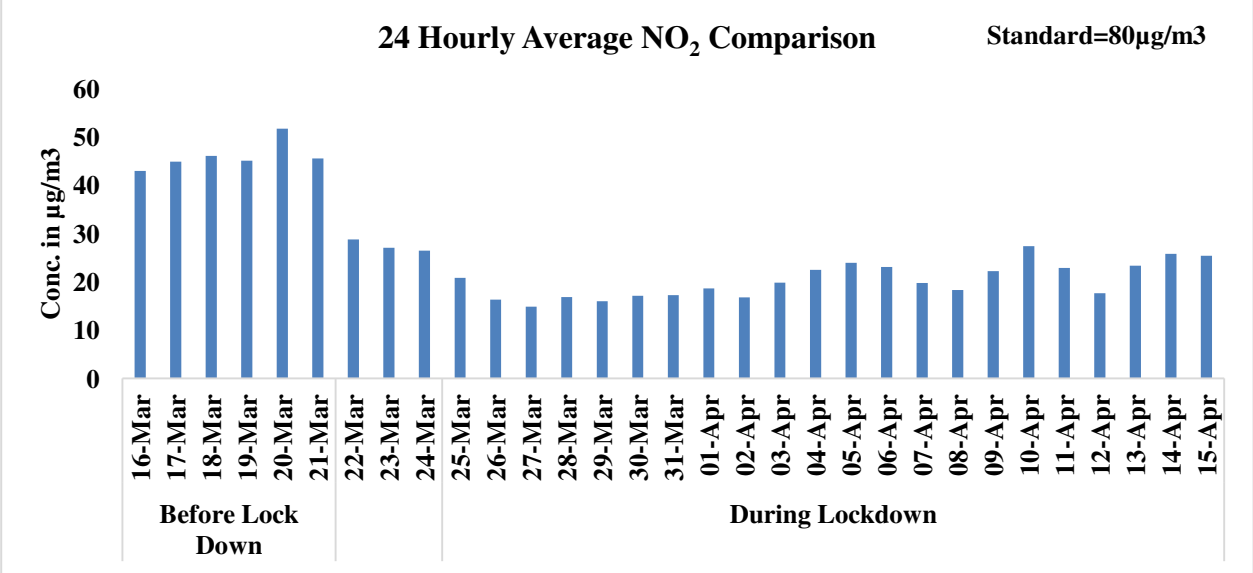
11-Apr
12-Apr
13-Apr
14-Apr
15-Apr
Before Lock Down
During Lockdown


24 Hourly Average NO2 Comparison
Standard=80µg/m3
Conc. in µg/m3
60
50
40
30
20
10
0
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
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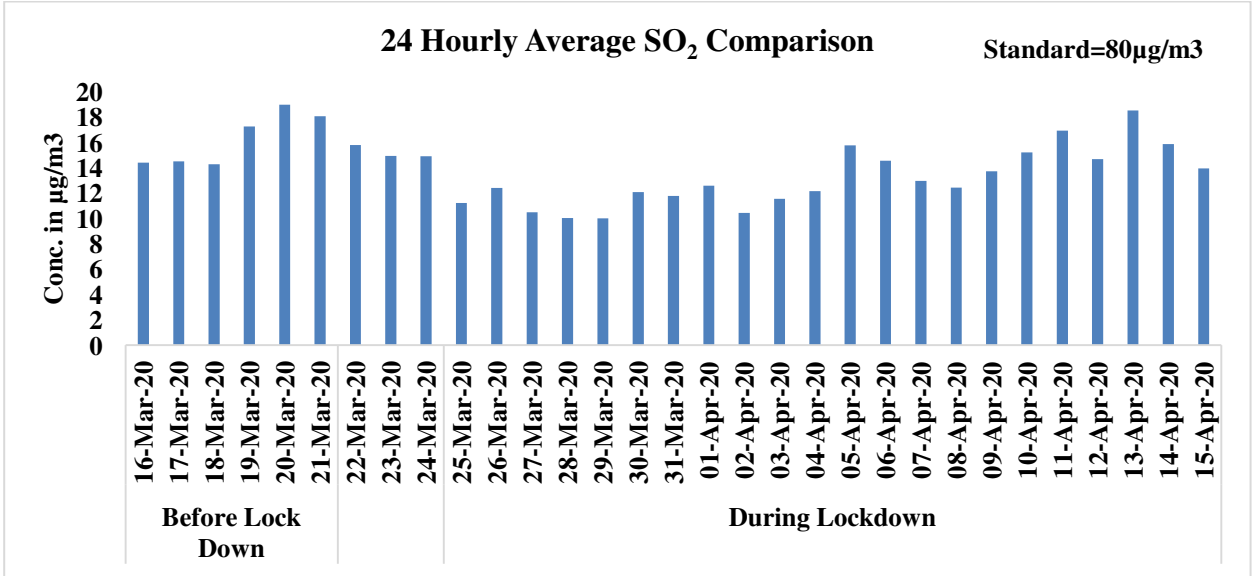
10-Apr
11-Apr
12-Apr
13-Apr
14-Apr
15-Apr
Before Lock Down
During Lockdown


24 Hourly Average SO2 Comparison
Standard=80µg/m3
Conc. in µg/m3
20
18
16
14
12
10
8
6
4
2
0
16-Mar-20
17-Mar-20
18-Mar-20
19-Mar-20
20-Mar-20
21-Mar-20
22-Mar-20
23-Mar-20
24-Mar-20
25-Mar-20
26-Mar-20
27-Mar-20
28-Mar-20
29-Mar-20
30-Mar-20
31-Mar-20
01-Apr-20
02-Apr-20
03-Apr-20
04-Apr-20
05-Apr-20
06-Apr-20
07-Apr-20
08-Apr-20
09-Apr-20
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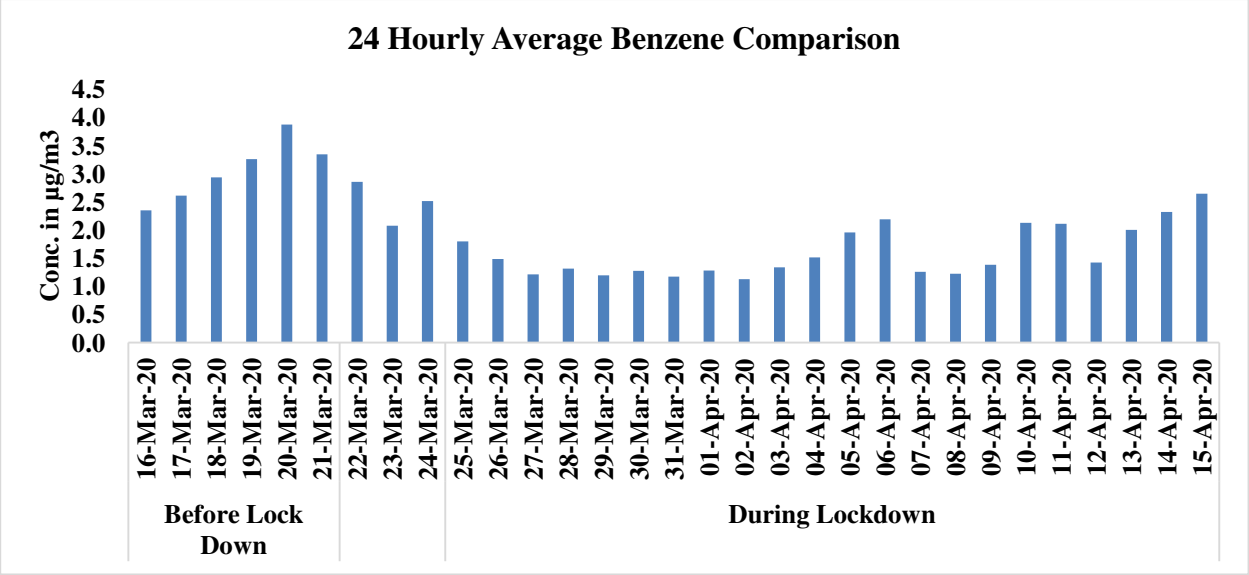
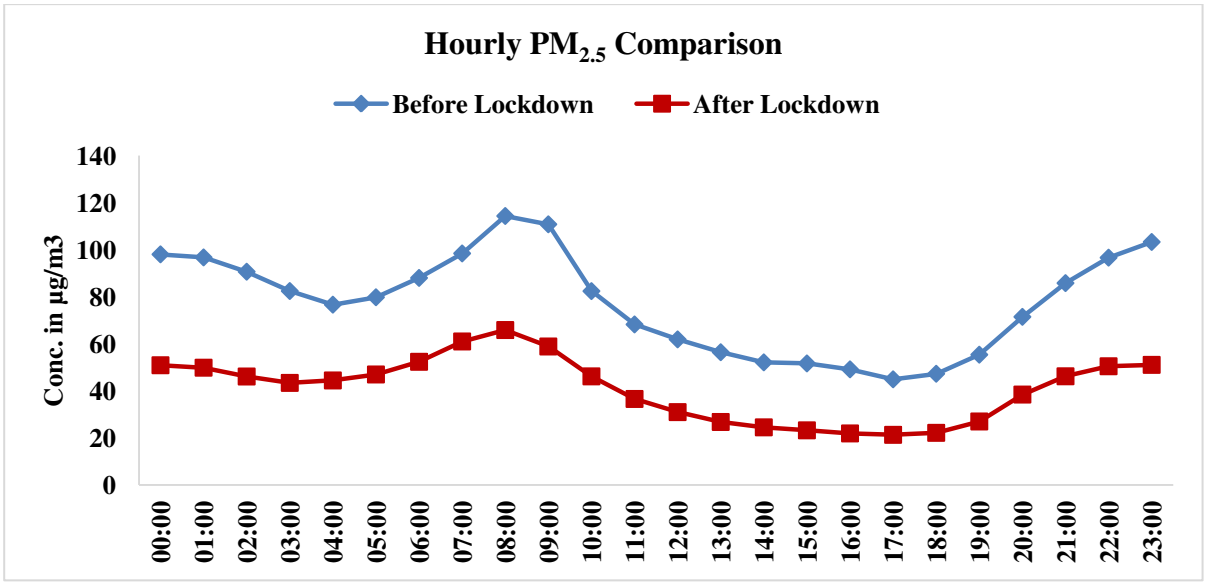
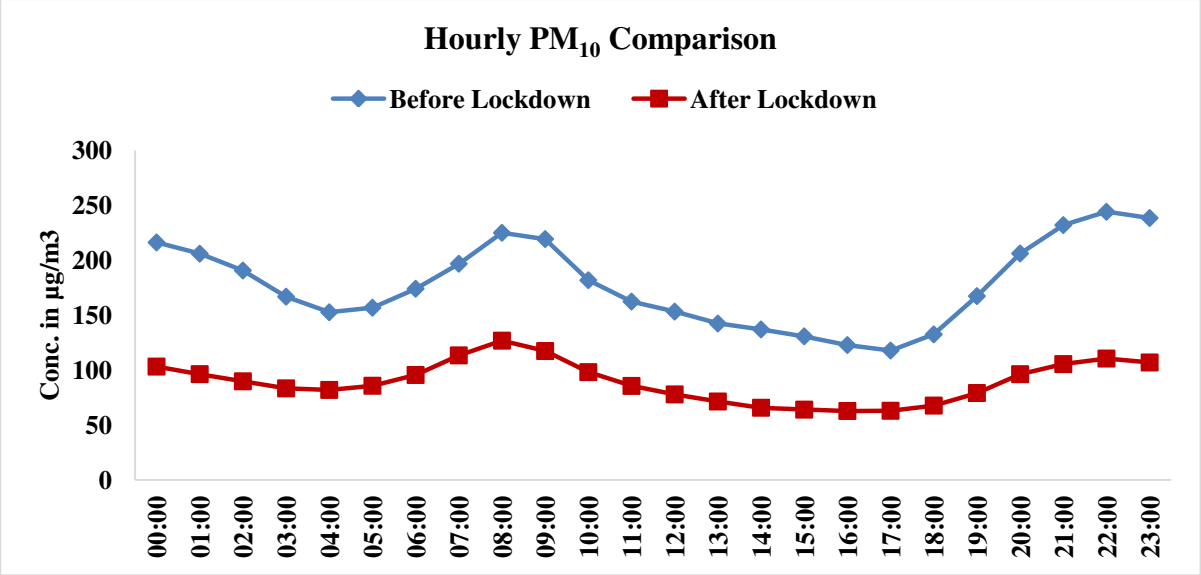
11-Apr-20
12-Apr-20
13-Apr-20
14-Apr-20
15-Apr-20
Before Lock Down
During Lockdown



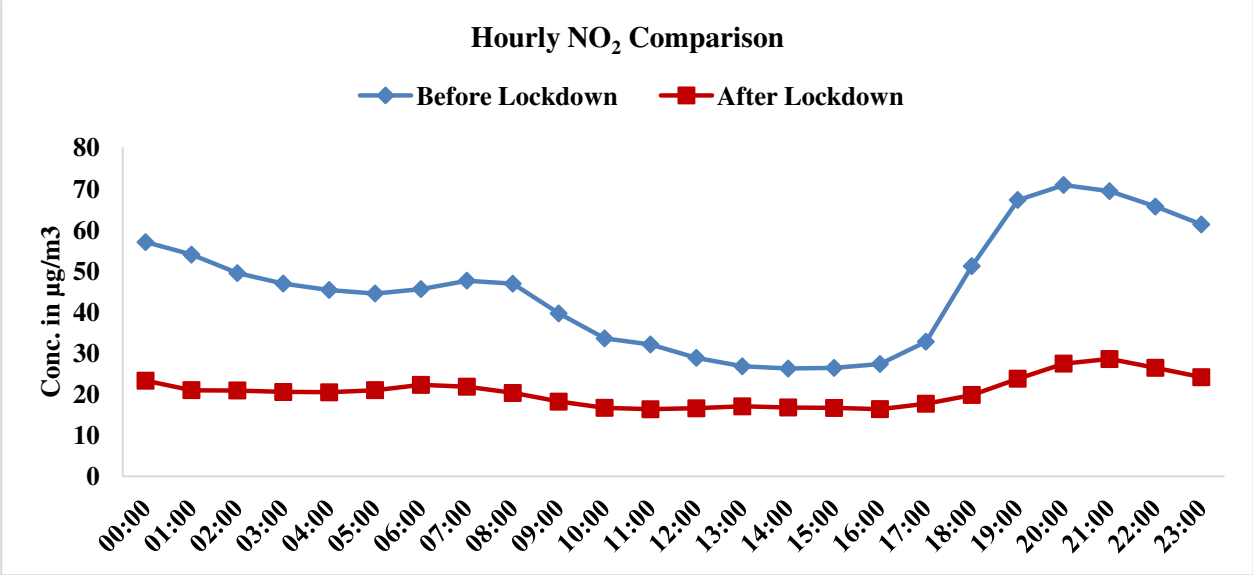
The graphs below depict hourly concentration trend for $PM_{2.5}$ and PM_{10}, for pre-lockdown period (16th March 2020 to 21st March 2020) and lockdown period (25th March 2020 to 15th April 2020).

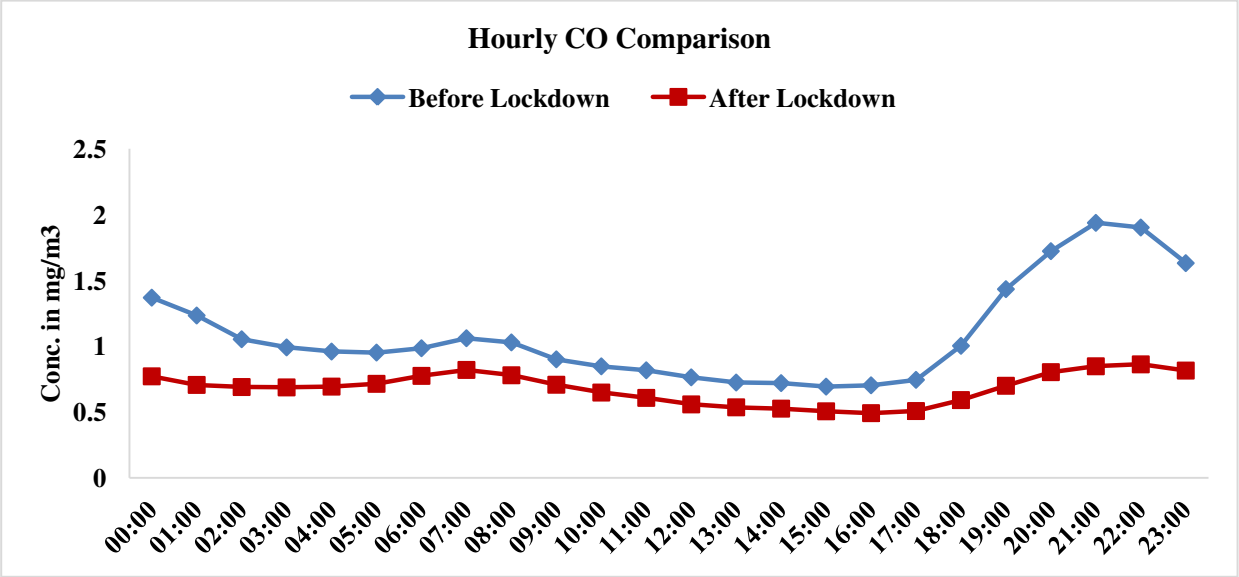




The hourly comparison of average concentration values shows a clear declining trend in levels of PM_{10} and $PM_{2.5}$ during the lockdown period. During the pre-lockdown period, the maximum hourly value of PM_{10} was 244 µg/m^3 at 22:00 Hrs, which dropped to 127 µg/m^3 during the lockdown period. Similarly, the lowest concentration during the pre-lockdown period was 118 µg/m^3 at 17:00 Hrs, which dropped to 63 µg/m^3 during the lockdown period. The drop in coarse particles may be attributed to restriction on construction activities, less road dust resuspension and to some extent curb on industrial activities. A similar and clear decline was seen for $PM_{2.5}$ with concentration value falling from a peak of 114 µg/m^3 at 08:00 Hrs (during the pre-lockdown period) to a minimum value of 21 µg/m^3 at 17:00 Hrs during the lockdown period. The absence of non-essential vehicles and combustion activities in industrial and commercial sites during the period is attributable to the decline.

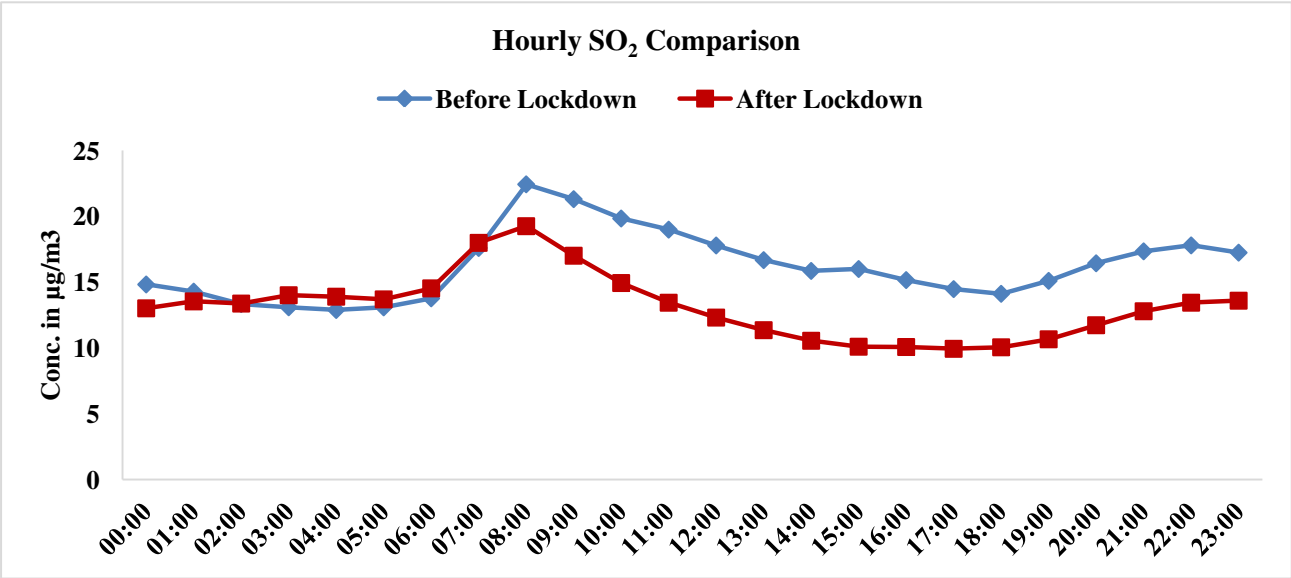
The graphs below depict hourly concentration trend for NO_2 and CO for pre-lockdown period (16th March 2020 to 21st March 2020) and lockdown period (25th March 2020 to 15th April 2020).

