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Impact of covid-19 lockdown on changing concentration of particulate matter (pm) & air quality status: Study of Ghaziabad city, Uttar Pradesh, India

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Abstract
In recent times air pollution level in urban areas has become a serious threat for people not only in India but worldwide. Covid-19 Pandemic being the major crisis of this century has made major changes in environmental condition and most importantly Air quality status worldwide. Indian governments along with other countries declared nationwide lockdown in order to control the spread of Covid-19. This study focuses on investigating the impact of lockdown upon particulate matter concentration (PM 10, PM 2.5) with the overall Air Quality Status by AQI (Air Quality Index) during different phases from 25th March to 31st May. This study was conducted upon Ghaziabad city of Uttar Pradesh, Which is regarded among the most polluted cities in India in recent times. Result obtained from the study shows that every considered area of Ghaziabad city has recorded significant reduction in PM 10 (µg/m3) and PM 2.5(µg/m3) concentration than the previous year and also less than the National Permissible limit. Ghaziabad has shown an unexpected drop in AQI to "Satisfactory" level in 2020 where the AQI used to be recorded as "Poor", "Very Poor" and "Severe" in previous years. The focus of the study is to detect the changes in air quality due to the absence of major human activities like industries, construction works, vehicular movement which are the major contributors of Particulate matter in the air. Overall findings of this study focus on the need for efficient human activity management to control air pollution and also as a preventive measure for future environmental disasters.

Keywords: Covid-19, Air Pollution, Particulate Matter, AQI, Ghaziabad, Uttar Pradesh, India

Introduction

In recent times with the growing urbanization process quality of air become a topic of concern worldwide and for India as well. According to WHO exposure to polluted air has become a major risk factor in present dates worldwide. With the increasing population and related urban growth consumption of energy and other recourses also increased, which contributes air pollution [1]. Currently India is experiencing widespread of air pollution in mainly different urban areas where vehicles are major contributor [2]. Other activity like industrial activities, outdoor constructional activities also contributes to changing air quality in different areas.

The COVID -19 pandemic has been recognized as a major threat to humanity in 2020 for the whole world. As from the initial stage of this pandemic the Covid-19 virus has transmitted very fast in different countries with the movement of people across the countries. After reporting some of the positive cases throughout the country the Government of India have taken different restriction like complete shut down on different commercial activities, educational institutes, other institutes, different government and private offices, complete restrictions in vehicular movement as preventive measures of controlling Covid-19 pandemic. All this restrictions in lockdown were predicted to have an impact in decreasing the major pollutants of air pollution from different anthropogenic activities throughout the different regions of world and that have been reported in many studies in India also [3, 4, 5]. Several studies also highlighted the surprising changes in overall air quality pattern due to sudden lockdown of different regions/cities of the world including different polluted cities of India [6, 7, 8, 9, 10, 11].

The Indian Government first declared a "Janta Curfew" on 22nd March to see the changes in spread of the novel covid-19 and therefore the Government declare its first Phase of Complete Lockdown from 25 of March to 14 of April (21 days) in India and lockdown extended to another three phases.

The prime objective our study was investigating the impact of lockdown period, i.e. from March 25th 2020 to 31st May 2020 (Four Phases) mainly on Particulate matter (PM 10, PM 2.5) Concentration and changing air quality status of Ghaziabad city. The air pollution trends during this lockdown days of different phases were in comparison to the same time period of previous year (2019) to quantify any changes. Additionally, the peak concentrations during the lockdown were also examined through available data. Temporal changes in different stages of (4 Phases) for both the concentration of particulate matter and overall air quality status has been investigated. In this study status of air quality in Ghaziabad city was analyzed using AQI (Air Quality Index) for two consecutive years.

Study area

Ghaziabad is a city in Uttar Pradesh and comes under the National Capital Region (NCR) of Delhi and is known as administrative headquarters of the Ghaziabad Districts. It is also termed as "Gateway of Uttar Pradesh" due to its well connectivity with northern part of India (Wikipedia). The coordinates of the city is

from 28˚40ˈN and 77˚25ˈE. It is situated on the grand trunk road which is located in the east of the Hindon River. The city has a population 3343334 (2011 census) and growth rate of 53%. Ghaziabad is an important place for industrial development. In recent times with the development of Delhi, people are attracted towards this city and the city is experiencing tremendous growth of population which ultimately leads to environmental deterioration mainly air quality. According to the world Air quality report of IQ Air Ghaziabad was the 2nd most polluted (2018) and most polluted (2019) regional cities in the world. This city has been selected as a study area to observe the changes in Lockdown period.