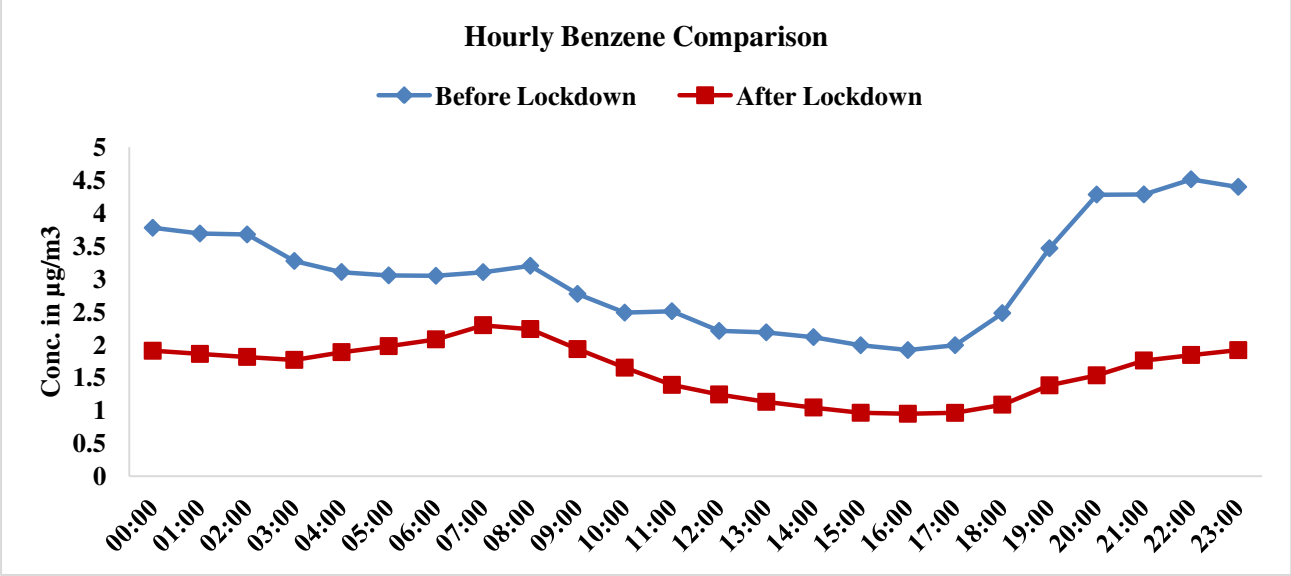




Hourly NO_2 and CO values during the lockdown period remained below the hourly values observed during the pre-lockdown period. The peak hourly value of NO_2 during the pre-lockdown period was more than twice the peak value observed during the lockdown period. Similarly, peak hourly CO value also decreased by 55% during the lockdown period. The routine diurnal variation of NO_2 and CO is twin-crested with a larger crest during night hours. During the lockdown period, the night crest is much reduced, highlighting the absence of vehicular emissions.

The graphs below depict hourly concentration trend for SO_2 and Benzene for pre-lockdown period (16th March 2020 to 21st March 2020) and lockdown period (25th March 2020 to 15th April 2020).

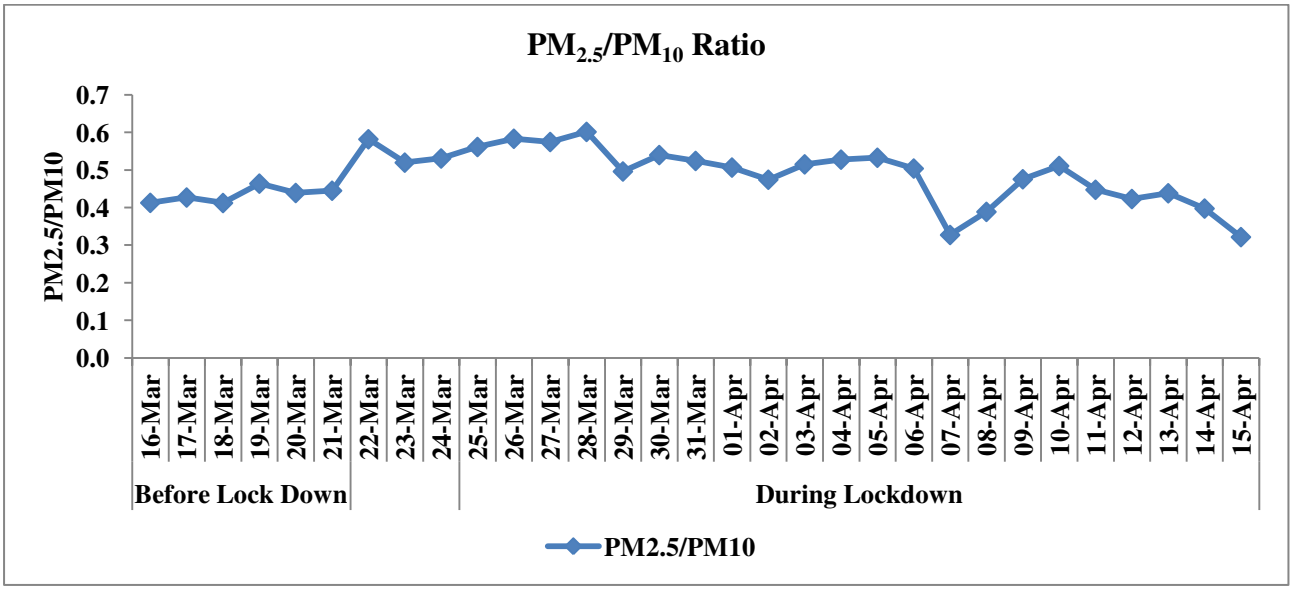




Hourly Benzene levels during the lockdown period remained below the hourly values observed during the pre-lockdown period. Due to the reduced vehicular activity and restrictions on industrial operations, peak benzene levels reduced by 49% while its minimum value reduced by over 50%. However, hourly SO_2 values during the lockdown period were almost similar to the pre-lockdown values in the early morning hours, i.e. when mixing height layer is less and ventilation is reduced. Moreover, the peak hourly SO_2 value only reduced by about 14% as Delhi's SO_2 largely comes from the power plants operating in its vicinity and that power plants were operational during the lockdown period.

It is important to mention here, the impact of meteorological factors was partially favorable, with maximum mixing depth of 4980m during the lockdown period higher than 3200 m recorded in the pre-lockdown period. Wind speed was higher during the lockdown period (4.7 m/s) as compared to the pre-

lockdown period (3.9 m/s). However, with increase in temperature due to onset of summers, with high wind speed, there is an increased possibility of localized lifting of dust, thereby negatively affecting air quality. This is also depicted in the $PM_{2.5}/PM_{10}$ Ratio graph below. $PM_{2.5}/PM_{10}$ ratio started decreasing after 5th April and has been largely below 0.5 since then. This implies that the coarser particle (dust) is playing a dominant role in Delhi's Air Quality. The ratio fell drastically after 10th April and almost reached 0.3 on 15th April, primarily due to a mild dust storm from the Gulf regions (reported by IITM) hitting Delhi, thus significantly increasing the PM_{10} concentration in Delhi.



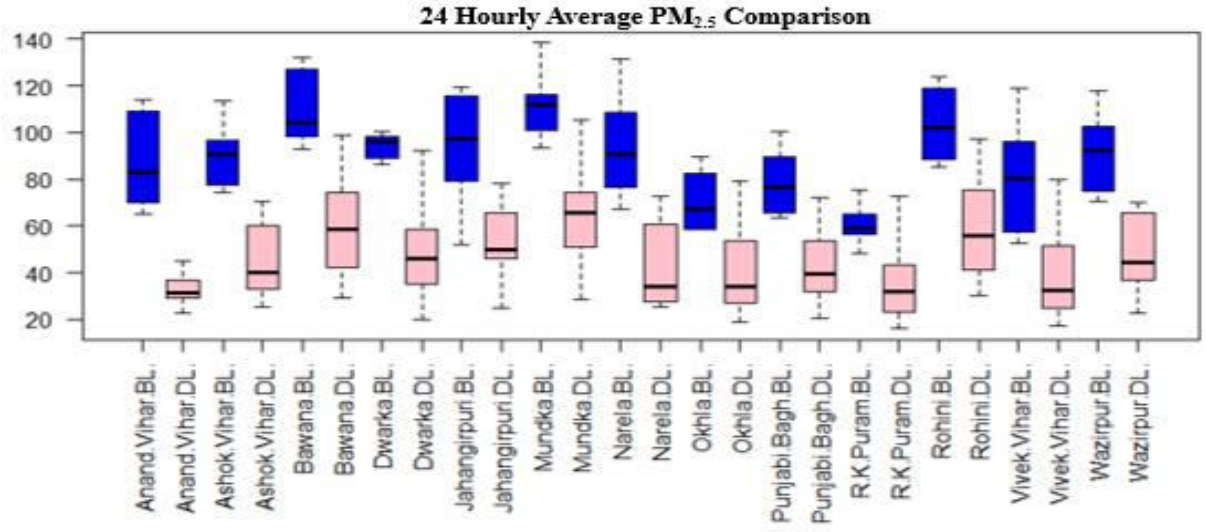
As reported in source apportionment study conducted by TERI & ARAI, 2018, during summers, dust & construction activities (35%), transport sector (20%) and industry (20%), are major source of particulate matter in Delhi. As result of complete restrictions on non-essential vehicular movement and commercial activities, the emissions from construction activities and industries were stopped. The on-road vehicles were relatively sparse compared to normal days thus contribution from road dust resuspension & transport sector was much reduced. As evident from monitored data, the PM_{10} emissions and $PM_{2.5}$ emissions were reduced by up to 50% and 46% respectively.

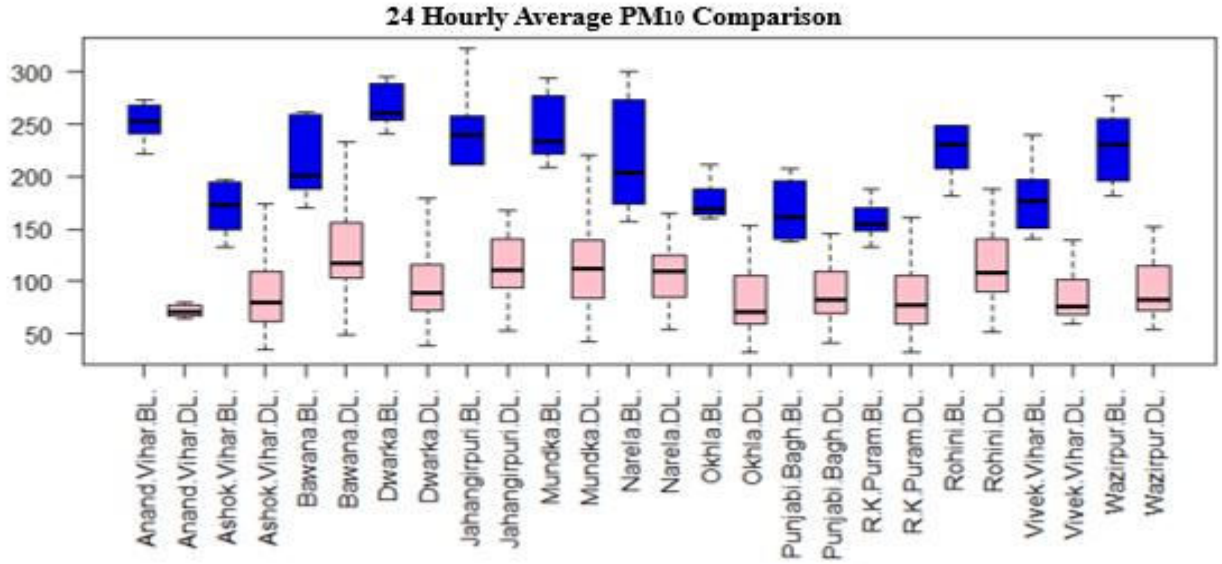
Air Pollution Hotspots in Delhi

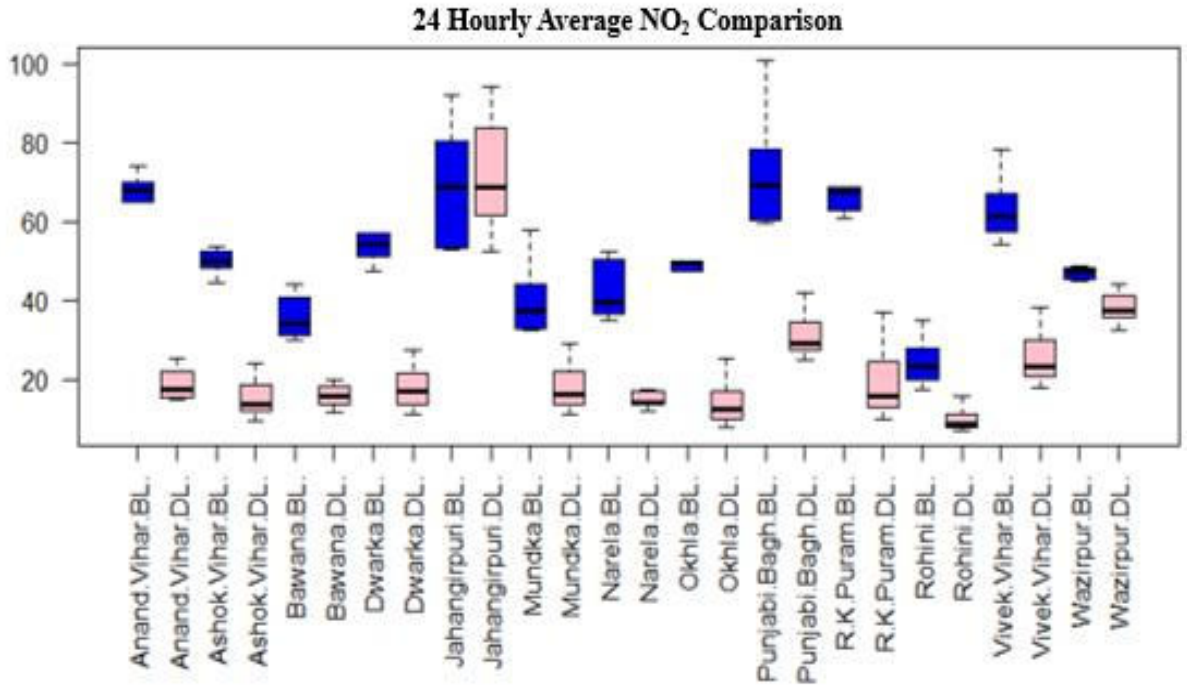
The data analysis of the 13 hotspots of Delhi reveals that Anand Vihar recorded 62%, 69% and 72% reduction in $PM_{2.5}$, PM_{10} and NO_2 levels respectively during the lockdown period, as compared to the pre-lockdown period. However, data availability was low. Vivek Vihar, which is near to GT Road, a major traffic corridor, saw 60% reduction in NO_2 levels. Similarly, 48%, 61% and 68% reduction was observed in Dwarka Sector-8. Further, Okhla recorded 72% reduction in NO_2 levels. It is to be noted that while Anand Vihar is a major transport hub and Okhla is major industrial suburb, Dwarka has substantial presence of

residential cum institutional sites with substantial traffic movements, thus sharp decline in NO_2 levels further affirm that traffic and industrial operation restrictions were instrumental in improving air quality.

The box plots given below depict average $PM_{2.5}$, PM_{10} and NO_2 concentrations in the 13 hotspots in the pre-lockdown period (BL) and during the lockdown period (DL).







The plots clearly indicate the distribution of values or the standard deviation for all hotspots has decreased considerably, suggesting the absence of major emission sources which contribute to variation in pollutant levels. Median values were seen to decrease for all hotspots for $PM_{2.5}$ and PM_{10} but increased for Jahangirpuri in the case of NO_2. This could be attributed to the presence of several inter-state goods carriers in the vicinity due to a major national highway located nearby.

EFFECT OF LOCKDOWN IN MAJOR NCR TOWNS

The air pollution reduction trend in NCR towns was relatively less pronounced compared to NCT of Delhi. Over 48% Reduction in PM_{10} and $PM_{2.5}$ levels were observed during lockdown period in all neighboring towns with sharp improvement in Faridabad with 55% reduction in $PM_{2.5}$ levels and Gurugram with 54% reduction in PM_{10} levels While significant reduction in NO_2 levels was observed in Noida (68%), Ghaziabad (60%) and Gurugram (40%), the same was not noted in Faridabad (17%), where NO_2 emissions were found higher during a few days in lockdown period, seemingly due to the gas-based power plants in and around Faridabad. Significant reduction in SO_2 levels was only seen in Faridabad (47%) and Ghaziabad (22%), while Gurugram (14%) and Noida (10%) recorded slight reductions during the lockdown period which may be attributed to their proximity to thermal power plants and some operational industries in the vicinity. Moreover, while Delhi's industries have largely switched over to gas-based and other less polluting energy systems, some industries in NCR might still be using coal and biomass, etc.. Overall, average CO levels decreased in all major NCR towns with peak hourly values decreasing by 56% in Faridabad, 52% in Noida and 48% in Gurugram indicating reduced vehicular exhaust impact during lockdown. In terms of Benzene levels, Noida and Ghaziabad recorded an enormous reduction of 90% and 60% respectively during

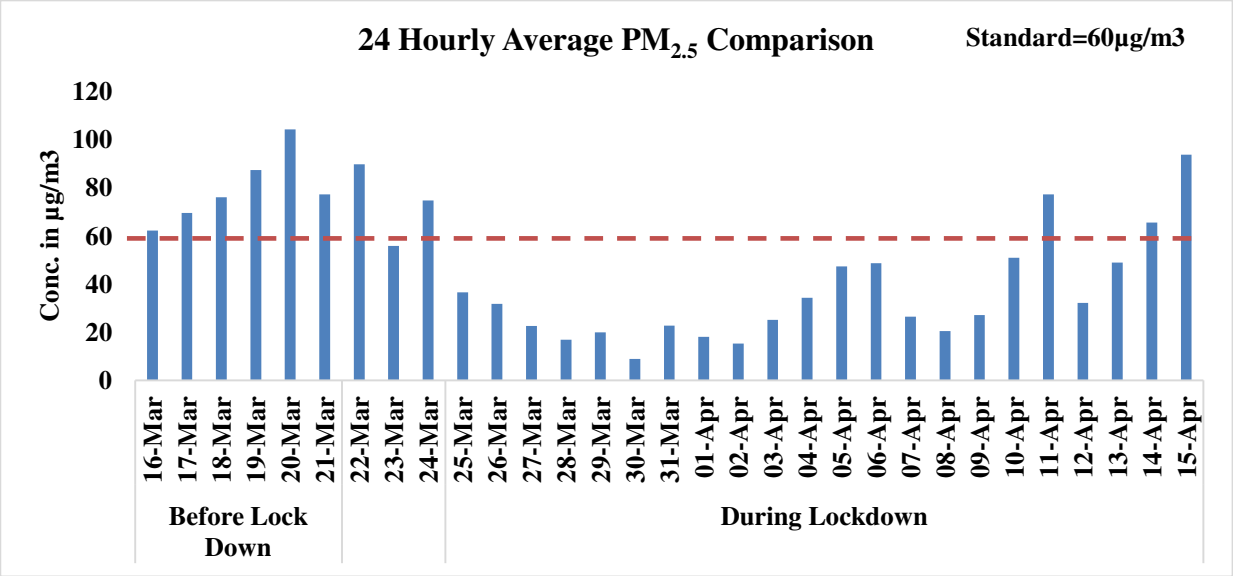
the lockdown period. However, Faridabad saw a slight increase in Benzene levels. The operation of certain units or processes (chemical/pharmaceutical/paints) utilizing benzene, and other solvents, etc. in Faridabad cannot be ruled out and may be responsible for the increase in Benzene levels. It is also important to mention that there are lesser number of real time air quality monitoring stations in NCR towns as compared to Delhi and the impact of localized sources on air quality data is always a possibility which may require further data for complete analysis. Moreover, in absence of complete data on scale of industrial operation in various categories except power plants and essential activities like food, bakery, dairy etc, it may be difficult to assess the impact of these sources on air quality at this point of time.

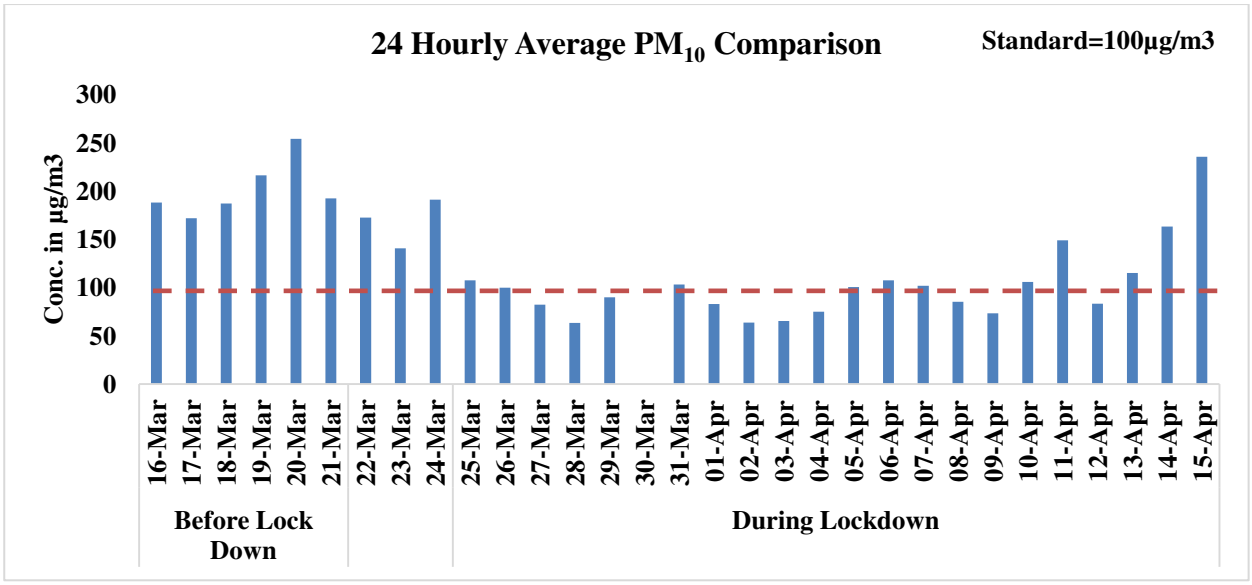
The trends for neighboring NCR towns are presented in detail in subsequent paras,

Faridabad

The impact of restrictions was visible in Faridabad. 19 days in the 22-day lockdown period witnessed 24 hourly $PM_{2.5}$ levels within National Ambient Air Quality Standards (NAAQS). However, SO_2 and NO_2 values remained within National standards during pre-lockdown and lockdown period. While there has been a big drop in the peak hourly values of $PM_{2.5}$ (44%), PM_{10} (60%), SO_2 (57%) and CO (56%) during the lockdown period as compared to the pre-lockdown period, the minimum hourly value of NO_2 dropped only by 10% and hourly NO_2 values roughly remained the same throughout the day, in all probability due to localized combustion activities and operation of gas-based power plants in the vicinity. However, 57% reduction in peak hourly SO_2 levels with the minimum hourly SO_2 levels also decreasing by 29% during the lockdown period indicates that SO_2 emissions from coal-based power plants in NCR might be playing a more dominant role in Delhi than Faridabad

The data trends for Faridabad is as presented below,




24 Hourly Average PM10 Comparison
Standard=100µg/m3
Conc. in µg/m3
300
250
200
150
100
50
0
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
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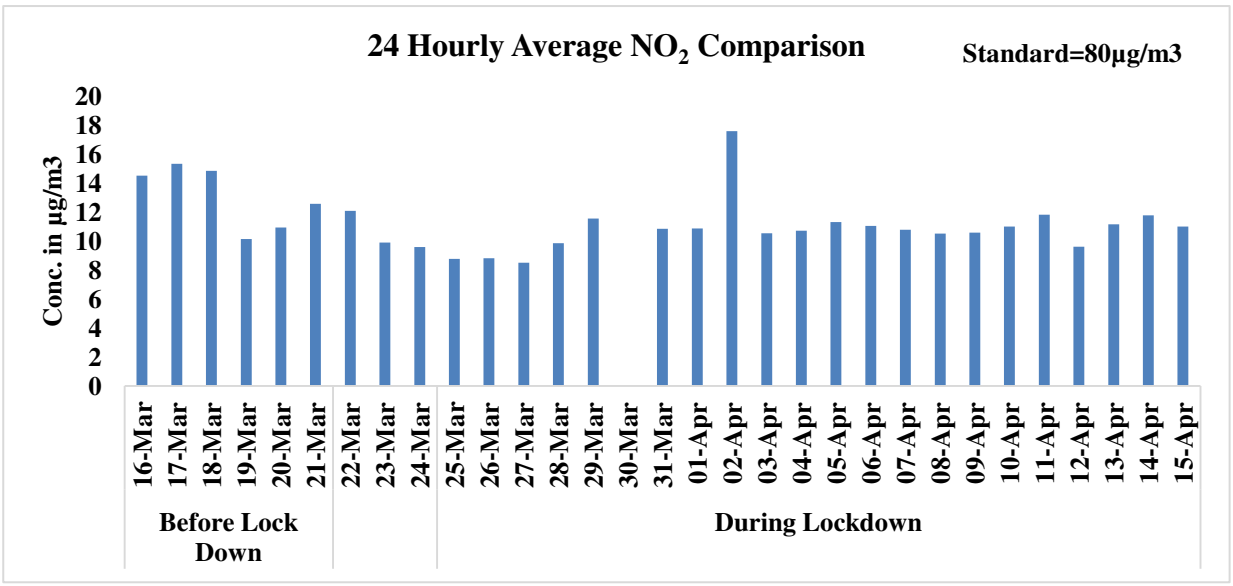
15-Apr
Before Lock Down
During Lockdown


24 Hourly Average NO2 Comparison
Standard=80µg/m3
Conc. in µg/m3
20
18
16
14
12
10
8
6
4
2
0
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
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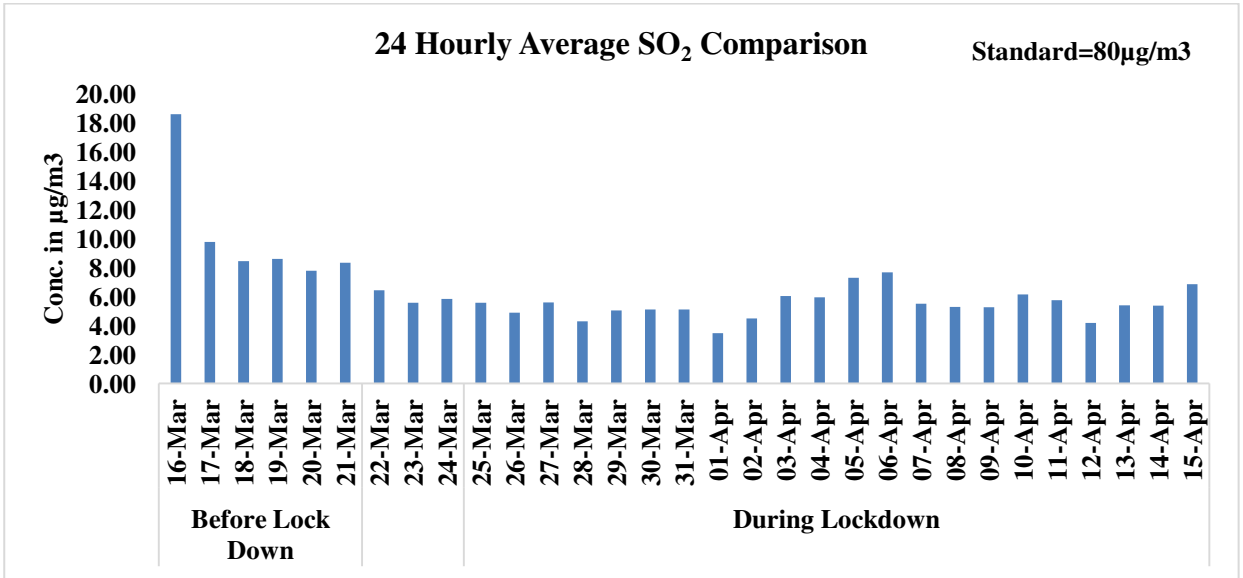
14-Apr
15-Apr
Before Lock Down
During Lockdown


24 Hourly Average SO2 Comparison
Standard=80µg/m3
Conc. in µg/m3
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
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01-Apr
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12-Apr
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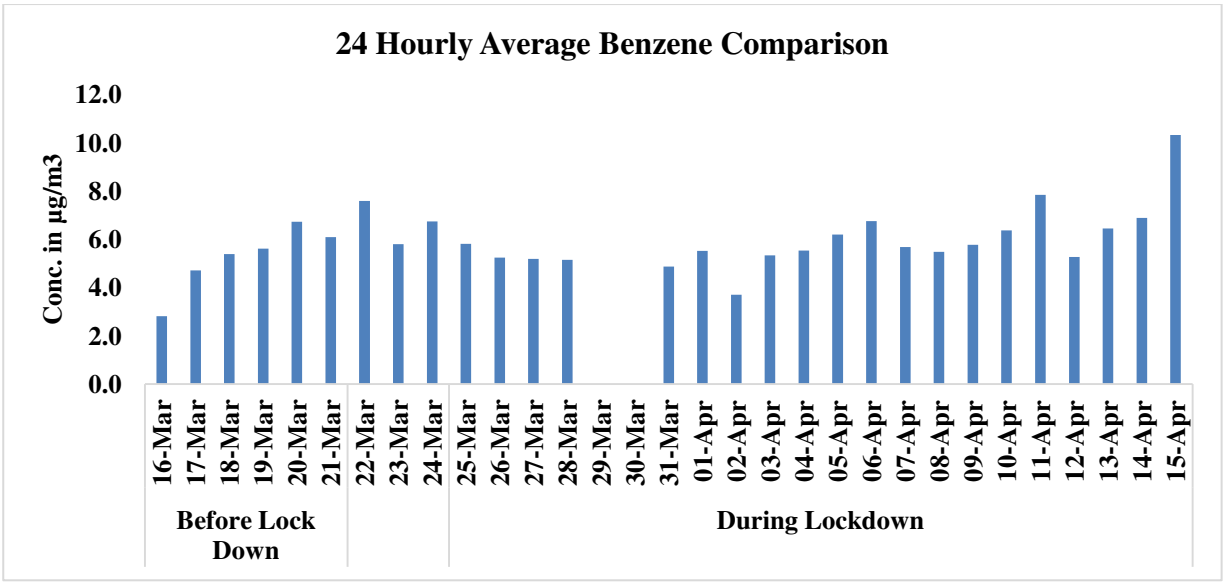
14-Apr
15-Apr
Before Lock Down
During Lockdown


24 Hourly Average Benzene Comparison
Conc. in µg/m3
12.0
10.0
8.0
6.0
4.0
2.0
0.0
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
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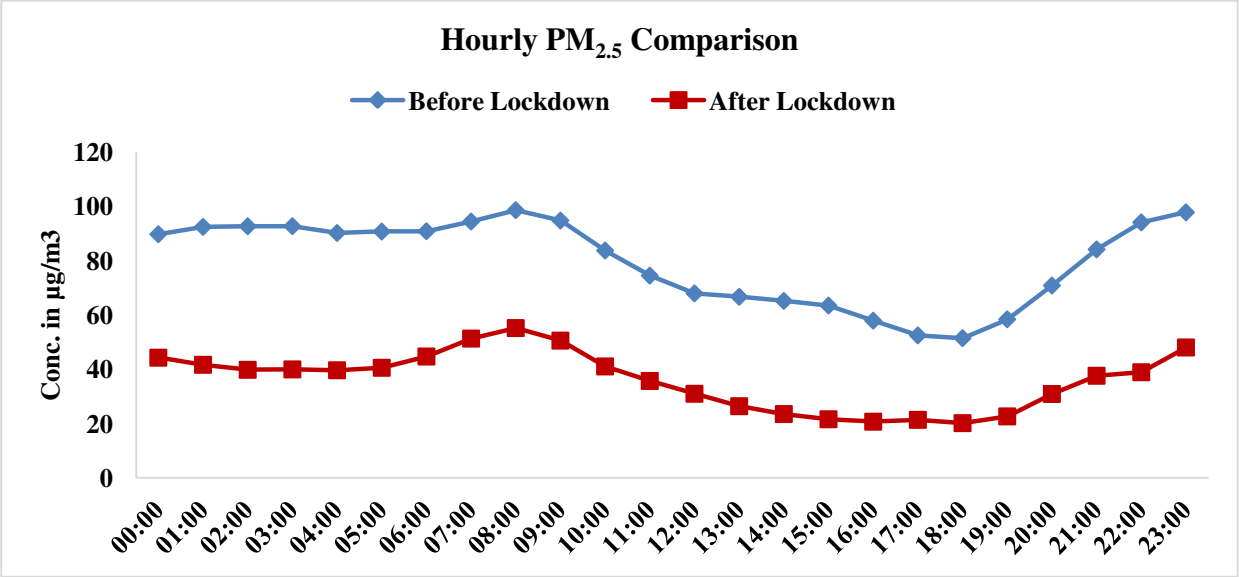
15-Apr
Before Lock Down
During Lockdown


Hourly PM2.5 Comparison
Before Lockdown
After Lockdown
Conc. in µg/m3
120
100
80
60
40
20
0
00:00
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02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
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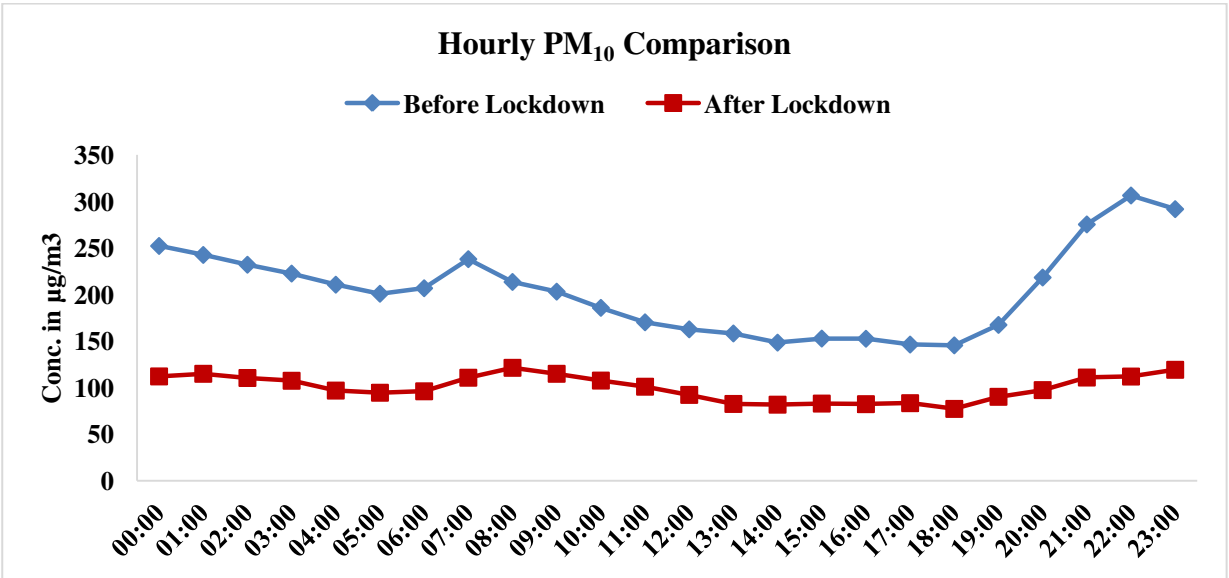
22:00
23:00


Hourly PM10 Comparison
Before Lockdown
After Lockdown
Conc. in µg/m3
350
300
250
200
150
100
50
0
00:00
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02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
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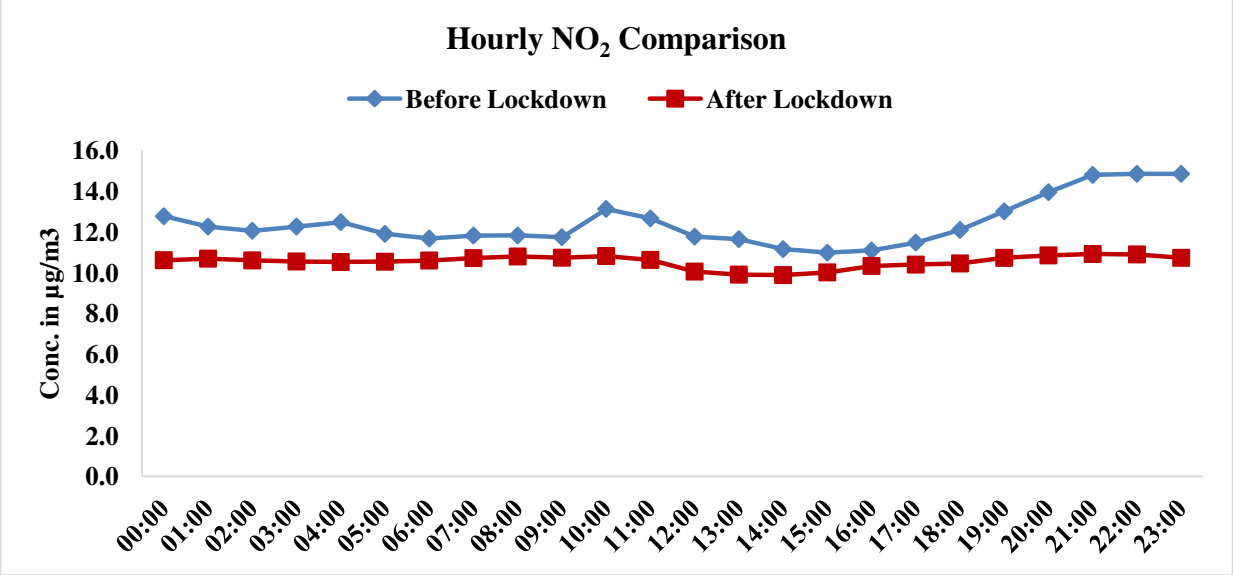
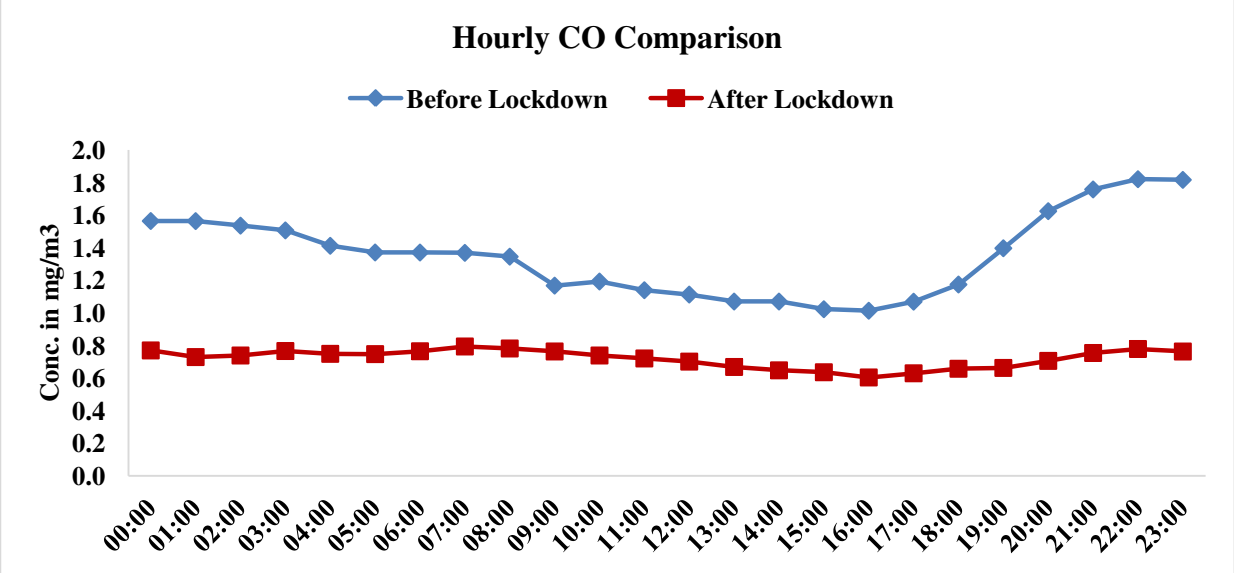
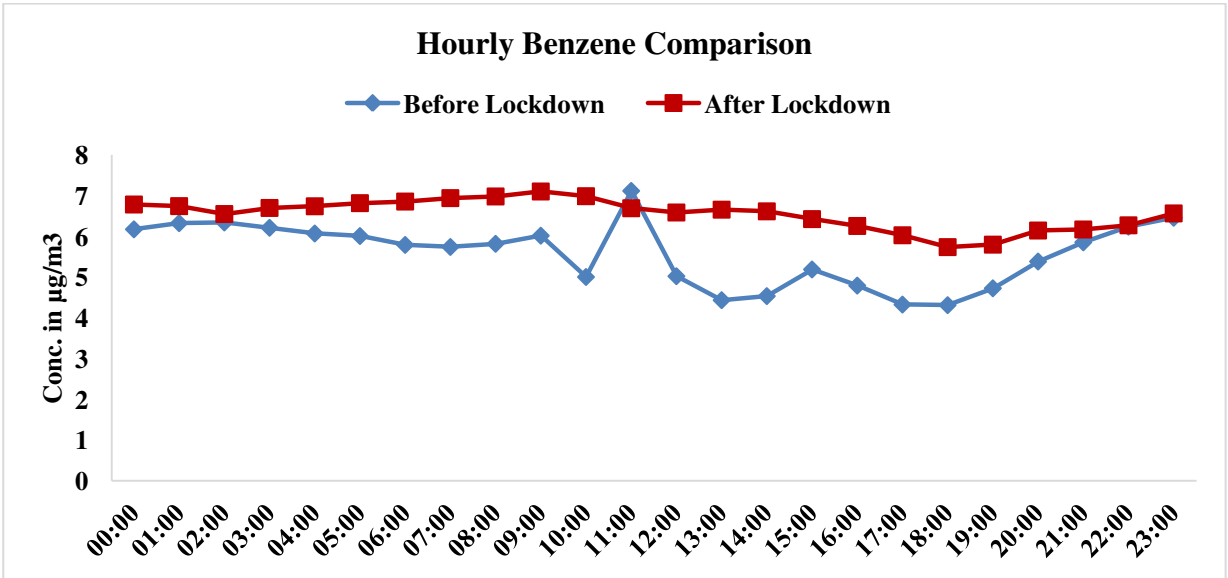
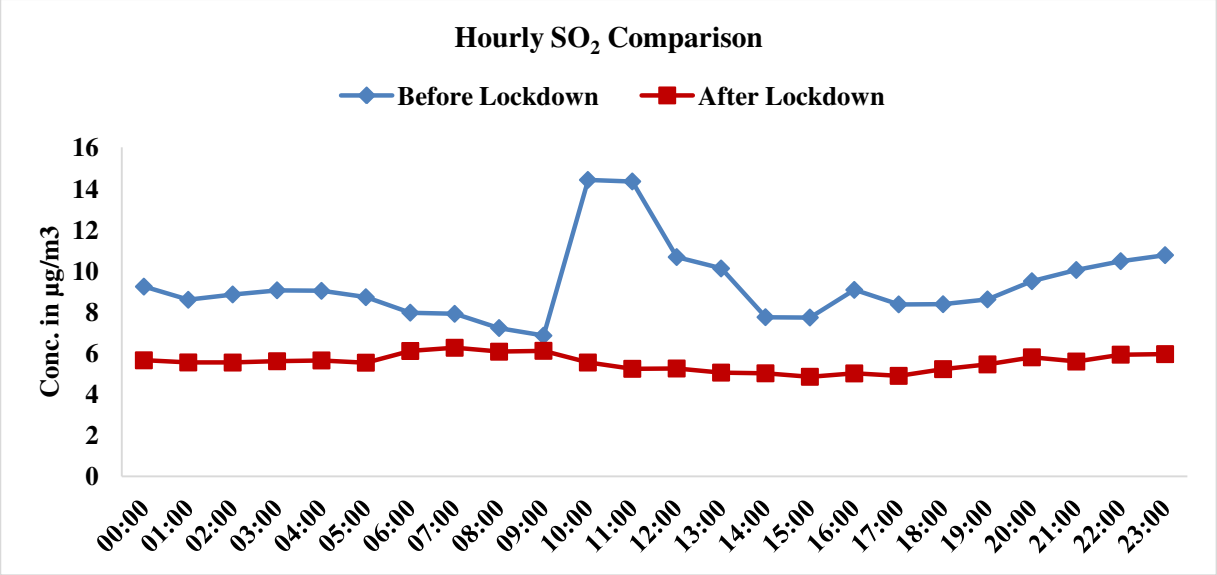
22:00
23:00