Materials and Methods

For the evaluation of changing concentration of particulate matter in of Ghaziabad city all the information was collected and analyzed based on available data from CPCB (Central Pollution Control Board) and UPPCB (Uttar Pradesh Pollution Control Board). Ghaziabad city has four automated air quality monitoring stations at present namely Indhirapuram, Lony, Sanjay Nagar, Vasundhara. In the present study mainly particulate matter of >10um size (PM 10) and particulate matter of >2.5um (PM 2.5) has been considered for the evaluation of change in concentration during lockdown period. Day wise 24 hourly average data of this particulate matter (PM) taken into consideration mainly for different lockdown phases (25thMarch – 31stMay) declared by the Government of India. Total data set has been divided into two segments one is reference year (2019) and another is current year (2020) for further comparisons. To quantify the possible changes regarding pollutant and air quality status percentage of change has been calculated by using following equation

$$D = (Yc - Yr) / Yr * 100$$ [12]

Where,

D is the percentage of change, Yc is the concentration of pollutant in the current year (2020) during lockdown period (considering different phases), and Yr is the concentration of pollutants in reference year (2019) during same period as current year.

In order to know about the scenario of air quality of Ghaziabad city, AQI data of 2019 and 2020 (same period) was prepared based on the automated stations of Ghaziabad (www.app.cpcdccr.com). All AQI data was presented through two master tables with different color based on AQI index given by CPCB for better understanding. These master tables reflects a clear picture of air quality status of Ghaziabad in the year 2019 and 2020, Specially it helps to compare the effect of Covid-19 lockdown on the status of air quality. For preparation of theses master tables daily average data of 24 hours were collected from AQI bulletin of CPCB and further analyzed.

Air quality Index

According to CPCB (2014) the most effective tool to highlight the Air Quality status is Air Quality Index (AQI). This index makes easy for people to understand the air quality status of their respective area. Using AQI the complex data of different air pollutants are transformed into index value, colour and nomenclature. CPCB has divided AQI into six different categories, namely Good, Satisfactory, Moderate, Poor, Very Poor, and Severe. Every categories have different ambient concentration values of pollutants. This categories also characterized by different health break points based on health impacts. To calculate AQI sub-index and health breakpoints there are eight pollutants (PM10, PM2.5, NO2, SO2, CO, O3, NH3, and Pb) which are taken into consideration in most of the case. The short term (24 Hours) national ambient air quality standards for these pollutants has been prescribed CPCB (Table 1).

Table 1: Categories and break point concentration of AQI System (CPCB, 2014)

AQI Class (Range)	Health Impacts	PM 10 24h	PM 2.5 24h
		Concentration Range	
Good(0-50)	Minimal impacts	0-50	0-30
Satisfactory(51-100)	Minor breathing discomfort to sensitive people	51-100	31-60
Moderately polluted(101-200)	Breathing discomfort to people with lung diseases	101-250	61-90
Poor(201-300)	Breathing discomfort to people on prolonged exposure	251-350	91-120
Very poor(301-400)	Respiratory illness to the people on prolonged exposure	351-430	121-250
Severe(401-500)	Respiratory illness to the people on prolonged exposure	>430	>250

Basic descriptive statistics has been used to highlight day wise changes of air quality and concentration of particulate matter.

Result and Discussion

In recent years Ghaziabad consistently been one of the most polluted city in India and worldwide as well. In terms of growing population and traffic growth in recent times the city has experienced very poor and severe air quality many times in previous year (2019). According to the CPCB data particulate matter (PM 10, PM 2.5) has been considered as a major pollutants for poor air quality in urban areas. Mostly poor air quality resultant from vehicle and industrial effluents mainly. Deteriorating air quality of Ghaziabad has become a major concern for human health.

Normally as every region has different weather pattern and weather elements like temperature, precipitation, Relative humidity, Wind direction & velocity changes spatiotemporally. These weather elements tend to have impact on pollutant level at that time. Meteorological parameters like Wind speed, Precipitation etc plays a major part in diffusion and transportation of air pollutants [13]. In every region there is a strong seasonal variability of meteorological elements which modulate the air quality level [14, 15] So in Ghaziabad city in terms of overall air quality status there must be some seasonal variations but in the present study only changes due to lockdown and its comparison with previous year has been done.

In the year 2020 as every region of India has went through a partial lockdown process as controlling measures of Covid-19 pandemic. So maximum portion of traffic vehicle, industries and constructional activities were shut down completely. So, this sudden closure of every human activity has reduced the air pollution level and concentration of particulate matter of the city

like other cities surprisingly. Some of the recent studies show that pollutants level mainly level of particulate matter has decreased in a significant level in urban areas across the globe [16, 17, 18].

Table 2: National Ambient Air Quality Standards (NAAQS) for Particulate Matter

Pollutants	Weighted Average Based On Time	Residential, Industrial and other areas	Ecologically Sensitive area
PM 10	24 Hours	100	100
PM 2.5	24 Hours	60	60

Evaluating the Changing scenario of PM10 and PM2.5 concentrations during Lockdown phases with compare to reference year

In order to analyze the change in PM10 and PM2.5 concentrations we tried to explored 24 hours average pattern of two pollutants over reference year (2019) considering the same period as lockdown in current year (2020). Continuous monitoring data of PM 10 and PM 2.5 were obtained from automated monitoring stations of Ghaziabad.

Table 3,4,5,6 highlights the basic statistics regarding the major differences in PM10 and PM2.5 concentration of different lockdown phases (25th March to 31st May of 2020) in compare to reference year (2019) for the same period of time.

Indirapuram: Variation in PM 10 and PM 2.5 of Indirapuram are shown in Table-3. it can be noticed that in the previous year (2019) average concentration of PM 10 was very high in different phases of time period and it has reduced significantly by -71.3%,-58.9%,-70.6%,-23.2% respectively in lockdown periods of 2020. The maximum concentration of PM 10 was near to severe as 410, 409, 495, and 411(µg/m3) respectively in different time phases in 2019. But in the same period of lockdown in 2020 this concentration has reduced surprisingly (-62.2%,-39.4%,-67.1%,-39.7%). Likewise average PM 2.5 concentration has decreased by about -67.2%, -48.7%, -58.5%, -21% respectively in lockdown with compare to same time periods of previous year (2019).

Table 3: Basic statistics considering 24 hour average PM10 and PM2.5 concentration for different phases of lockdown (2020) and the previous year records (2019) in Indirapuram, Ghaziabad

	Statistics	Phase 1		Phase 2		Phase 3		Phase 4		Variation in % (2020 and 2019)			
		2019	2020	2019	2020	2019	2020	2019	2020	Phase 1	Phase 2	Phase 3	Phase 4
		PM10											
Indirapuram	Maximum	410	155	409	248	495	163	411	248	-62.2	-39.4	-67.1	-39.7
	Median	259	70	308	99	380.5	108	207.5	193.5	-73	-67.9	-71.6	-6.7
	Minimum	186	34	84	66	166	58	118	36	-81.7	-21.4	-65.1	-69.5
	Average	285.0	81.7	284.1	116.7	362.4	106.6	225.5	173.1	-71.3	-58.9	-70.6	-23.2
	Std	71.0	33.8	85.4	46.6	105.0	29.3	76.8	72.9	-52.4	-45.4	-72.1	-5.1
		PM2.5											
	Maximum	182	83	140	93	179	80	100	116	-54.4	-33.6	-55.3	16
	Median	88	26	85	46	113	48.5	74	51	-70.5	-45.9	-57.1	-31.1
	Minimum	52	15	24	22	70	23	45	16	-71.2	-8.3	-67.1	-64.4
	Average	103	33.8	89	45.7	116.5	48.3	71.9	56.8	-67.2	-48.7	-58.5	-21
	Std	40.9	18.9	29.3	19.1	34.3	15.4	18.5	33.8	-53.8	-34.8	-55.1	82.7

Loni: Variation in PM 10 and PM 2.5 of Loni are shown in Table 4**.** In this area average concentration of PM10 has decreased significantly in lockdown phases by -52.5%, -36.9%, -57.7%, -14.1% respectively compare to same time period of previous year. The maximum concentration of PM10 in this area has recorded as high as 457, 521, 598, and 454 which considered as "severe" in terms of Breakpoint concentration of AQI system by CPCB (Table-1) which has significantly reduced in same period of lockdown. Reduction rate in different phases are -52.5%, -36.9%, -57.7%,-14.1%. Average concentration of PM2.5 in lockdown periods has decreased by -53.4%, -35.7%, -58.9%, -15.1% in comparison to same period of previous year.

Table 4: Basic statistics considering 24 hour average PM10 and PM2.5 concentration for different phases of lockdown (2020) and the previous year records (2019) in Loni, Ghaziabad

	Statistics	Phase 1		Phase 2		Phase 3		Phase 4		Variation in % (2020 and 2019)			
		2019	2020	2019	2020	2019	2020	2019	2020	Phase 1	Phase 2	Phase 3	Phase 4
		PM 10											
Loni	Maximum	457	217	521	329	598	253	454	390	-52.5	-36.9	-57.7	-14.1
	Median	290	115	393	162	426.5	163	275.5	272.5	-60.3	-58.8	-61.8	-1.1
	Minimum	184	46	129	88	165	79	117	44	-75	-31.8	-52.1	-62.4
	Average	300.1	116.9	347.1	183.3	428.3	168.4	267.9	253.1	-61.1	-47.2	-60.7	-5.5
	Std	82.1	50.6	118.8	62.8	134.7	51.4	92.0	111.8	-38.4	-47.2	-61.8	21.5
		PM 2.5											
	Maximum	187	91	145	112	197	112	154	155	-51.1	-22.8	-43.2	0.7
	Median	108	46	89	48	165.5	62	90	63	-57.4	-46.1	-62.5	-27
	Minimum	48	15	38	25	73	32	50	15	-68.8	-34.2	-56.2	-70
	Average	105.7	49.3	93	59.8	155.5	63.9	91.3	77.5	-53.4	-35.7	-58.9	-15.1
	Std	40.9	23.2	34.7	25.4	39.7	22.2	34.3	48.2	-43.3	-26.8	-44.1	40.5

Sanjay Nagar: Variation in PM 10 and PM 2.5 in Sanjay Nagar are shown in Table 5**.** It can be noticed that in this area average concentration of PM10 was very high in different phases in 2019 and it has reduced significantly in lockdown in the same time period by-66.1%,-56.7%,-70.0%,-33.1%. The maximum concentration of PM10 was near to "severe" as 402, 452, 636, and 396(µg/m3) respectively in different phases in 2019 which has reduced surprisingly by-56.7%,-38.5%,-70.3%,-33.6% in lockdown. Likewise average PM2.5 concentration in four phases of lockdown has decreased by -57.4%, -40%, -58.6%, -22.8% respectively in compare to same time periods of previous year (2019).