Hourly NO2 Comparison
Before Lockdown
After Lockdown
Conc. in µg/m3
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00


Hourly CO Comparison
Before Lockdown
After Lockdown
Conc. in mg/m3
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00

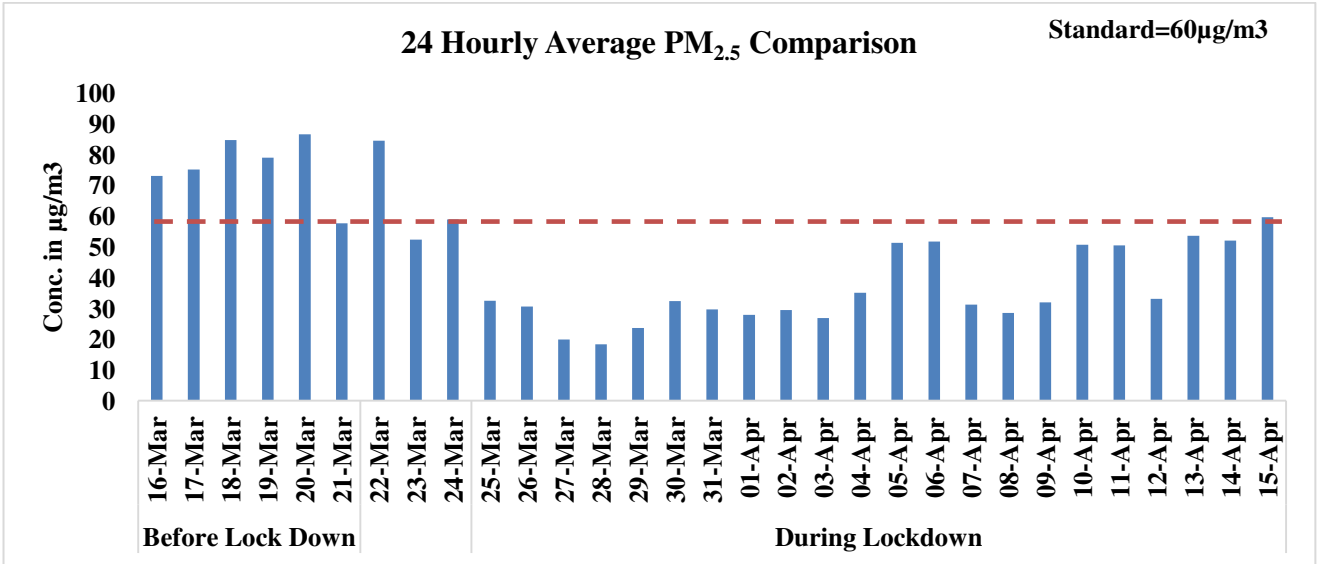

Hourly Benzene Comparison
Before Lockdown
After Lockdown
Conc. in µg/m3
8
7
6
5
4
3
2
1
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00

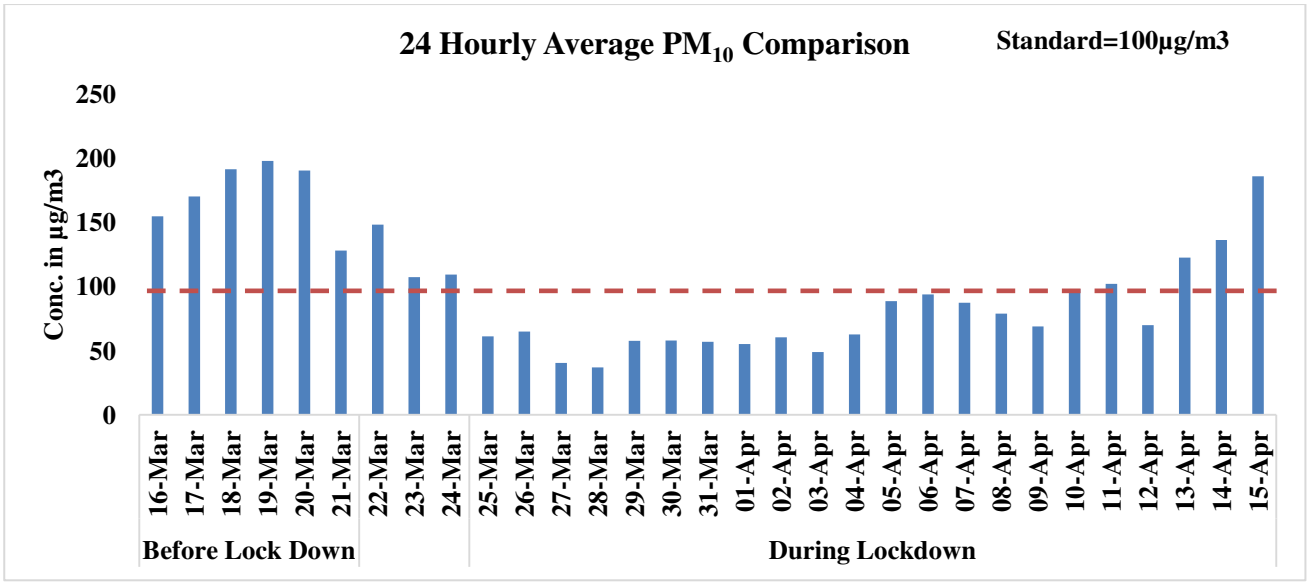


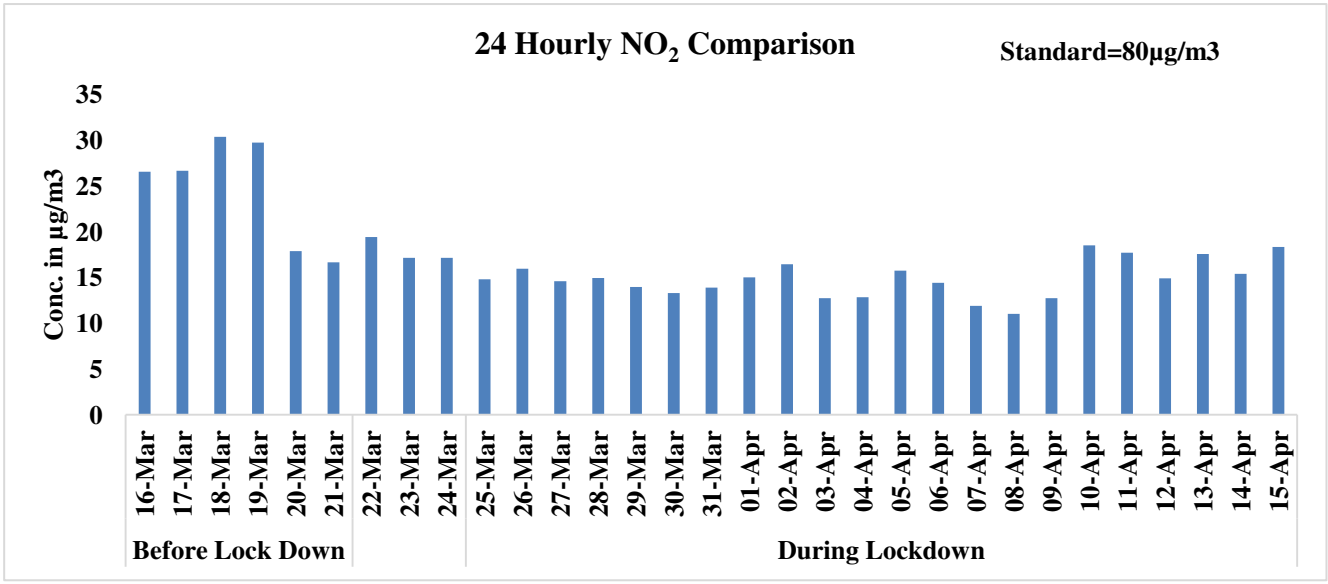
Gurugram

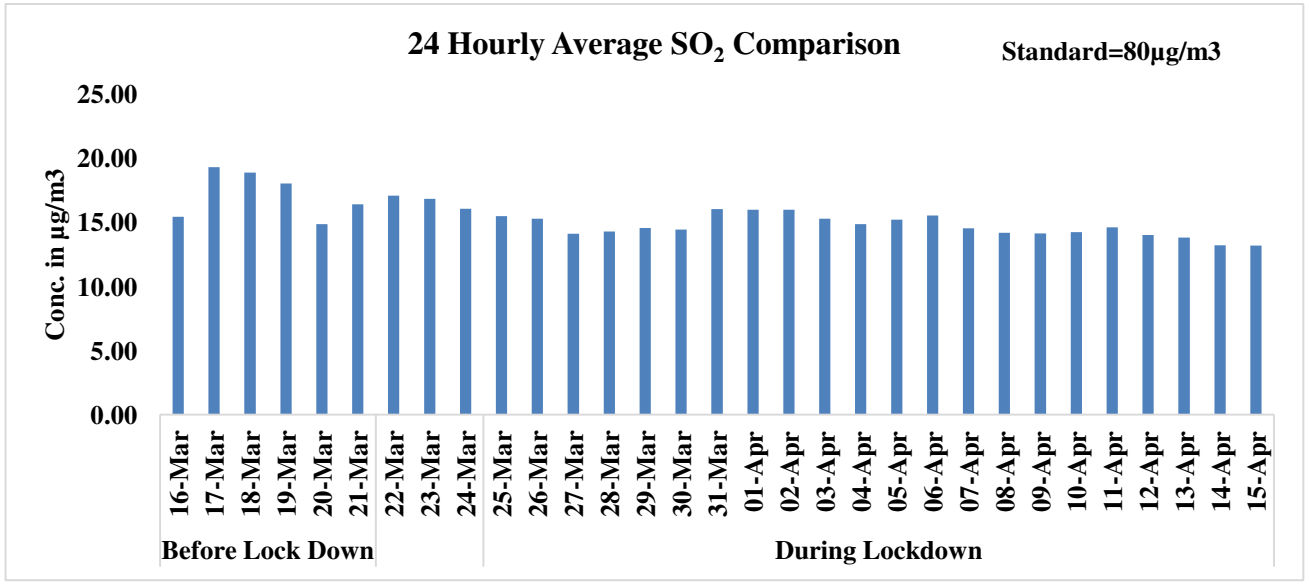
$PM_{2.5}$,NO_2 and SO_2 levels remained below National Ambient Air Quality Standards on all days during the lockdown, while PM_{10} levels were above NAAQS on just 4 days in the 22-day lockdown period. Hourly data reveals a declining trend in pollutant levels from 07:00 Hrs onwards for major pollutants. Further, since dust & construction activities contribute 49% to $PM_{2.5}$ and 52% to PM_{10} in Gurugram (TERI Source Apportionment study, 2018), it is likely that road dust resuspension due to vehicle restrictions might have come down resulting in lower emissions with 42% and 52% reduction in peak hourly $PM_{2.5}$ and PM_{10} levels respectively. Peak hourly CO values reduced by almost 48% while peak hourly NO_2 and benzene levels reduced by 42% and 36% respectively during the lockdown period, indicating reduced vehicle movement. Peak SO_2 values fell by 20%, i.e. on a similar scale as Delhi.

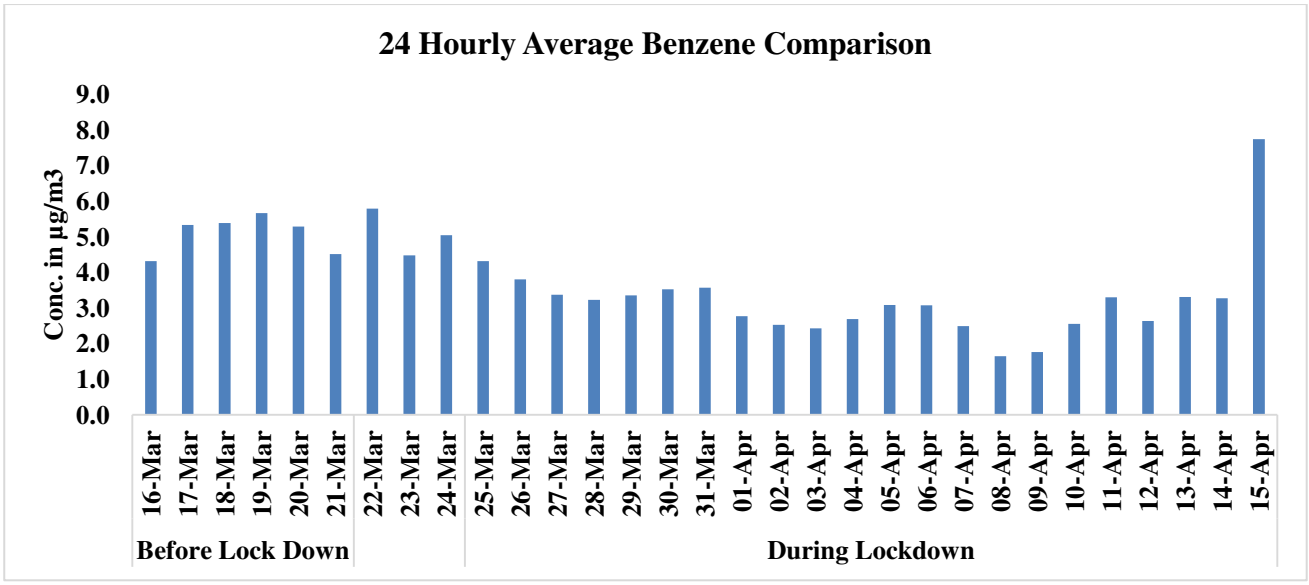
The data trend for Gurugram is as presented below,

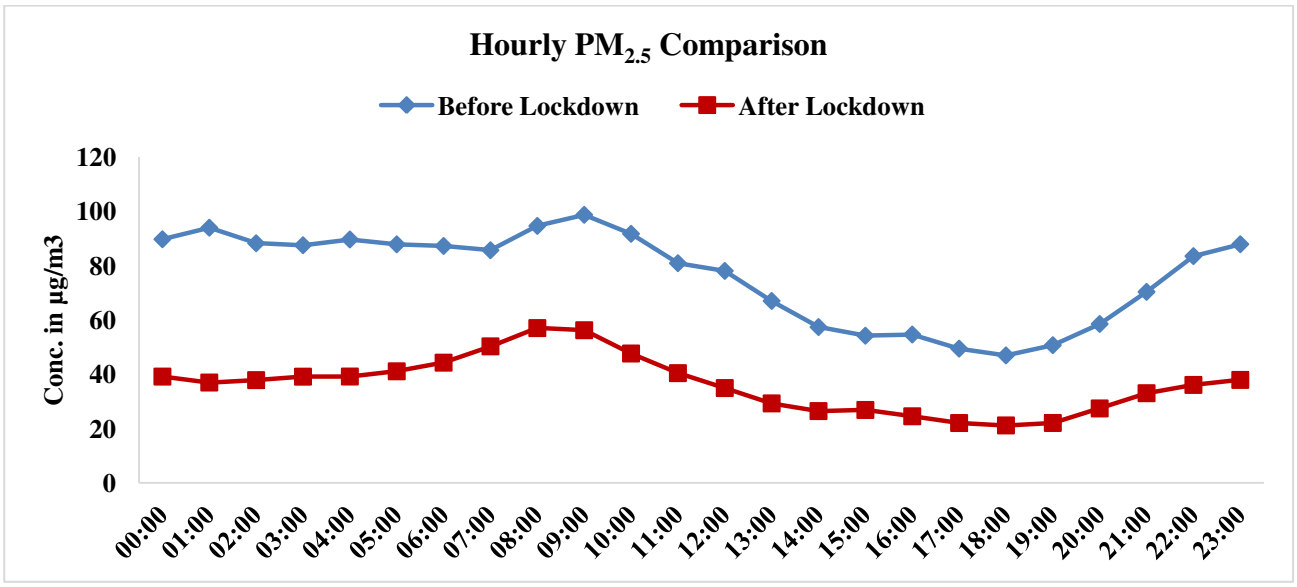



24 Hourly Average PM10 Comparison
Standard=100µg/m3
Conc. in µg/m3
250
200
150
100
50
0
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
06-Apr
07-Apr
08-Apr
09-Apr
10-Apr
11-Apr
12-Apr
13-Apr
14-Apr
15-Apr
Before Lock Down
During Lockdown


24 Hourly NO2 Comparison
Standard=80µg/m3
Conc. in µg/m3
35
30
25
20
15
10
5
0
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
06-Apr
07-Apr
08-Apr
09-Apr
10-Apr
11-Apr
12-Apr
13-Apr
14-Apr
15-Apr
Before Lock Down
During Lockdown


24 Hourly Average SO2 Comparison
Standard=80µg/m3
Conc. in µg/m3
25.00
20.00
15.00
10.00
5.00
0.00
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
06-Apr
07-Apr
08-Apr
09-Apr
10-Apr
11-Apr
12-Apr
13-Apr
14-Apr
15-Apr
Before Lock Down
During Lockdown


24 Hourly Average Benzene Comparison
Conc. in µg/m3
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
06-Apr
07-Apr
08-Apr
09-Apr
10-Apr
11-Apr
12-Apr
13-Apr
14-Apr
15-Apr
Before Lock Down
During Lockdown