Table 5: Basic statistics considering 24 hour average PM10 and PM2.5 concentration for different phases of lockdown (2020) and the previous year records (2019) in Sanjay Nagar, Ghaziabad.

	Statistics	Phase 1		Phase 2		Phase 3		Phase 4		Variation in % (2020 and 2019)			
		2019	2020	2019	2020	2019	2020	2019	2020	Phase 1	Phase 2	Phase 3	Phase 4
Sanjay Nagar	PM10												
	Maximum	402	174	452	278	636	189	396	263	-56.7	-38.5	-70.3	-33.6
	Median	286	90	326	121	458	132	249.5	183	-68.5	-62.9	-71.2	-26.7
	Minimum	179	38	93	57	158	68	139	36	-78.8	-38.7	-57	-74.1
	Average	293.4	99.5	308.5	133.6	423.3	126.9	258.4	172.8	-66.1	-56.7	-70.0	-33.1
	Std	65.0	39.8	95.4	54.2	151.0	37.2	84.4	78.1	-38.8	-43.2	-75.4	-7.5
	PM2.5												
	Maximum	190	94	145	118	215	95	141	132	-50.5	-18.6	-55.8	-6.4
	Median	99	48	100	51	130.5	55	93	57.5	-51.5	-49	-57.9	-38.2
	Minimum	54	22	22	24	79	22	52	23	-59.3	9.1	-72.2	-55.8
	Average	117.4	50	91.6	55	136.7	56.6	91.2	70.4	-57.4	-40	-58.6	-22.8
	Std	41.3	21.9	33.1	25.5	43.8	19.7	24.9	39.8	-47	-23	-55	59.8

Vasundhara: Variation in PM 10 and PM 2.5 in Vasundhara are shown in Table 6. In this area average concentration of PM10 has decreased significantly in lockdown phases by -72.9%, -59%, -68.7%, -33.7% respectively compare to same time period of previous year. The maximum concentration of PM 10 in this area has recorded as high as 444, 387, 510, and 420 which considered as "severe" in terms of Breakpoint concentration of AQI system by CPCB (Table 1) which has significantly reduced in same period of lockdown by -60.1%, -35.4%, -66%,-42.1%). Average concentration of PM2.5 in lockdown periods has decreased by -60.9%, -40.8%, -53.3%, -28.1% in comparison to same period of previous year.

Table 6: Basic statistics considering 24 hour average PM10 and PM2.5 concentration for different phases of lockdown (2020) and the previous year records (2019) in Vasundhara, Ghaziabad

	Statistics	Phase 1		Phase 2		Phase 3		Phase 4		Variation in % (2020 and 2019)			
		2019	2020	2019	2020	2019	2020	2019	2020	Phase 1	Phase 2	Phase 3	Phase 4
Vasundhara	PM10												
	Maximum	444	177	387	250	510	172	420	243	-60.1	-35.4	-66	-42.1
	Median	268	60	312	103	371	114.5	277.5	185.5	-77.6	-67	-69.1	-33.2
	Minimum	174	40	90	48	167	63	134	43	-77	-46.7	-62.3	-67.9
	Average	281.1	76.3	282.3	115.7	364.4	114	262.5	174	-72.9	-59	-68.7	-33.7
	Std	72.4	47.4	87.3	47.6	104.5	34.2	72.8	71.6	-34.5	-45.5	-67.3	-1.7
	PM2.5												
	Maximum	191	94	136	100	235	85	123	118	-50.8	-26.5	-63.8	-4.1
	Median	91	33	83	47	111	51.5	82.5	56.5	-63.7	-43.4	-53.6	-31.5
	Minimum	56	20	17	27	52	30	50	22	-64.3	58.8	-42.3	-56
	Average	105.3	41.2	83.3	49.3	113.8	53.1	85.4	61.4	-60.9	-40.8	-53.3	-28.1
	Std	39.3	20.5	29.8	19.0	49.6	14.9	23.3	31.0	-47.8	-36.2	-70.0	33.1

As we can see from the overall condition spatiotemporally every areas of Ghaziabad are having a very much positive impact of lockdown on particulate matter concentration. Except 4th phases of lockdown every phases has experience more than 60% reduction in an average for both PM10 & PM2.5 concentration considering same time period of previous year. Generally urban areas like Ghaziabad having major industrial activities, constructional activities and heavy vehicular load everyday which are the major contributor of particulate matter in the air. In this lockdown absence of these major activities has surprisingly reduced the amount of particulate matter concentration in air and the whole city became cleanest than ever based on air quality.

Day wise trend of PM10 and PM2.5 concentration in Lockdown Phases and its comparison with NAAQS:

There is a variation of air pollutants diurnally, monthly and seasonally as well in different environments.[12] In order to understand the tendency of air pollutants here a comparison of particulate matter in lockdown phases and same periods of previous year (2019) has been done with the Nation Ambient Air Quality Standards.

Trends of PM 10: Trends of PM10 in different areas of Ghaziabad are shown in the Figure (a),(b),(c),(d). In 2019 all these areas recorded very high PM10 level than criteria given by NAAQS except two-three days among the whole period. In every areas PM10 level many times crossed 300(µg/m3) which seems to be poor based on AQI breakpoints by CPCB (Table1) which may cause discomfort in Breathing to people with exposure. But in lockdown in the same period all areas recorded PM10 level well below the standard which made air quality cleanest than ever in those areas.

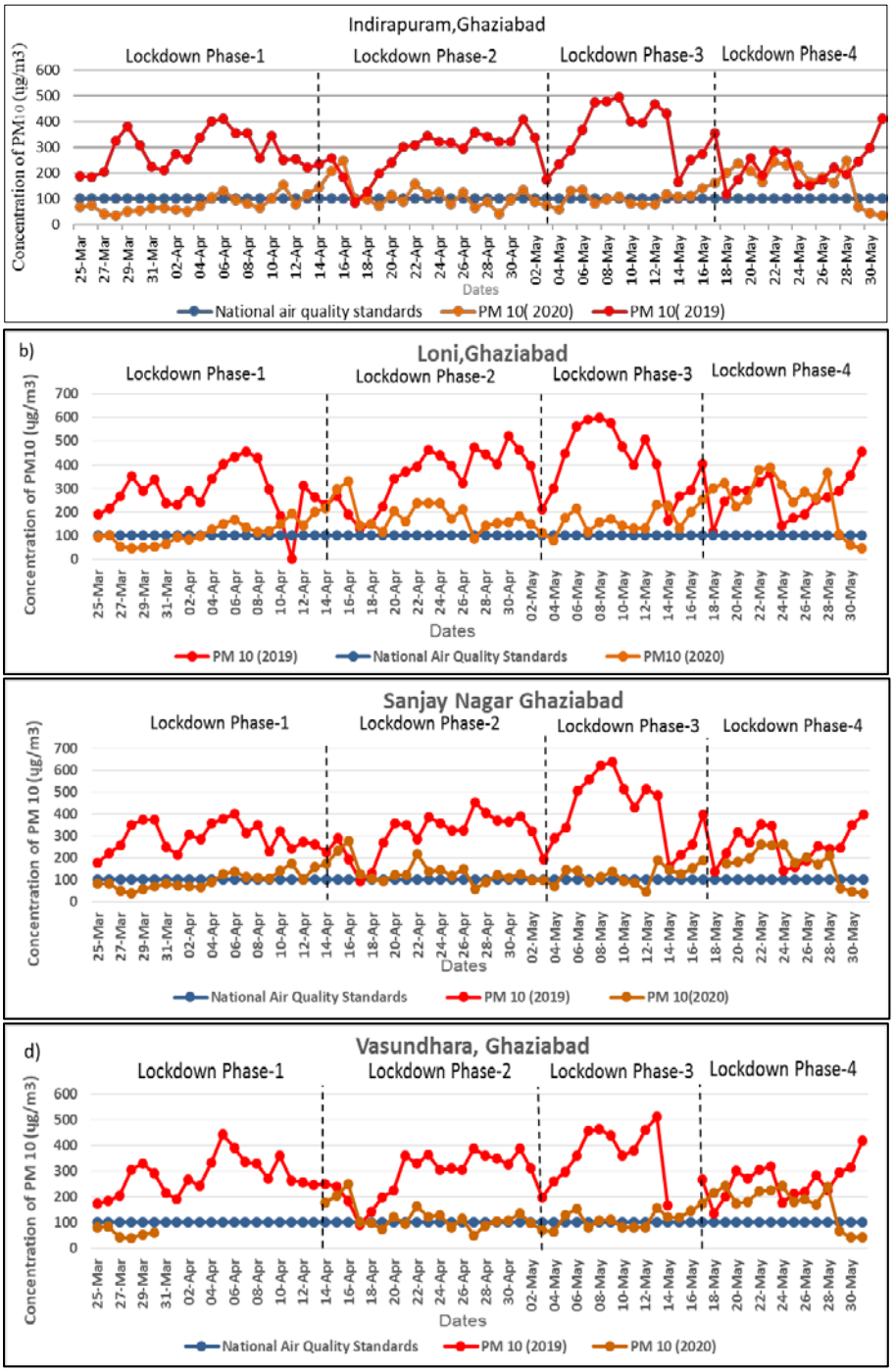

Fig 1: Daly mean concentration Trend of PM10 in different phases of lockdown periods and same periods of previous year with National Standard in Ghaziabad City.