Hourly PM2.5 Comparison
Before Lockdown
After Lockdown
Conc. in µg/m3
120
100
80
60
40
20
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
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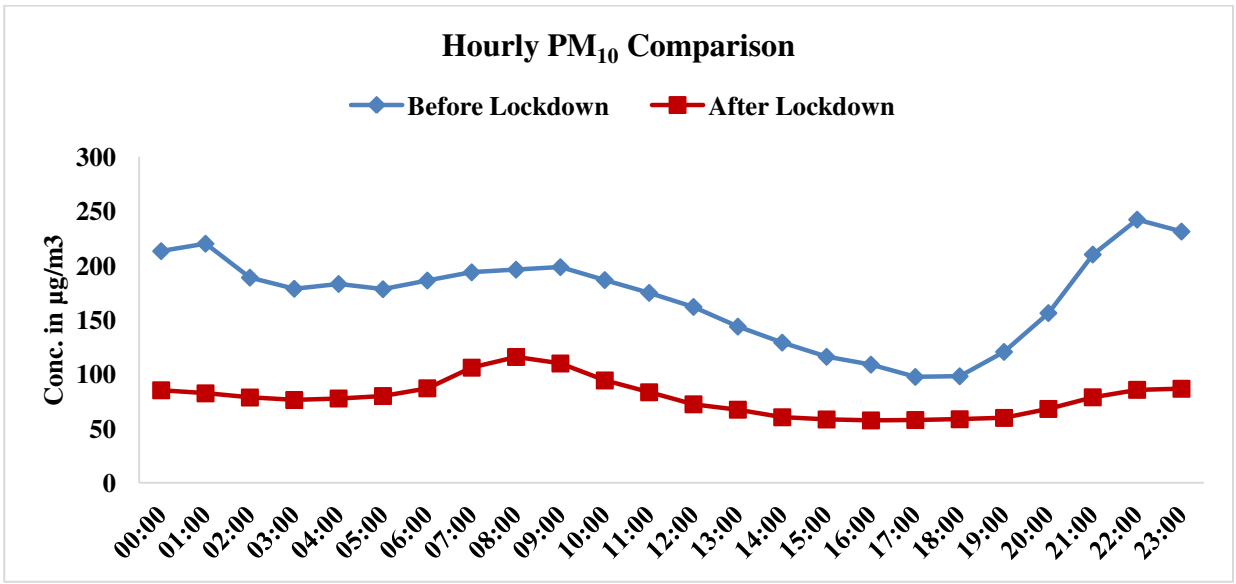
17:00
18:00
19:00
20:00
21:00
22:00
23:00


Hourly PM10 Comparison
Before Lockdown
After Lockdown
Conc. in µg/m3
300
250
200
150
100
50
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
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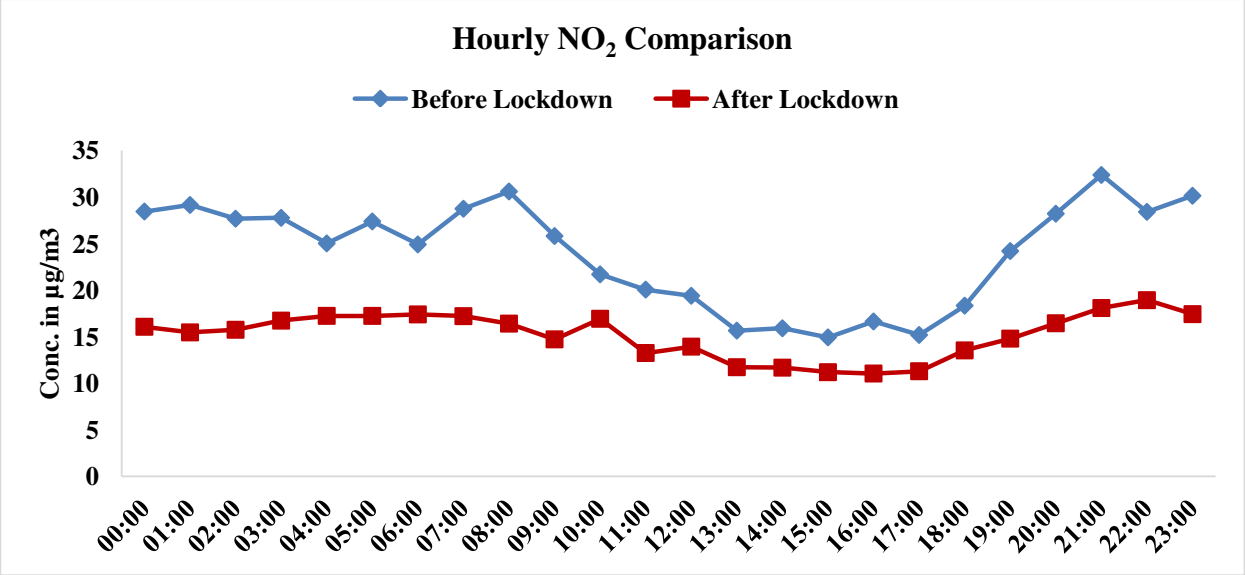
18:00
19:00
20:00
21:00
22:00
23:00


Hourly NO2 Comparison
Before Lockdown
After Lockdown
Conc. in µg/m3
35
30
25
20
15
10
5
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
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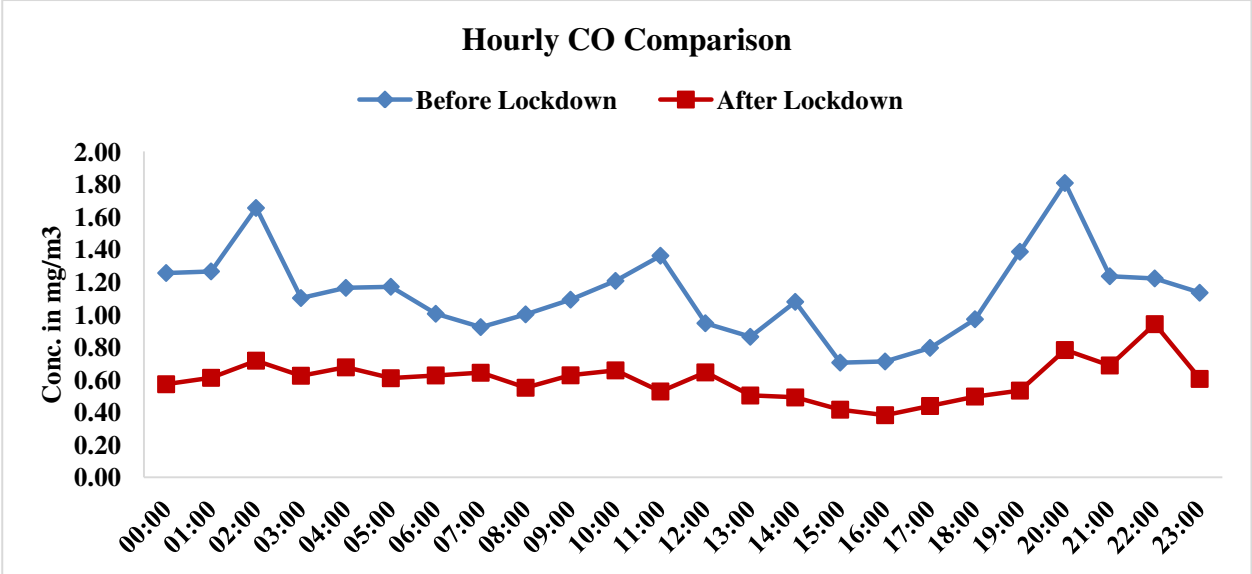
17:00
18:00
19:00
20:00
21:00
22:00
23:00


Hourly CO Comparison
Before Lockdown
After Lockdown
Conc. in mg/m3
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
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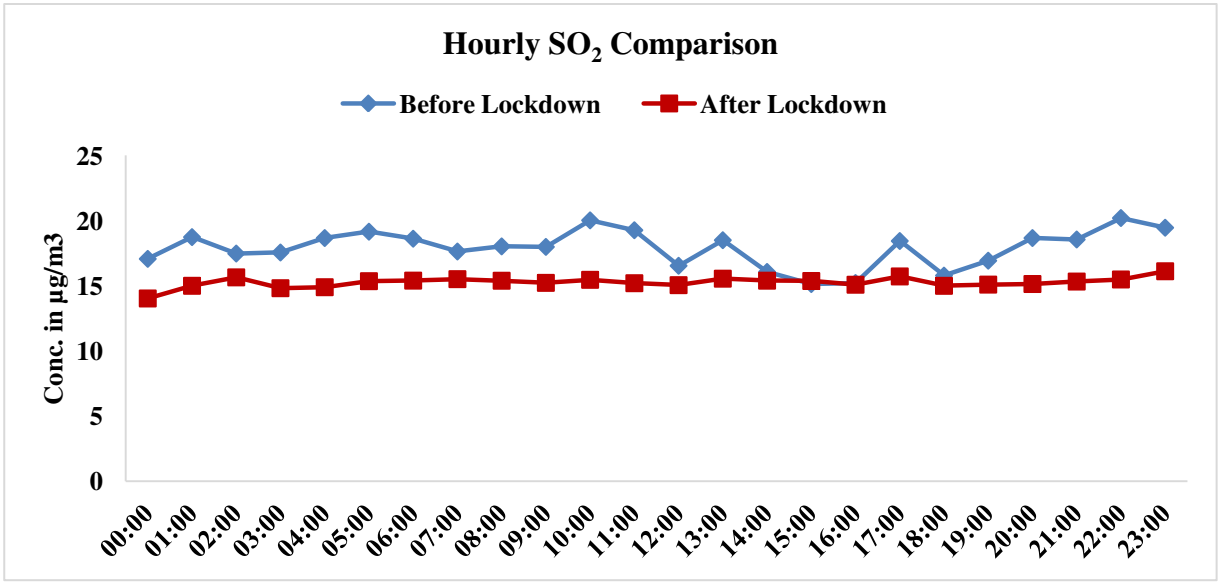
18:00
19:00
20:00
21:00
22:00
23:00


Hourly SO2 Comparison
Before Lockdown
After Lockdown
Conc. in µg/m3
25
20
15
10
5
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
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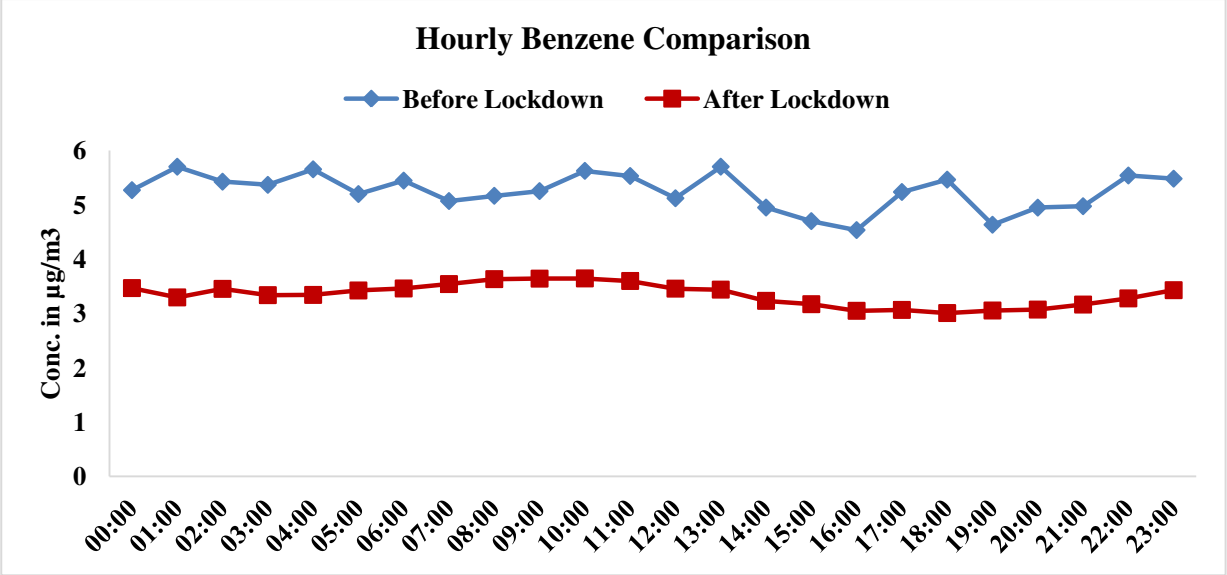
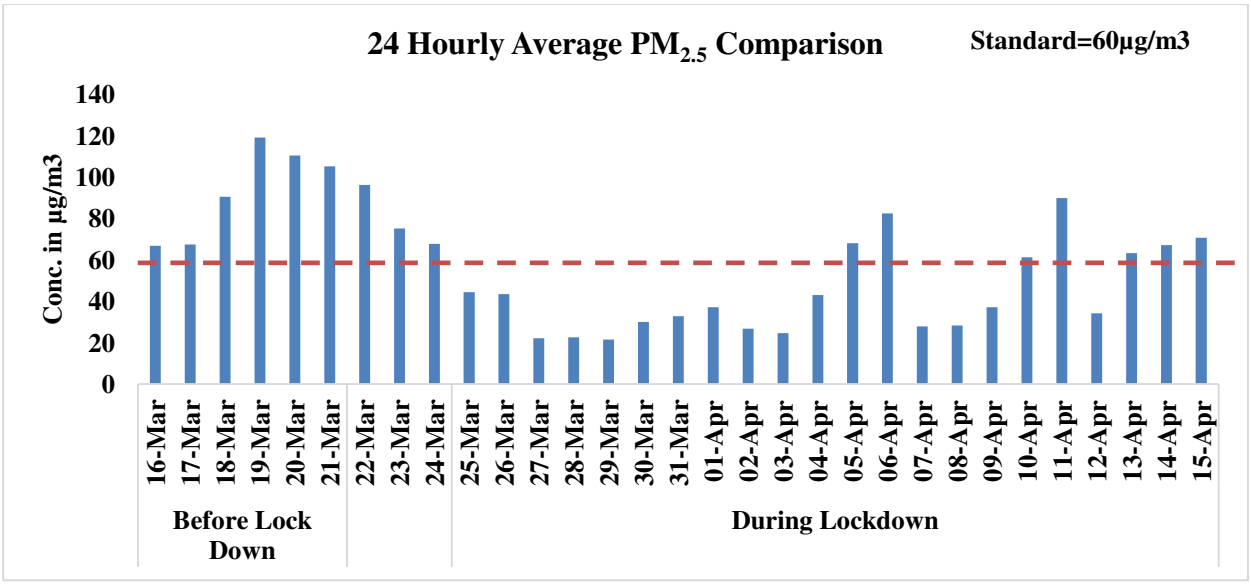
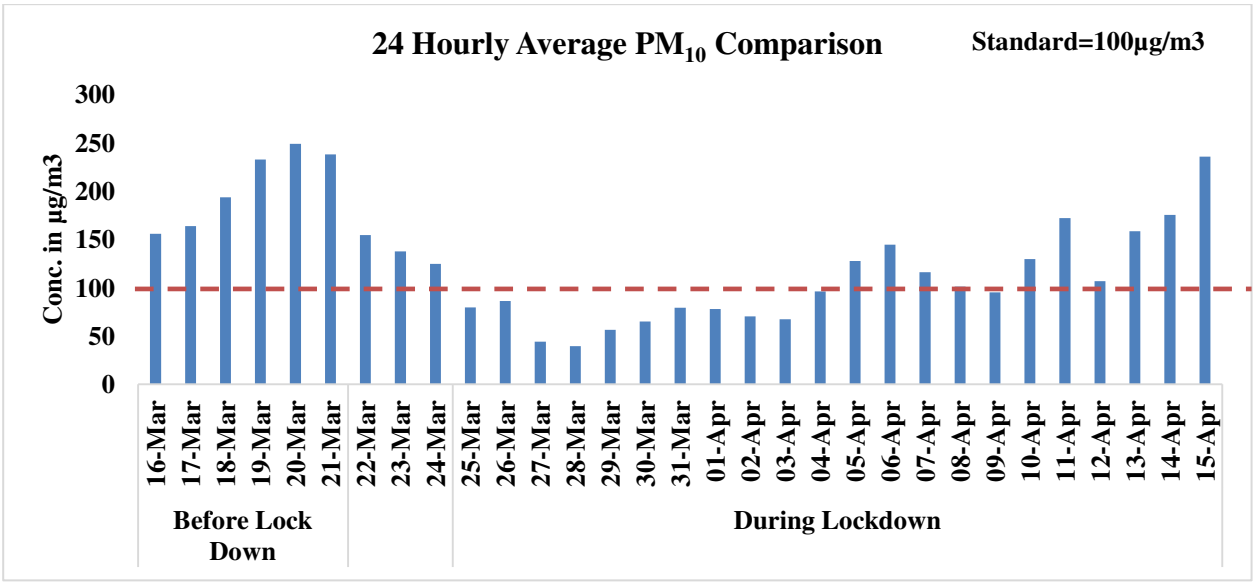
20:00
21:00
22:00
23:00

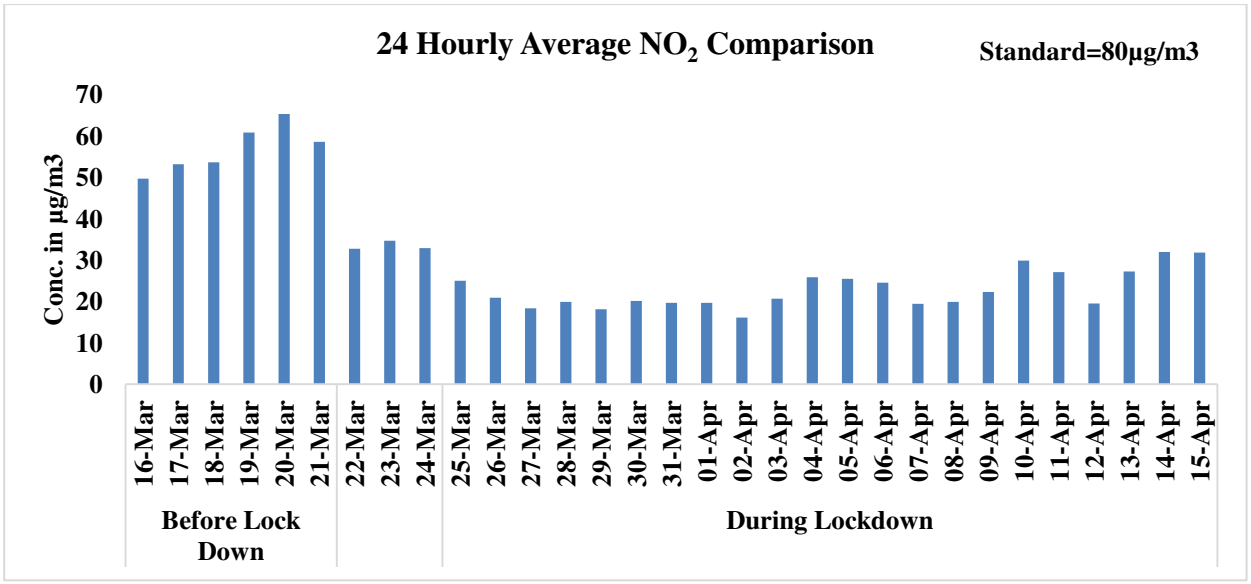


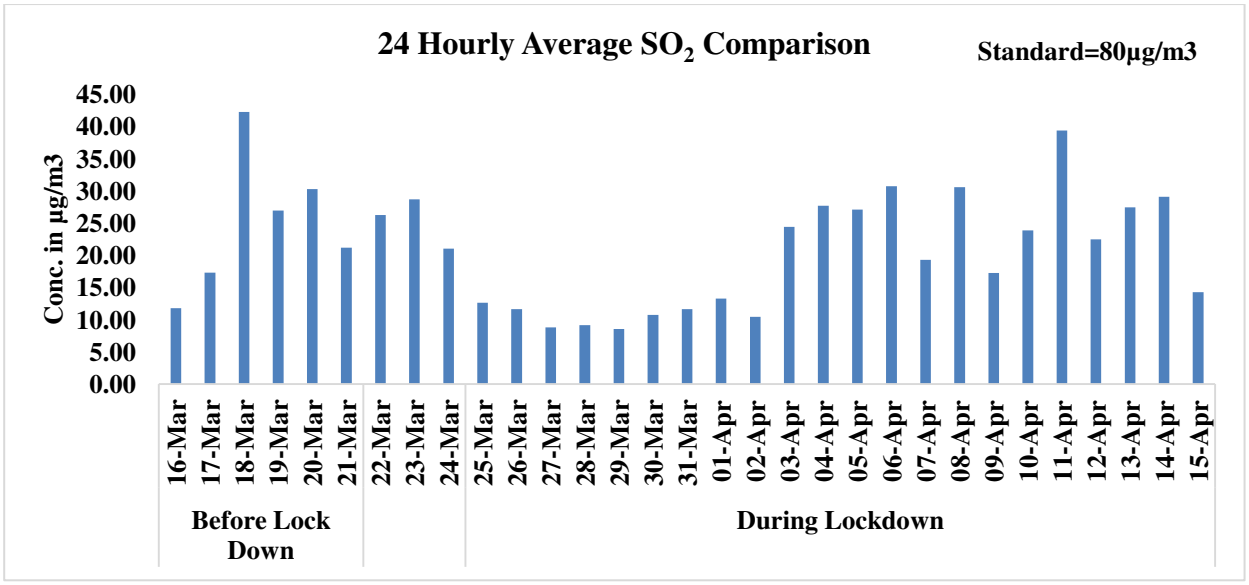
Ghaziabad

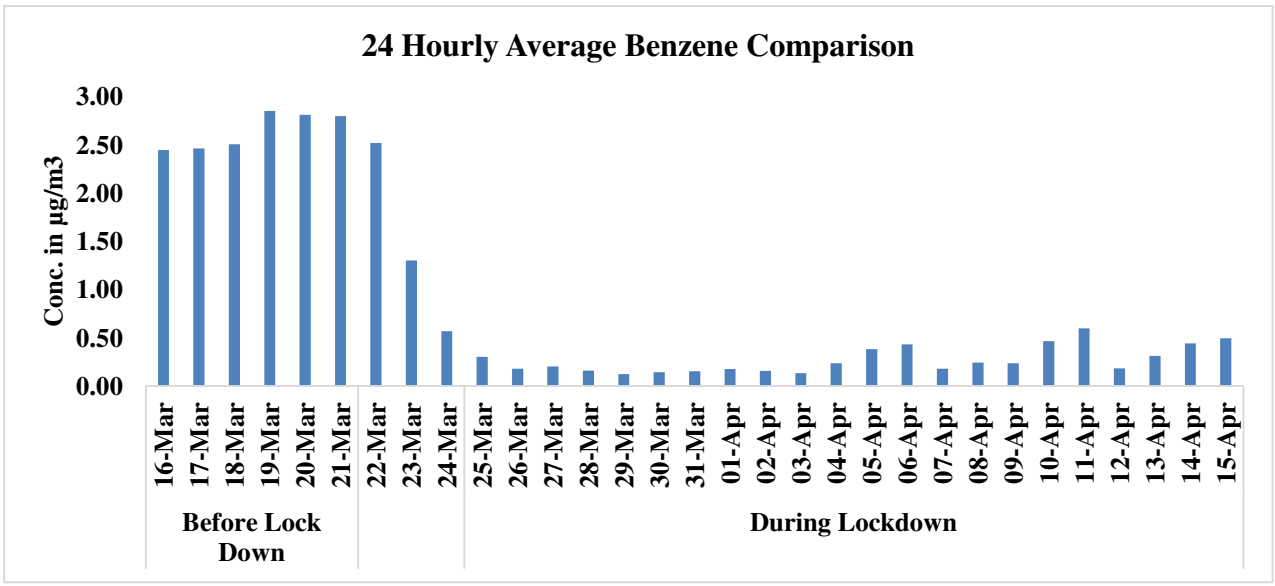
SO_2 and NO_2 levels remained below National Ambient Air Quality Standards on all days during the lockdown, while $PM_{2.5}$ levels were above NAAQS in the second week of April i.e. for 7 days in the 22-day lockdown period. Although $PM_{2.5}$ and PM_{10} levels were higher during early morning hours and late night hours, characteristically due to reduced ventilation and mixing height, peak hourly $PM_{2.5}$ and PM_{10} levels reduced by 49% and 57% respectively. Major reduction of 91% in peak benzene levels and 66% in peak NO_2 values was observed, largely due to the reduced presence of vehicular and industrial activity. Major reduction in benzene levels (highest in Delhi NCR) during lockdown period indicate closure of some large scale benzene utilizing/generating source like paint, petro products, plastics, resins, synthetic fibers, rubber lubricants, dyes, detergents, drugs and pesticides in Ghaziabad region apart from reduced impact of vehicular related emissions. While average CO values during lockdown period remained below their pre-lockdown levels to a great extent and reduced by almost 30%, analysis of hourly CO values indicate peak hourly CO value rising by 11%, seemingly due to local combustion activities which may include increased use of solid fuels/biomass in household cooking etc. Further, the diurnal cycle of CO concentration presents two peaks, in the morning and in the evening. Notably, mixing height is generally low in these two periods of the day. In the early hours of the morning, surface heating by solar radiation is also not enough to break the previous night's thermal inversion layer, causing the pollutants to remain concentrated in regions close to the surface. As mixing height increases allowing transport of pollutants to the upper layers, CO levels on the surface decrease and rise again by the end of the afternoon, when convective activity decreases and traffic generally increases.

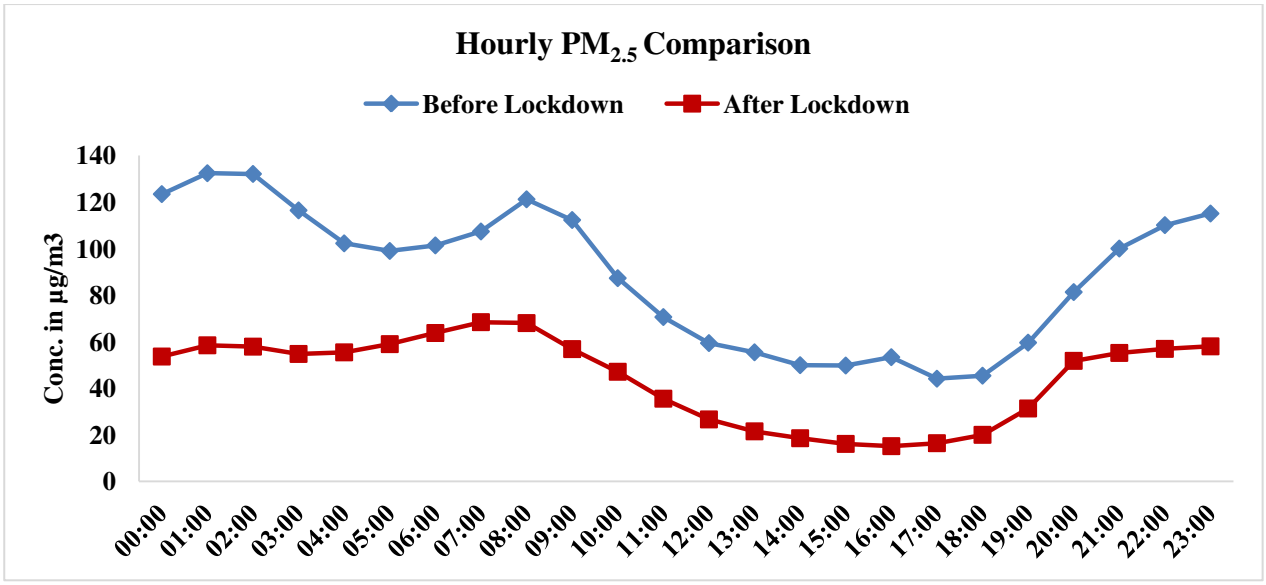

24 Hourly Average PM2.5 Comparison
Standard=60µg/m3
Conc. in µg/m3
140
120
100
80
60
40
20
0
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
06-Apr
07-Apr
08-Apr
09-Apr
10-Apr
11-Apr
12-Apr
13-Apr
14-Apr
15-Apr
Before Lock Down
During Lockdown


24 Hourly Average PM10 Comparison
Standard=100µg/m3
Conc. in µg/m3
300
250
200
150
100
50
0
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
06-Apr
07-Apr
08-Apr
09-Apr
10-Apr
11-Apr
12-Apr
13-Apr
14-Apr
15-Apr
Before Lock Down
During Lockdown


24 Hourly Average NO2 Comparison
Standard=80µg/m3
Conc. in µg/m3
70
60
50
40
30
20
10
0
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
06-Apr
07-Apr
08-Apr
09-Apr
10-Apr
11-Apr
12-Apr
13-Apr
14-Apr
15-Apr
Before Lock Down
During Lockdown


24 Hourly Average SO2 Comparison
Standard=80µg/m3
Conc. in µg/m3
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
06-Apr
07-Apr
08-Apr
09-Apr
10-Apr
11-Apr
12-Apr
13-Apr
14-Apr
15-Apr
Before Lock Down
During Lockdown


24 Hourly Average Benzene Comparison
Conc. in µg/m3
3.00
2.50
2.00
1.50
1.00
0.50
0.00
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
06-Apr
07-Apr
08-Apr
09-Apr
10-Apr
11-Apr
12-Apr
13-Apr
14-Apr
15-Apr
Before Lock Down
During Lockdown


Hourly PM2.5 Comparison
Before Lockdown
After Lockdown
Conc. in µg/m3
140
120
100
80
60
40
20
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
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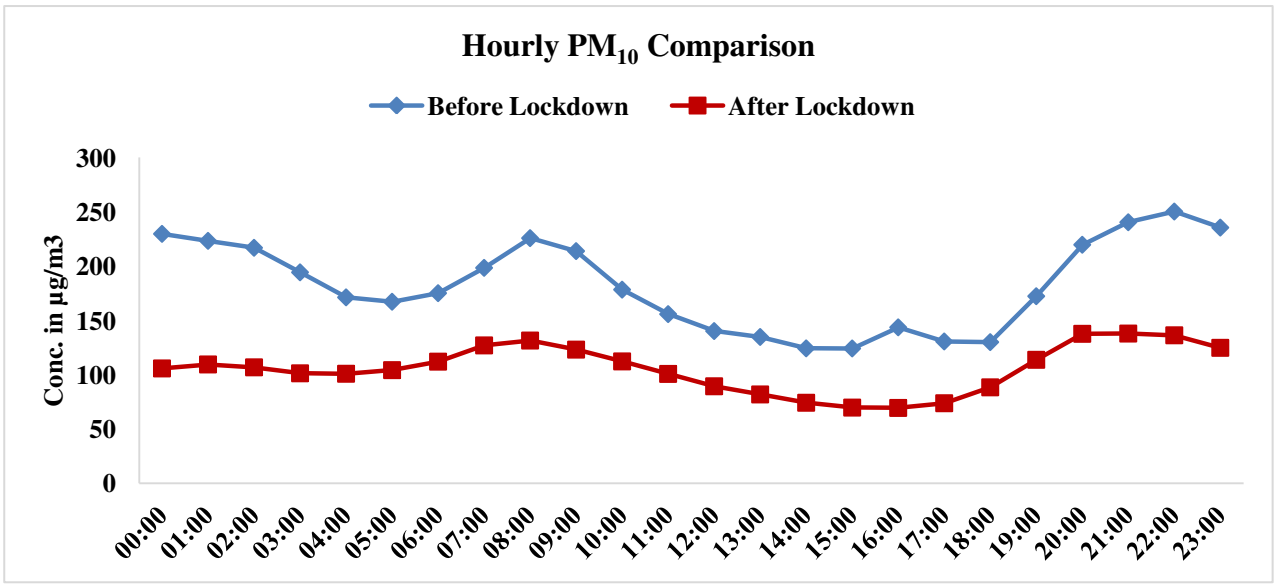
18:00
19:00
20:00
21:00
22:00
23:00


Hourly PM10 Comparison
Before Lockdown
After Lockdown
Conc. in µg/m3
300
250
200
150
100
50
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
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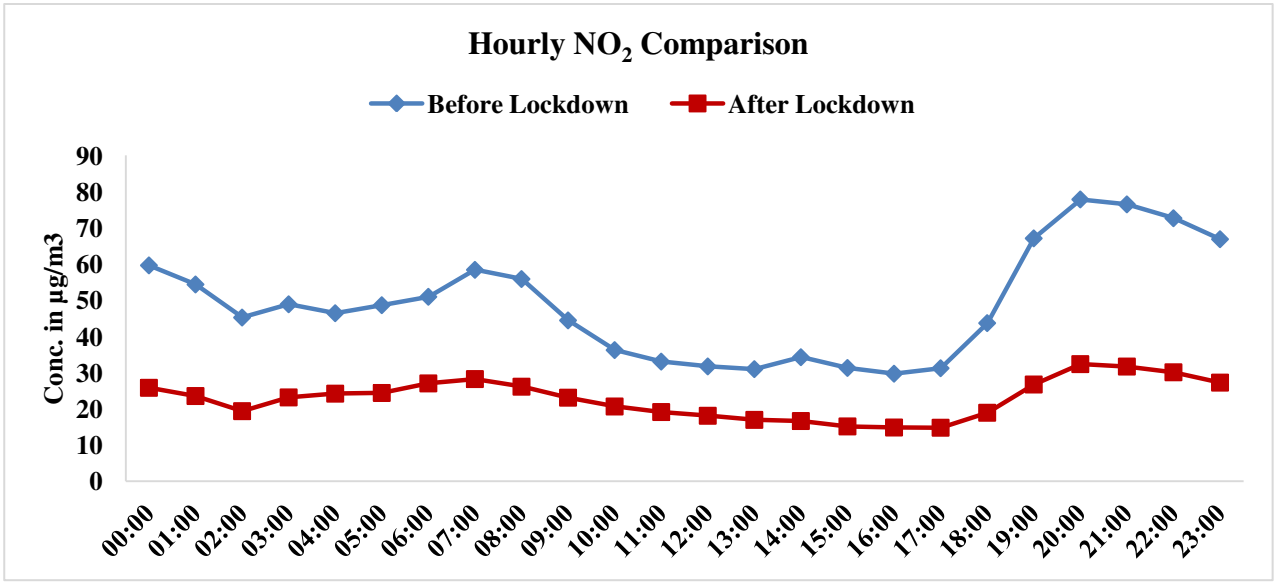
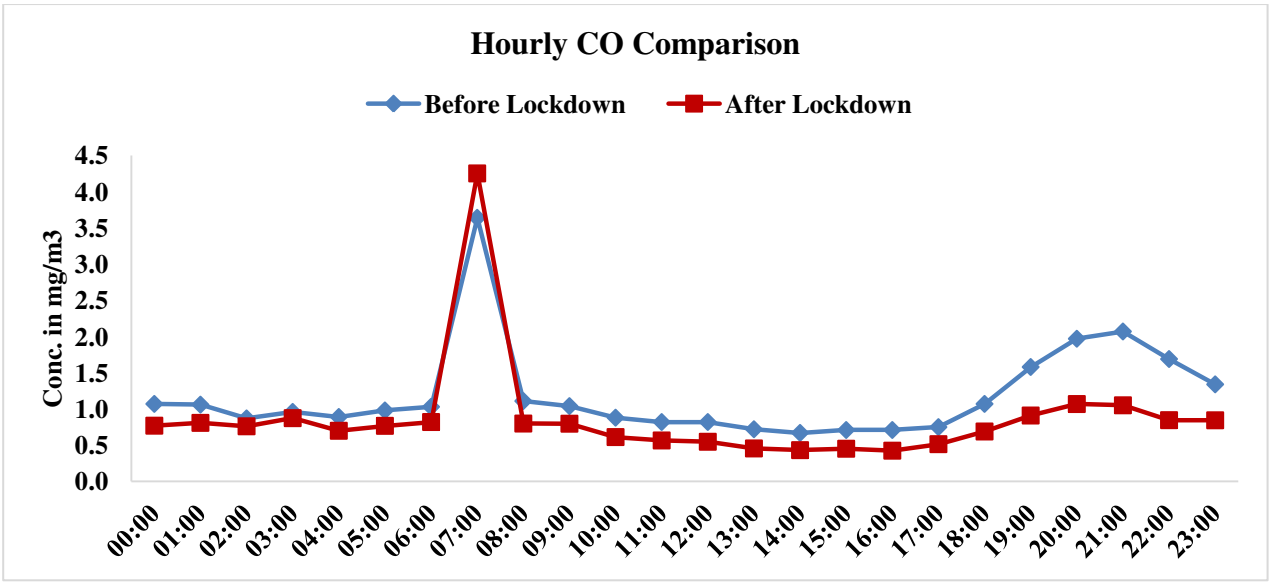
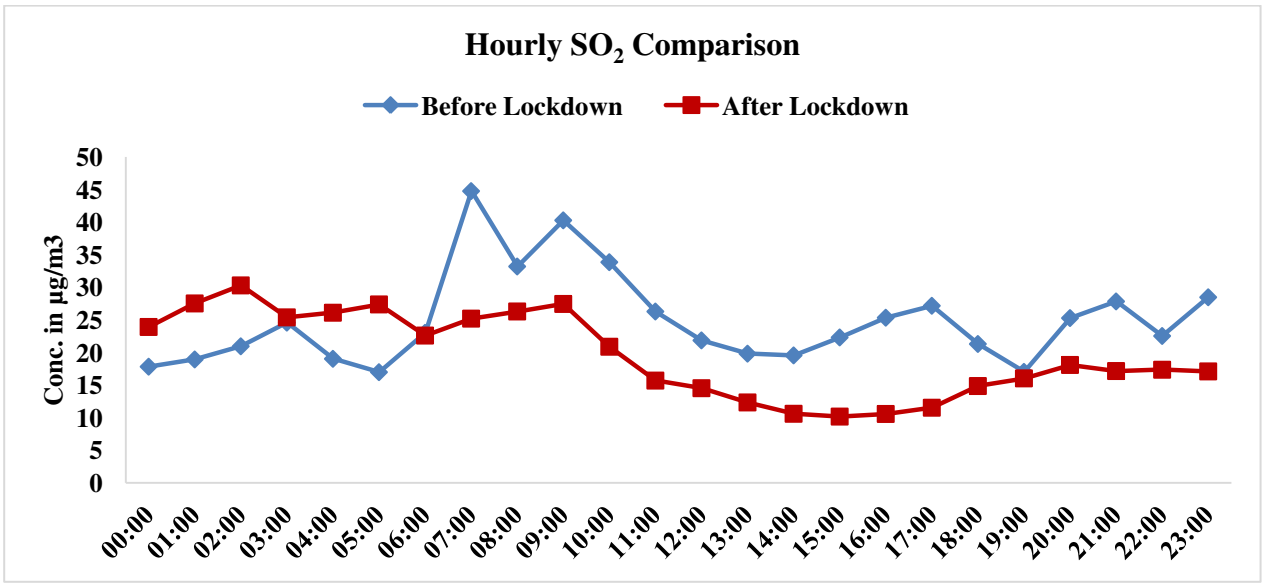
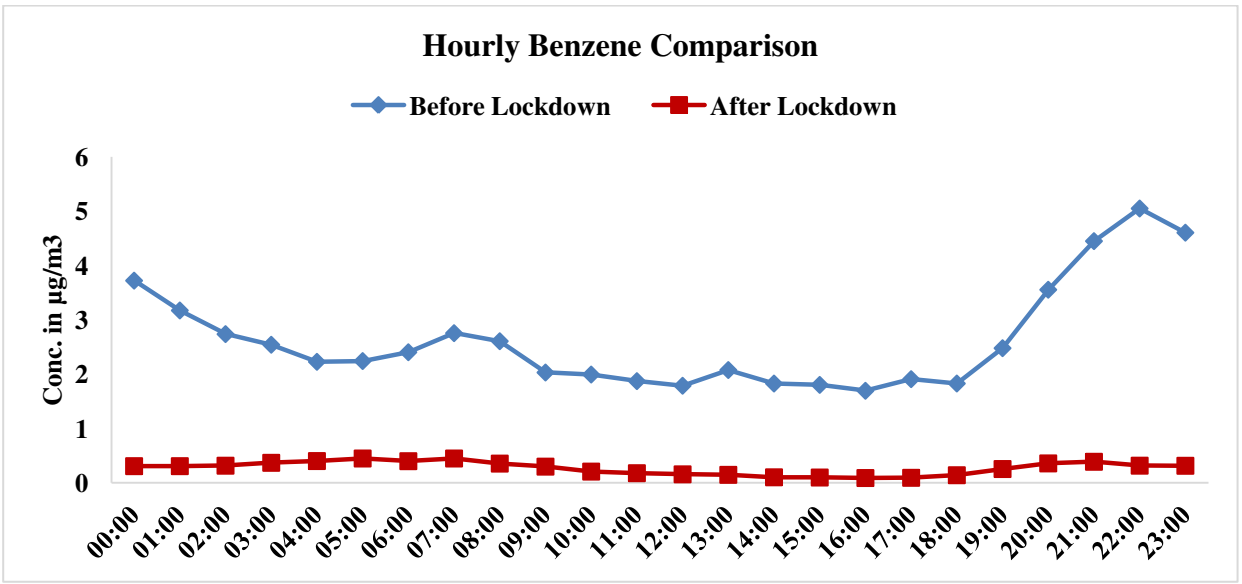
17:00
18:00
19:00
20:00
21:00
22:00
23:00


Hourly NO2 Comparison
Before Lockdown
After Lockdown
Conc. in µg/m3
90
80
70
60
50
40
30
20
10
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00