Trends of PM 2.5: Trends of PM2.5 in different areas of Ghaziabad are shown in Figure (e),(f),(g),(h). Areas like Indirapuram, Loni,Sanjay nagar and Vasundhara recorded very higher level of PM 2.5 even more than 100(µg/m3) many times which categorized as poor to very poor according to AQI break points by CPCB(Table 1). This higher level of pollutants may cause discomfort to human health. Surprisingly in lockdown periods mostly in first three phases level of PM 2.5 has reduced significantly even below given criteria of NAAQS. During lockdown these areas became cleanest for the very fast time in long term.

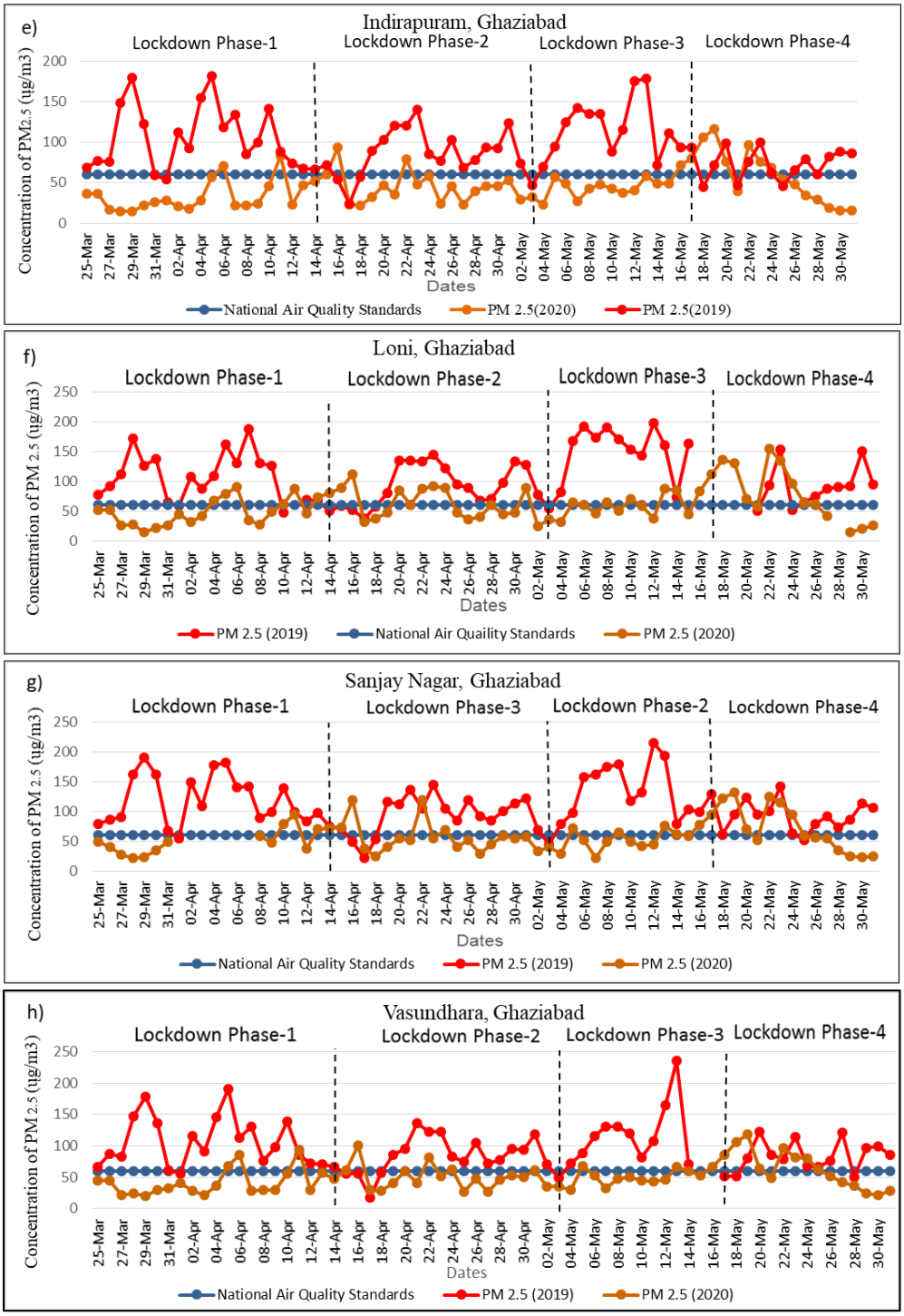

Fig 2: Daily mean concentration Trend of PM 2.5 in different phases of lockdown periods and same periods of previous year with National Standard in Ghaziabad City.