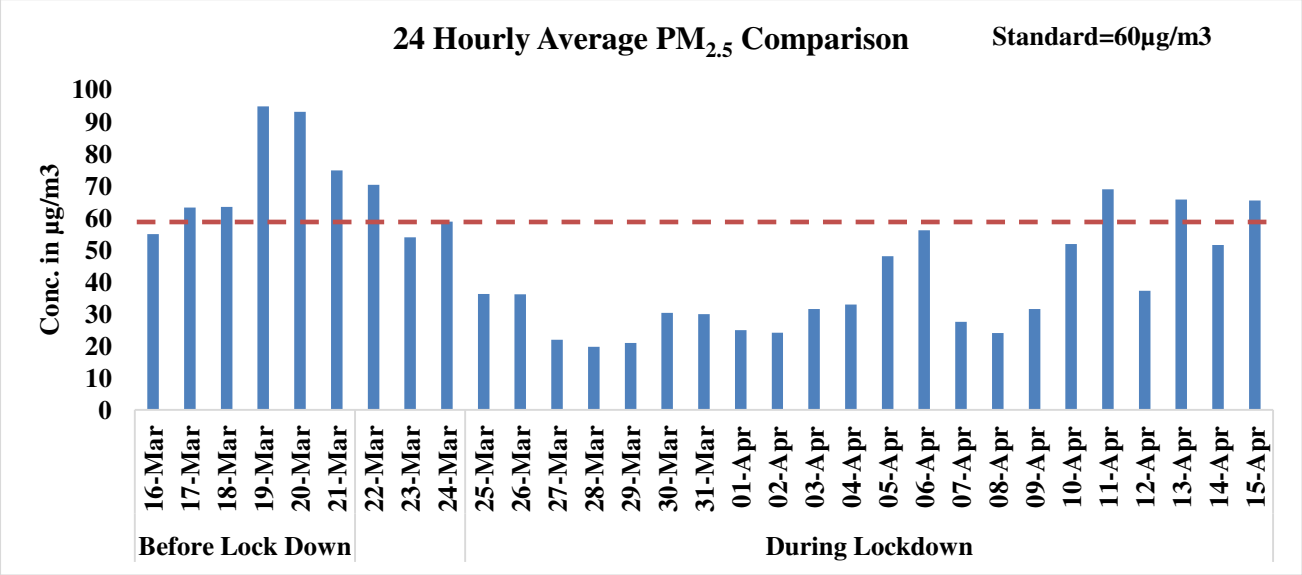

Hourly CO Comparison
Before Lockdown
After Lockdown
Conc. in mg/m3
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00

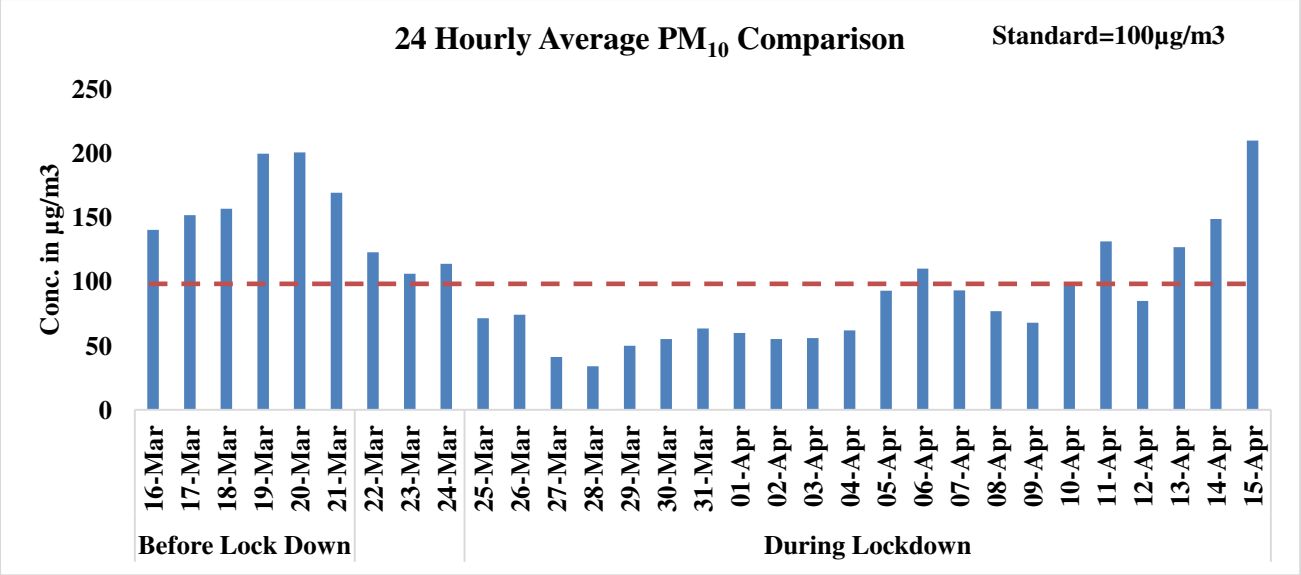

Hourly SO2 Comparison
Before Lockdown
After Lockdown
Conc. in µg/m3
50
45
40
35
30
25
20
15
10
5
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00

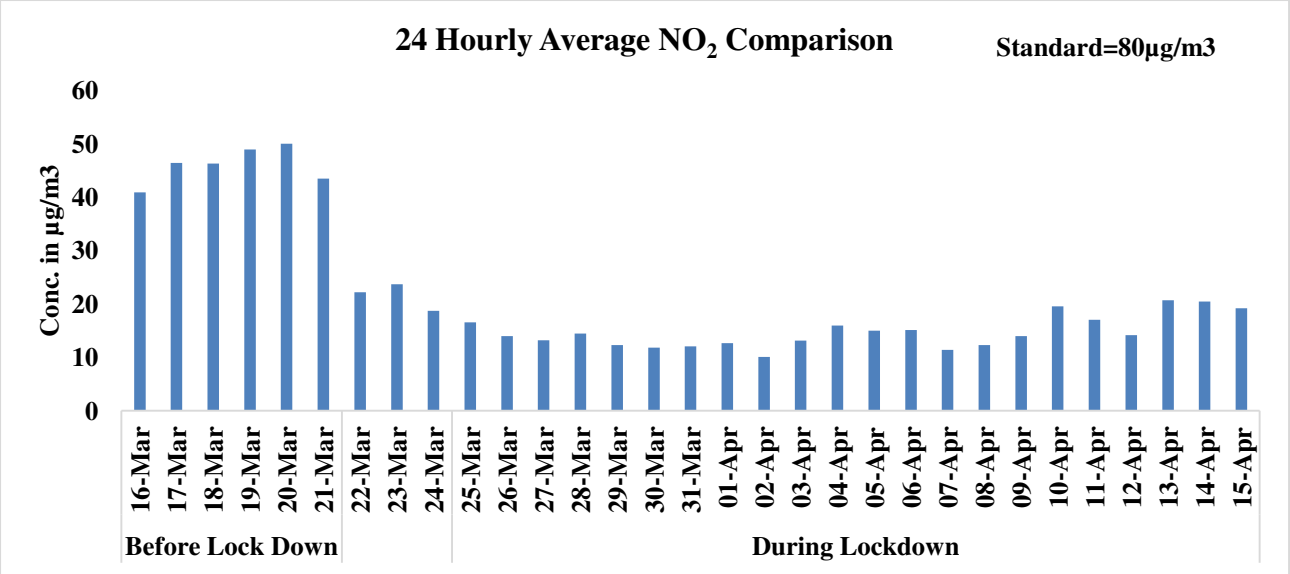

Hourly Benzene Comparison
Before Lockdown
After Lockdown
Conc. in µg/m3
6
5
4
3
2
1
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00

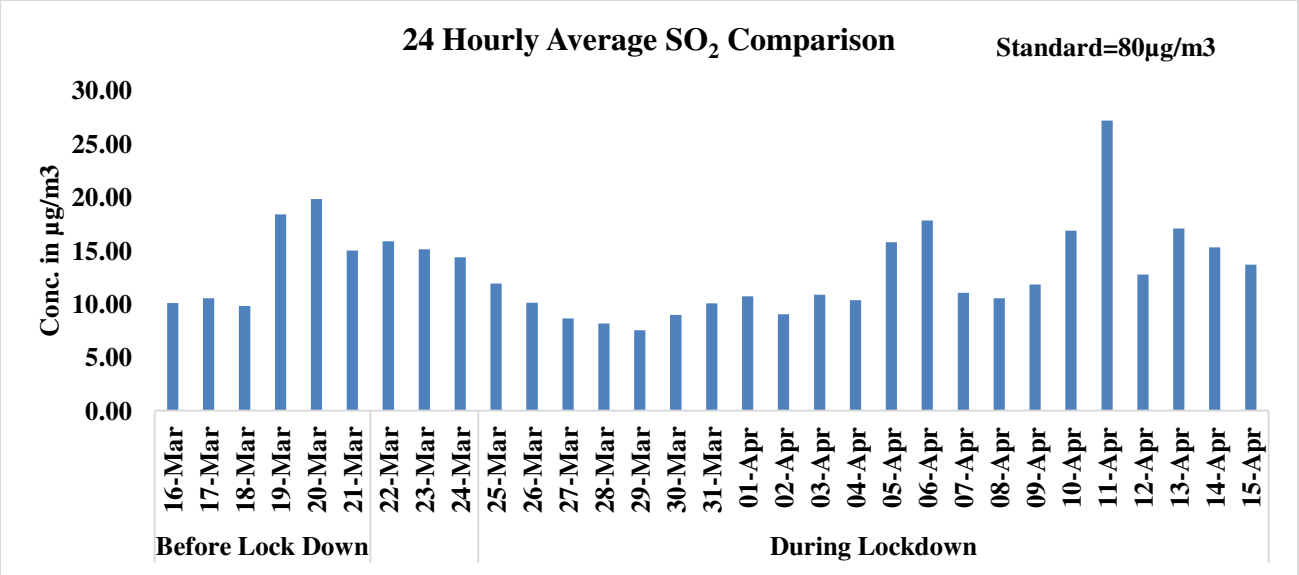
Noida

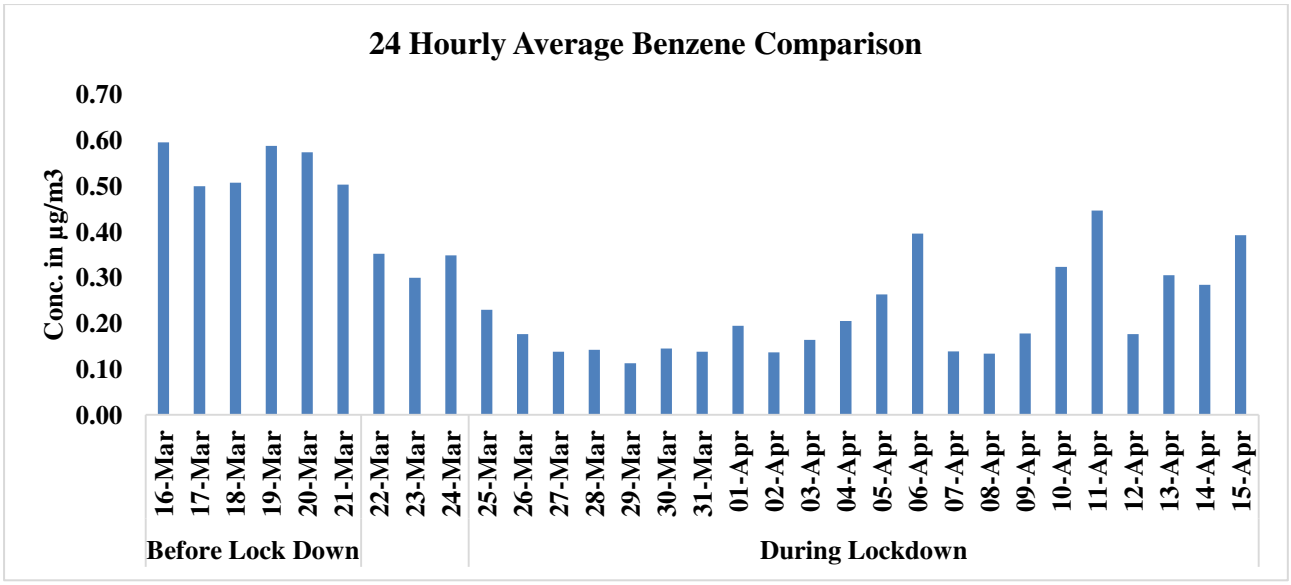
Positive effects of lockdown on air pollution levels were observed in Noida, as emission levels considerably reduced from the pre-lockdown period with over 48% reduction in $PM_{2.5}$ and PM_{10}. 24 hourly average $PM_{2.5}$ and PM_{10} concentrations remained within NAAQS for 19 and 17 days respectively out of the 22 days in the lockdown period. NO_2 and SO_2 levels remained within NAAQS on all days of the lockdown period with the peak hourly NO_2 value decreasing from 76 µg/m^3 in the pre-lockdown period to 20 µg/m^3 in the lockdown period. Peak hourly Benzene levels reduced by 67% , in all possibility due to the restrictions on vehicular activity and industrial operations. While construction activity is a major emission source in Noida contributing 47% to PM_{10} (TERI source apportionment study, 2018) , significant reduction in PM_{10} levels with hourly peak values decreasing by 55%, suggest reduced contribution of road dust resuspension & C & D activities. Reduction in $PM_{2.5}$ and CO emission levels was lower during morning hours signifying contribution of combustion activities. Further, over 52% reduction in peak hourly CO values was observed. While overall SO_2 levels were seen to decline during the lockdown period, peak hourly SO_2 value increased marginally. Hourly SO_2 levels were also higher during the early morning hours, when dispersion of pollutants is lower. It may be said that thermal power plants located in NCR and use of fuels like coal and biomass/,wood etc in industrial and household activities including operation of some brick kilns, Sugar and distilleries, might be playing a more dominant role in affecting SO_2 levels in Noida.

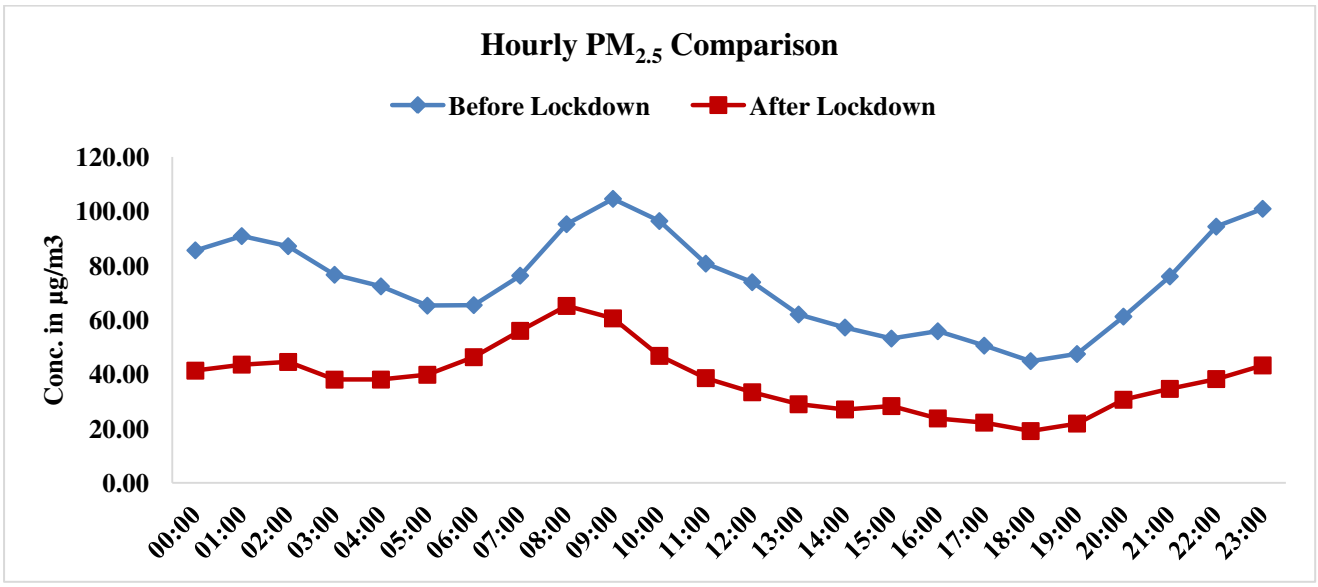



24 Hourly Average PM10 Comparison
Standard=100µg/m3
Conc. in µg/m3
250
200
150
100
50
0
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
06-Apr
07-Apr
08-Apr
09-Apr
10-Apr
11-Apr
12-Apr
13-Apr
14-Apr
15-Apr
Before Lock Down
During Lockdown


24 Hourly Average NO2 Comparison
Standard=80µg/m3
Conc. in µg/m3
60
50
40
30
20
10
0
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
06-Apr
07-Apr
08-Apr
09-Apr
10-Apr
11-Apr
12-Apr
13-Apr
14-Apr
15-Apr
Before Lock Down
During Lockdown


24 Hourly Average SO2 Comparison
Standard=80µg/m3
Conc. in µg/m3
30.00
25.00
20.00
15.00
10.00
5.00
0.00
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
06-Apr
07-Apr
08-Apr
09-Apr
10-Apr
11-Apr
12-Apr
13-Apr
14-Apr
15-Apr
Before Lock Down
During Lockdown


24 Hourly Average Benzene Comparison
Conc. in µg/m3
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
01-Apr
02-Apr
03-Apr
04-Apr
05-Apr
06-Apr
07-Apr
08-Apr
09-Apr
10-Apr
11-Apr
12-Apr
13-Apr
14-Apr
15-Apr
Before Lock Down
During Lockdown


Hourly PM2.5 Comparison
Before Lockdown
After Lockdown
Conc. in µg/m3
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
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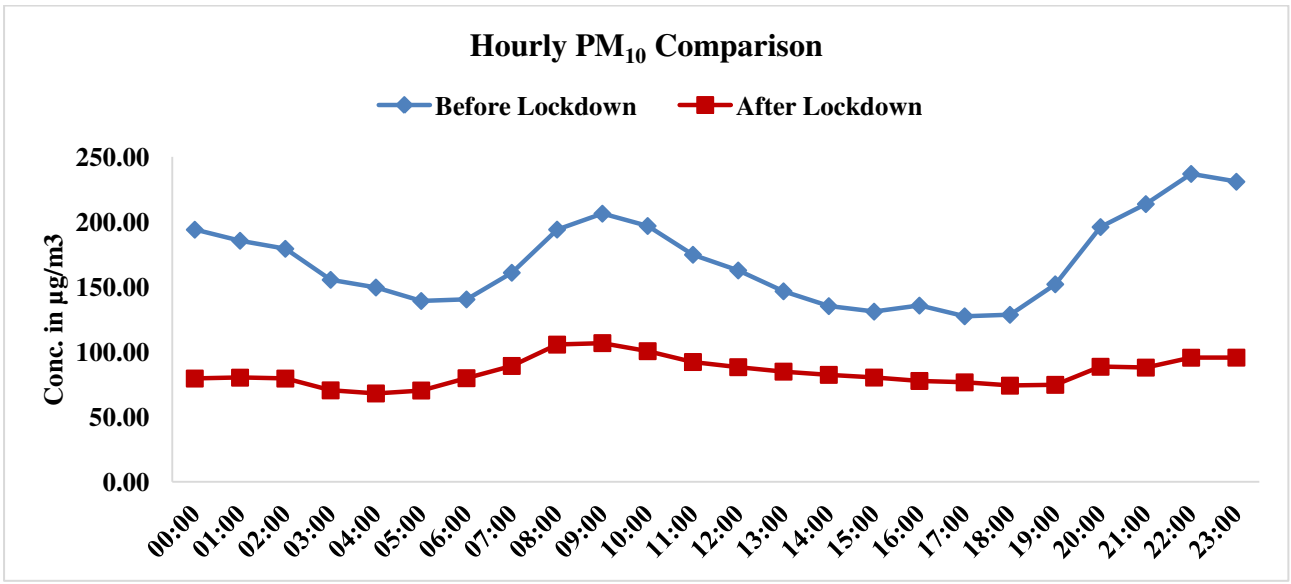
18:00
19:00
20:00
21:00
22:00
23:00


Hourly PM10 Comparison
Before Lockdown
After Lockdown
Conc. in µg/m3
250.00
200.00
150.00
100.00
50.00
0.00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
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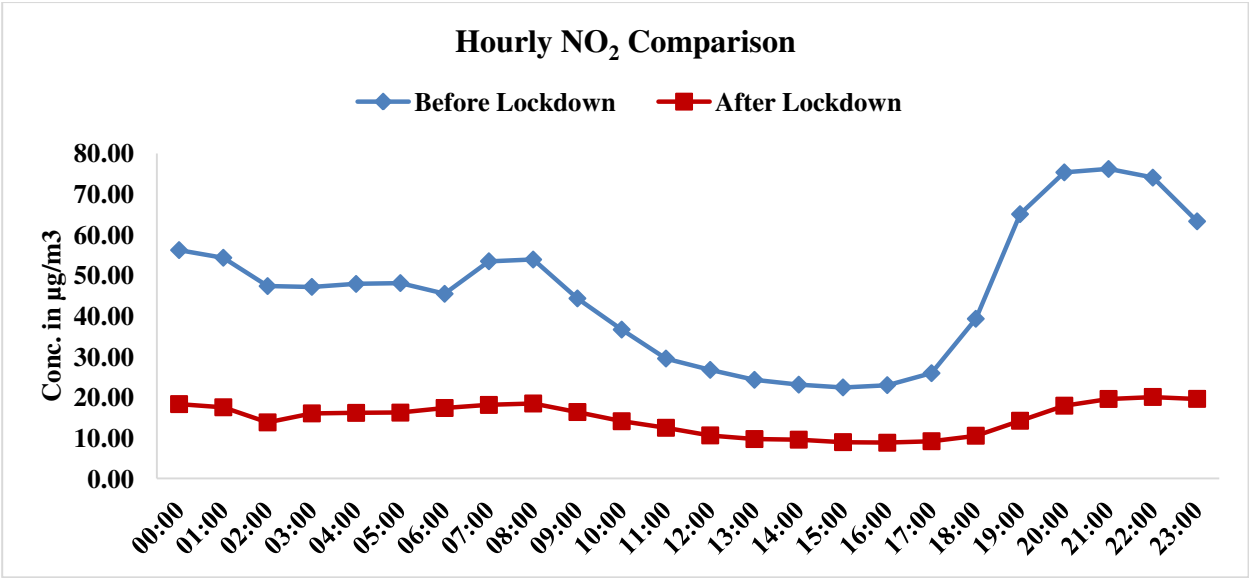
20:00
21:00
22:00
23:00


Hourly NO2 Comparison
Before Lockdown
After Lockdown
Conc. in µg/m3
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
00:00
01:00
02:00
03:00
04:00
05:00
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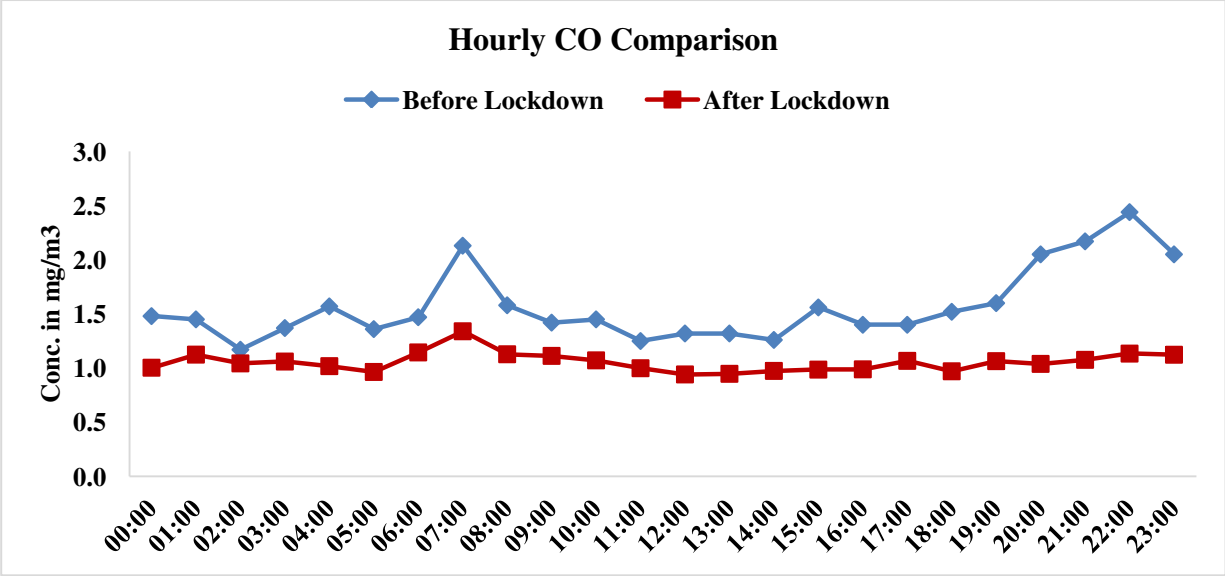
23:00


Hourly CO Comparison
Before Lockdown
After Lockdown
Conc. in mg/m3
3.0
2.5
2.0
1.5
1.0
0.5
0.0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
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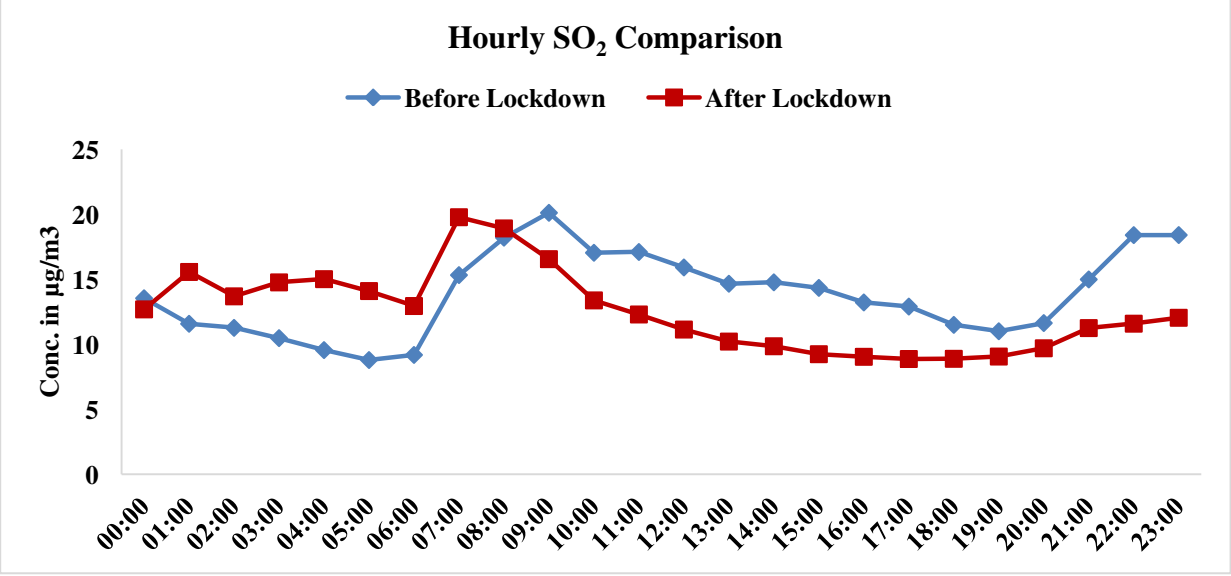
18:00
19:00
20:00
21:00
22:00
23:00


Hourly SO2 Comparison
Before Lockdown
After Lockdown
Conc. in µg/m3
25
20
15
10
5
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
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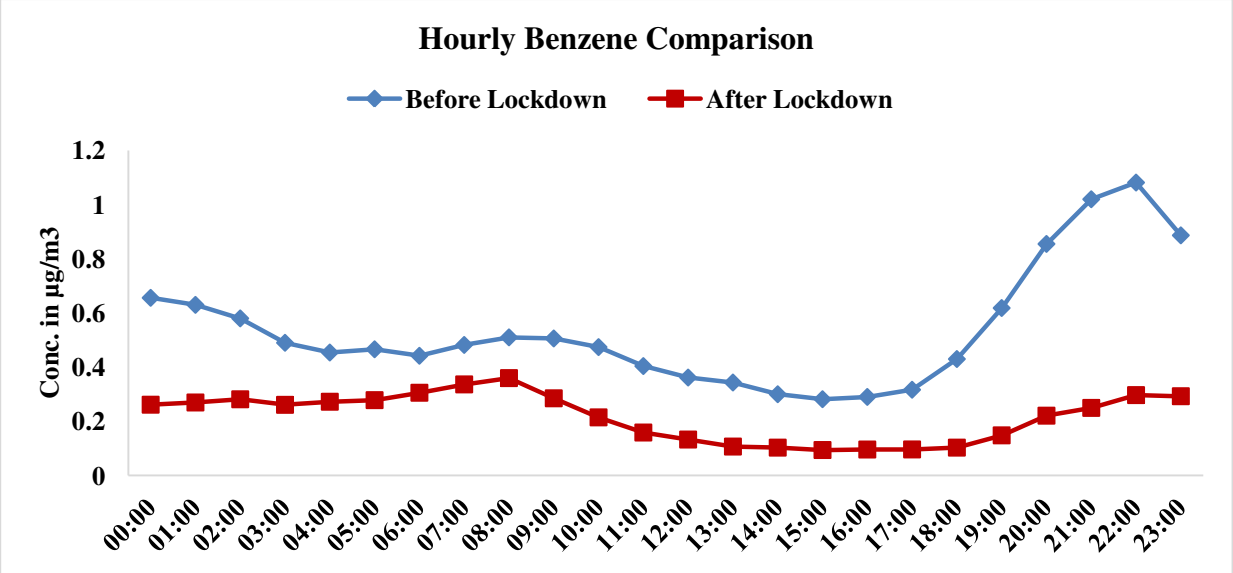
19:00
20:00
21:00
22:00
23:00



EFFECT OF LOCKDOWN IN DELHI NCR

Substantial improvement in air quality of Delhi NCR is noted during the lockdown period, as the major contributing sources to PM & NO_2 emissions (prominent pollutants in Delhi NCR) have been restricted. The AQI in Delhi NCR was largely under 'moderate' category in the week before start of lockdown period. As days progressed, under cumulated effect of restricted vehicle movement ,industrial & commercial activities and increased mixing height, the AQI improved to 'Satisfactory' category. On March 26, 2020, high surface winds (25 kmph) maintained AQI category even though mixing height dropped to 1100 m. Next day, though wind speed and mixing height were reduced to half value, AQI value improved further and Gurugram recorded 'Good' AQI category. Scattered rains in Delhi NCR on 27th March and during March 28- 29, 2020 along with increased wind speed and mixing height, AQI value improved further, with Delhi, Ghaziabad and Noida recording 'Good' AQI category on March 28, 2020. Favorable conditions ensued, leading to AQI remaining in 'Good' and 'Satisfactory' AQI categories. However, after 4th April due to change in temperature and onset of dry conditions, high winds led to lifting of local dust resulting in slight deterioration of air quality to 'moderate' category. Further, a dust storm from the gulf hit Delhi and the surrounding areas on 15th April, further pushing the air quality to the higher end of moderate category.

Date	Predominant Wind Speed (kmph)	Maximum Mixing Height (m)	Delhi	Ghaziabad	Noida	Faridabad	Gurugram
16-Mar	16	1800	139	134	118	184	165
17-Mar	12	1500	157	148	140	164	141
18-Mar	15	2000	151	172	137	164	168
19-Mar	14	3200	186	236	184	194	192
20-Mar	12	2400	192	235	195	212	175

21-Mar	16	2500	186	207	161	174	126
22-Mar (Janata Curfew)	12	2900	191	237	176	214	191
23-Mar	10	800	124	159	123	130	91
24-Mar	10	2700	122	166	130	187	127
IMPOSITION OF NATIONWIDE LOCKDOWN DUE TO COVID-19							
25-Mar	12	2500	77	86	80	100	69
26-Mar	25	1100	92	84	72	88	61
27-Mar	15	500	69	72	60	75	42
28-Mar	14	2250	45	39	38	64	54
29-Mar	20	2600	62	48	58	83	62
30-Mar	20	2100	71	64	61	97	76
31-Mar	12	1900	76	72	67	110	77
01-Apr	12	3200	73	79	73	90	69
02-Apr	20	3050	69	63	62	63	72
03-Apr	22	2100	79	104	72	97	82
04-Apr	20	3000	87	109	70	90	89
05-Apr	10	3500	102	124	84	117	91
06-Apr	15	3500	142	181	120	123	106
07-Apr	32	3750	90	101	78	100	86
08-Apr	20	3100	83	113	85	103	91
09-Apr	16	2400	86	86	80	103	96
10-Apr	15	3500	118	115	93	117	104
11-Apr	8	3050	124	194	146	203	152
12-Apr	20	2750	94	93	87	119	98
13-Apr	18	3700	126	132	120	122	106
14-Apr	12	4480	130	145	123	146	113
15-Apr	12	4980	155	194	184	186	142

EFFECT OF LOCKDOWN IN OTHER CITIES

Air Quality Indices are calculated for cities all over India using data from CAAQM stations. If cities appearing in CPCB AQI Bulletin are grouped according to their respective AQI categories, it is observed that about 78% of cities in the AQI bulletin are falling in Good and Satisfactory categories in the lockdown phase, increasing from the average of 44% seen in the pre-lockdown phase. Since Good and Satisfactory categories have their breakpoints within the National Ambient Air Quality Standards, it may be reasonable to state that more cities have their air quality within National standards during the lockdown period.

During the lockdown period, no city entered the very poor category. Among the cities in poor category during the lockdown period, instances of Singrauli and Brajrajnagar are found frequently. It is worth noting that Singrauli is home to several power plants, which are operational during the lockdown period and Brajrajnagar has in its vicinity numerous open-cast and underground coal mines.

The date wise AQI is given in Annexure I.

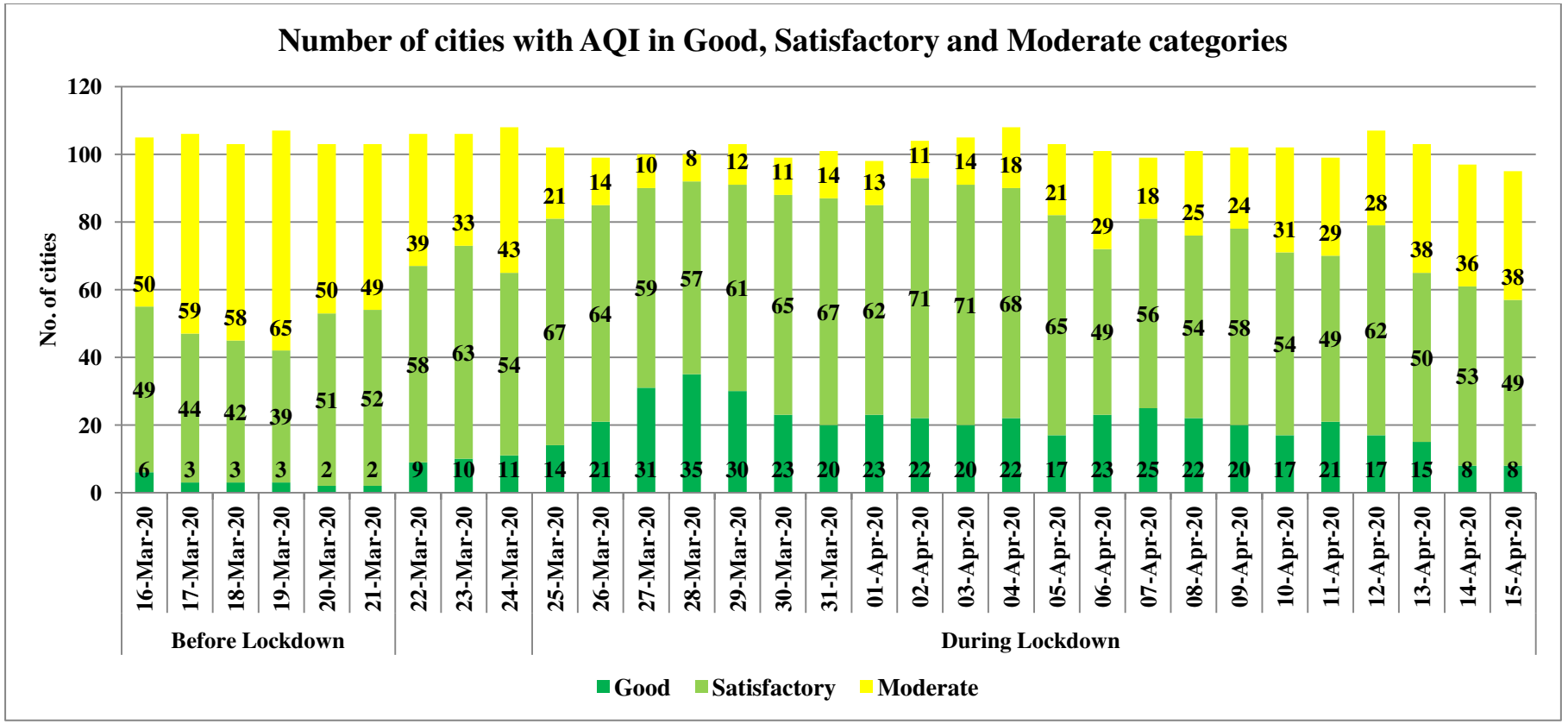
Annexure I

Comparative AQI Status from 16 March to 15 April, 2020
(based on CPCB AQI Bulletin, published at 4 PM)

Date	No of cities for which data is available	No. of cities in AQI category						No. of cities with AQI in range of Good to Satisfactory	No. Of cities with AQI in Moderate Category	No. of cities with AQI in range of Poor to Severe
		Good	Satisfactory	Moderate	Poor	Very Poor	Severe			
16-Mar-20	108	6	49	50	3	0	0	**55**	**50**	3
17-Mar-20	111	3	44	59	5	0	0	**47**	**59**	5
18-Mar-20	112	3	42	58	9	0	0	**45**	**58**	9
19-Mar-20	115	3	39	65	8	0	0	**42**	**65**	8
20-Mar-20	115	2	51	50	12	0	0	**53**	**50**	12
21-Mar-20	112	2	52	49	9	0	0	**54**	**49**	9
22-Mar-20 (Janata Curfew)	114	9	58	39	8	0	0	**67**	**39**	8
23-Mar-20	108	10	63	33	2	0	0	**73**	**33**	2
24-Mar-20	110	11	54	43	2	0	0	**65**	**43**	2
National Lockdown in effect due to COVID-19 Pandemic										
25-Mar-20	104	14	67	21	2	0	0	**81**	**21**	2
26-Mar-20	102	21	64	14	3	0	0	**85**	**14**	3
27-Mar-20	103	31	59	10	3	0	0	**90**	**10**	3
28-Mar-20	101	35	57	8	1	0	0	**92**	**8**	1
29-Mar-20	103	30	61	12	0	0	0	**91**	**12**	0
30-Mar-20	99	23	65	11	0	0	0	**88**	**11**	0
31-Mar-20	103	20	67	14	2	0	0	**87**	**14**	2
01-Apr-20	100	23	62	13	2	0	0	**85**	**13**	2
02-Apr-20	105	22	71	11	1	0	0	**93**	**11**	1

03-Apr-20	105	20	71	14	0	0	0	**91**	**14**	0
04-Apr-20	109	22	68	18	1	0	0	**90**	**18**	1
05-Apr-20	104	17	65	21	1	0	0	**82**	**21**	1
06-Apr-20	102	23	49	29	1	0	0	**72**	**29**	1
07-Apr-20	101	25	56	18	2	0	0	**81**	**18**	2
08-Apr-20	102	22	54	25	1	0	0	**76**	**25**	1
09-Apr-20	102	20	58	24	0	0	0	**78**	**24**	0
10-Apr-20	104	17	54	31	2	0	0	**71**	**31**	2
11-Apr-20	103	21	49	29	4	0	0	**70**	**29**	4
12-Apr-20	108	17	62	28	1	0	0	**79**	**28**	1
13-Apr-20	104	15	50	38	1	0	0	**65**	**38**	1
14-Apr-20	102	8	53	36	5	0	0	**61**	**36**	5
15-Apr-20	105	8	49	38	10	0	0	**57**	**38**	10

AQI Category	AQI Range	Associated Health Impact
Good	0-50	Minimal Impact
Satisfactory	51-100	Minor breathing discomfort to sensitive people
Moderate	101-200	Breathing discomfort to the people with lungs, asthma and heart diseases
Poor	201-300	Breathing discomfort to most people on prolonged exposure
Very Poor	301-400	Respiratory illness on prolonged exposure
Severe	401-500	Affects healthy people and seriously impacts those with existing diseases


Number of cities with AQI in Good, Satisfactory and Moderate categories
No. of cities
120
100
80
60
40
20
0
16-Mar-20 6 49 50
17-Mar-20 3 44 59
18-Mar-20 3 42 58
19-Mar-20 3 39 65
20-Mar-20 2 51 50
21-Mar-20 2 52 49
22-Mar-20 9 58 39
23-Mar-20 10 63 33
24-Mar-20 11 54 43
25-Mar-20 14 67 21
26-Mar-20 21 64 14
27-Mar-20 31 59 10
28-Mar-20 35 57 8
29-Mar-20 30 61 12
30-Mar-20 23 65 11
31-Mar-20 20 67 14
01-Apr-20 23 62 13
02-Apr-20 22 71 11
03-Apr-20 20 71 14
04-Apr-20 22 68 18
05-Apr-20 17 65 21
06-Apr-20 23 49 29
07-Apr-20 25 56 18
08-Apr-20 22 54 25
09-Apr-20 20 58 24
10-Apr-20 17 54 31
11-Apr-20 21 49 29
12-Apr-20 17 62 28
13-Apr-20 15 50 38
14-Apr-20 8 53 36
15-Apr-20 8 49 38
Before Lockdown
During Lockdown
Good
Satisfactory
Moderate