AQI data analysis

Air Quality Indices are calculated for cities all over India using data from CAAQM stations. CPCB publishes daily AQI bulletin at 4 PM for the cities with CAAQM stations. (CPCB). AQI value has been collected and presented through master tables. Table 7, 8 shows month wise AQI values of two consecutive years of Ghaziabad city. If we look at the average AQI values of the whole area it ranges from 93-349 in 2019 and 63-351 in 2020 respectively. From the AQI values of 2019 some seasonal variations can be seen. Months of August, September has recorded lowest average AQI which lies in satisfactory category mainly due to monsoonal effect. Months like January, February, March, April, May, June, October and November were the most polluted months which recorded Poor to very poor AQI value. From the table of 2019 it can be seen that months like January, February and November has recorded Very poor and Severe AQI value maximum times which signifies its vulnerable condition of peoples health in long exposure.

Table 7: Month wise (January-November) Daily AQI values of Ghaziabad 2019

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Dates	Daily average of AQI from automated Monitoring station of Ghaziabad city										
1	418	297	242	169	342	301	209	87	96	85	496
2	455	370	280	227	293	213	242	80	92	82	453
3	458	343	149	211	188	309	138	78	110	184	491
4	418	358	262	282	212	131	112	64	155	108	440
5	417	429	153	326	228	186	121	108	88	109	346
6	358	366	186	338	316	238	81	90	85	135	294
7	388	188	232	342	357	206	89	78	78	162	325
8	318	193	231	281	435	207	150	81	61	119	355
9	288	142	199	199	401	304	139	69	104	186	307
10	298	251	195	287	355	254	159	62	135	225	368
11	404	333	193	226	331	274	380	73	187	264	391
12	437	393	136	227	382	250	294	138	139	263	453
13	393	368	193	208	384	197	357	89	79	320	467
14	245	348	276	179	198	188	270	71	68	277	486
15	249	253	160	204	205	256	168	103	64	308	471
16	384	309	152	226	218	236	90	53	139	339	347
17	473	274	207	108	316	152	150	48	172	298	218
18	412	255	228	187	146	98	133	45	98	270	256
19	313	223	243	209	217	251	165	93	61	169	330
20	441	257	232	215	233	239	126	114	90	269	366
21	375	129	214	280	238	181	118	154	94	284	416
22	434	209	144	259	209	206	127	140	68	236	400
23	235	114	130	308	313	120	136	141	63	285	347
24	289	159	140	259	159	96	186	176	78	335	240
25	164	233	145	288	144	94	89	90	84	303	255
26	267	NA	188	259	182	164	67	50	74	303	300
27	249	75	171	317	210	225	52	109	55	395	143
28	254	230	271	330	186	226	54	114	57	396	105
29	282		299	297	201	266	60	90	54	446	84
30	323		270	287	263	285	73	93	59	478	256
31	380		223		339		83	114		482	
Max	473	429	299	342	435	309	380	176	187	482	496
Min	164	75	130	108	144	94	52	45	54	82	84
Mean	349	263	205	251	265	212	149	93	93	262	340
Std	81.8	93.4	49.0	57.1	82.4	61.8	83.6	32.1	35.7	110.6	111.7
Note: NA means data is not available for that day											
Source: Data has been collected and calculated by author from CPCB site											

Table 8: Month wise (January-November) Daily Air Quality values of Ghaziabad 2020

Months	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov
Dates	Daily Average AQI value from Automated Station of Ghaziabad (Based on four monitoring stations)										
1	412	278	86	79	148	115	126	66	57	174	384
2	384	266	256	63	110	173	147	64	85	204	355
3	316	306	240	104	95	178	162	77	101	212	340
4	394	342	228	109	66	163	124	73	90	222	389
5	360	328	74	124	144	121	111	87	122	216	464
6	351	265	50	181	130	112	78	58	127	195	433
7	297	312	58	101	136	112	64	49	96	246	436
8	262	308	232	113	162	124	44	95	91	236	456
9	256	295	113	86	160	159	160	75	124	248	482
10	292	327	203	115	118	188	88	60	127	246	444
11	305	345	133	194	113	146	86	70	138	231	360
12	374	342	138	93	121	180	131	68	136	302	328
13	393	254	188	132	151	144	111	63	142	299	382
14	363	167	82	145	178	171	151	51	157	291	456
15	299	162	148	194	166	147	128	55	160	322	448
16	326	278	134	250	208	149	85	64	172	266	207
17	247	307	148	127	208	105	87	60	136	289	166
18	245	259	172	96	237	131	80	55	129	269	236
19	331	323	236	89	237	129	92	50	130	253	305
20	313	270	235	144	186	141	126	48	167	223	325
21	398	162	207	102	187	114	70	48	146	254	238
22	386	82	237	172	222	122	54	45	118	318	288
23	220	248	159	143	247	79	105	50	80	344	365
24	163	140	166	149	209	68	103	74	96	356	428
25	300	277	86	114	176	106	68	82	142	379	444
26	382	308	84	150	175	124	78	75	199	365	301
27	400	291	72	66	166	126	141	66	140	306	166
28	284	248	39	83	241	271	86	71	178	317	240
29	232	174	48	113	89	285	103	41	202	389	300
30	228		64	124	69	120	50		169	382	377
31	207		72		61		72			383	
Max	412	345	256	250	247	285	162	95	202	389	482
Min	163	82	39	63	61	68	44	41	57	174	166
Mean	314	264	142	125	159	143	100	63	132	282	351
Std	67.3	68.1	69.8	41.9	53.3	46.4	32.7	13.3	35.0	61.9	91.5
Source: Data has been collecetd and calculated by author from CPCB site											

As in 2020 due to Covid 19 pandemic every region of India went down a complete lockdown from March 25- may 31, which reflected in the AQI values as well. Mainly in the lockdown months AQI values dropped significantly in Ghaziabad city than previous year irrespective of any weather condition. In Table 9 Different statistical parameters has been calculated which helps to understand the changes in AQI values in different phases of Lockdown than previous year. It shows that AQI of Ghaziabad dropped by -58.5%,-49.2%,-52.7%and -12.9% respectively in different phases of lockdown than reference year (2019). In 2019 Ghaziabad has recorded "very poor" and "severe" air quality several times which significantly dropped to "moderately polluted level" and made it cleaner than before.

Table 9: Basic statistics considering 24 hour average of AQI for different phases of lockdown (2020) and the previous year records (2019) in Ghaziabad

Statistics	Phase 1(25march-14 April)		Phase 2(15 April-3May)		Phase 3(4May-17May)		Phase 4(18 May-31 May)		Variation in % (2019 and 2020)			
	2019	2020	2019	2020	2019	2020	2019	2020	Phase 1	Phase 2	Phase 3	Phase 4
Max	342	194	342	250	435	208	339	247	-43.3	-26.9	-52.2	-27.1
Min	145	39	108	66	198	66	144	61	-73.1	-38.9	-66.7	-57.6
Mean	241	100	256	130	311	147	217	189	-58.5	-49.2	-52.7	-12.9

In this section a comparison of AQI of lockdown days (25 march to 31 may) with the same days of previous year (Figure 3) has been done which shows that in 2019 recorded AQI in those days were "Poor" and "Very poor" maximum times. On the other side same dates of lockdown period shows a surprising declination in AQI as here maximum time AQI has recorded "Moderately polluted" and "Satisfactory" level. So Nationwide lockdown as a preventive measure of Covid 19 pandemic has improved the overall air quality of Ghaziabad in a surprising way. It has been found that the main culprit behind "very poor" and "severe" AQI are PM 10 and PM 2.5 which are found in maximum cases of the whole area. With the growing of urban activities mostly Industry, vehicular movement contributes to increase level of Particulate Matter. Study says that the reduction in PM levels is resulted by reduced movement of vehicles and closure of industrial and construction activities.[12]

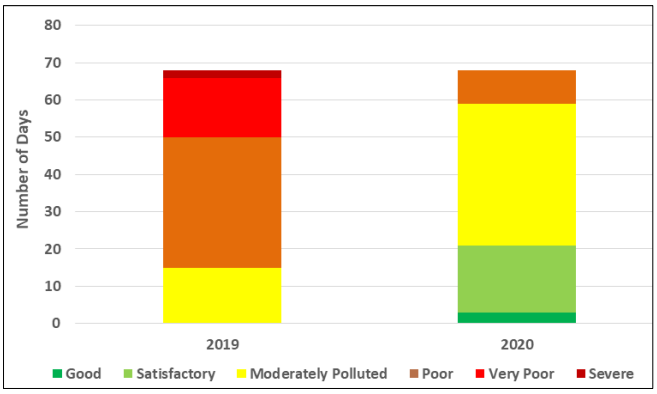

Fig 3: Comparative Air Quality Index during 25th March - 31st May 2019 and 2020 for Ghaziabad

Conclusion

Covid-19 induced lockdown has surprisingly resulted in positive environmental condition in many countries. Changing in air quality status has been the most identifiable phenomenon after lockdown throughout the regions/cities of the world. Present study highlighted the changing concentration of Particulate matter (PM 10, PM2.5) in the air in lockdown phases from 25th March – 31st May of Ghaziabad city, Uttar Pradesh, India. In every phases of lockdown concentration of particulate matter reduced significantly like never before and maximum time's concentration went down below National standard of CPCB.AQI value which basically generalize the pollution status of any area, here level of AQI in lockdown phases also validate the fact that air quality became cleaner than before. AQI reduced to "satisfactory" many times from "very poor" "severe". As in the recent years due to growing population and the effect of urban sprawl of National capital region of Delhi, activities like Industrialization, Vehicular movement, Constructional activities has increased significantly which ultimately uplifted the concentration of particulate matter in air and overall AQI of the concerned area. Due to this problem health condition of inhabitants of the area and overall social system becoming highly vulnerable day by day. The study needs to be extended to understand changes in other pollutants due to lockdown for better understanding. So overall this Lockdown and its surprising reduction of Particulate matter concentration in the air and overall AQI can be taken as suggestive measure for future to control air pollution in the cities like Ghaziabad. This lockdown happened due to some emergency situation worldwide, so it cannot be used in normal situations but in future in case of any environmental emergency and related problems this system can be utilize to control or mitigate many problems in a manageable way.

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Conflict of Interest

The authors declares no conflict of interest.

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