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Research Paper

Assessment of Air Quality Index of Kolkata, Howrah, and 24 Parganas North during COVID- 19 Lockdown

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Abstract
In the course of COVID- 19 pandemic, a nationwide lockdown in India has been imposed from 22nd March 2020 extended to June end, thereafter a partial lockdown was enforced as a precautionary measure to confine the spread of COVID- 19. The anthropogenic activity was restricted during lockdown therefore the pollution level across many cities in India reduced drastically. This eventually led us to analyze the air quality scenario of Kolkata metropolitan city along with suburban areas of North 24 Parganas and Howrah in the state of West Bengal, India. In the present research, the air quality parameters like PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO, O_3, and NH_3 were analyzed the during lockdown phase of 23rd March 2020 to 30th June 2020. A comparative study was done with the air quality data of the pre-lock down phase (March 2019 to 4th March 2020) and an Air Quality Index (AQI) was prepared. During lockdown coal/ fuel consumption was low due to the restriction of vehicle movement and road transport thus carbon emission in the air was less. AQI improved enormously with reduction of SO_2 content to <80 %; among other pollutants NO_2 and NH_3 reduced to <54 % and <91 % in Kolkata, Howrah, and 24 Parganas North. $P.M_{2.5}$ drastically reduced in the regions of Kolkata, Howrah, and 24 Parganas North of West Bengal effectively to <81%, <91 %, and <95% respectively. $P.M_{10}$ reduced to <75%, <79%, and < 81 % in Kolkata, Howrah, and 24 Parganas North. In Kolkata there was 55% reduction in the level of CO. There was 4 folds reduction of $P.M_{2.5}$ and $P.M_{10}$ in Kolkata compared to March- June 2019. About 50 % to 60 % improvement in air quality was identified within 7days of the lockdown. Improvement of air quality during lockdown has benefited the environment and ecology.

Keywords: *COVID- 19; Lockdown; Air quality index; Air pollutants; West Bengal*

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I. Introduction

In the history of mankind the industries, vehicle movement, and human activities halted for the first time as the COVID- 19 pandemics hit more than 210 nations worldwide. India was one of the worst knocked nations with high cases of COVID- 19 infection (Chen et al. 2020; Munster et al 2020; Shovonlal 2020; Wu et al. 2020). India was already struggling with issues related to air pollution, water pollution, and health hazard due to toxicity. Additionally, COVID- 19 outbreaks and its worldwide pandemic have started devastating human life, with greater than 6.47 Million confirmed cases, < 1.01 lakh death cases, as of 4th October 2020 (in India) (https://covid19.who.int/). The Government bodies in India enforced a complete lockdown from March to June as a precautionary measure to contain the COVID- 19 pandemics. Since industries and human activities have been shut off for a month or more in many parts of our nation; it is expected to show some improvements in existing environmental conditions (Kjellstrom et al 2006; Mahato et al. 2020; Shrestha et al. 2020). As an outcome of rapid industrialization in the regions of West Bengal; environmental pollution has seriously raised to a limit that is detrimental to human health. The most obvious consequence of it is the deterioration of air quality (Sharma 2020; Shovonlal 2020).

The concentration of a high number of air pollutants majorly CO, SO_2, NO_2, and NH_3 intensely causes significant public health issues predominantly related to shortness of breath, chronic respiratory disorders, pulmonary disorders, pneumonia, and acute asthma, etc. (http://www.indiaairquality.info/wpcontent/uploads/docs/2003_CPCB_Guidelines_for_Air_Monitoring.pdf). The presence of hazardous substances in air is harmful to humans and animals (https://App.Cpcbccr.Com/Ccr_Docs/Final-Report_Aqi_.Pdf). Thus, air quality monitoring and analysis in areas with high anthropogenic effects could be an important means for understanding the present air quality scenario. The air has been severely polluted because of rapid urbanization, industrialization, and overexploitation during the last few decades (https://www3.epa.gov/airnow/aqi_brochure_02_14.pdf) (Rodríguez-Urrego & Rodríguez-Urrego 2020; Saadat 2020). The lockdown period has stopped all the major industrial sources of pollution that affect both air and aquatic systems. Therefore, the level of pollution is expected to be reduced (Kjellstrom et al. 2006). To minimize the health burden due to air pollution the Central government and the State government of West Bengal, have imposed several regulatory measures extended as per international guidelines to prevent air pollution (https://App.Cpcbccr.Com/Ccr_Docs/Final-Report_Aqi_.Pdf; http://www.wbpcb.gov.in/). Air pollutants are usually classified into suspended particulate matter (PM) (dust, fumes, mists, and smokes) and gaseous pollutants (gases and vapor). As per EPA standards suspended PM can be categorized according to total suspended particles: the finer fraction, PM_{10} (median aerodynamic diameters of less than 10.0 microns), which can reach the alveoli, and the most hazardous and finest fraction, $PM_{2.5}$ (median aerodynamic diameters of less than 2.5 microns) may cause severe illness, toxicity, and lung associated diseases. Much of the secondary pollutants $PM_{2.5}$ consists of a condensation of gaseous pollutants, for example, sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) (Kjellstrom 2006; Munster 2020). In the guidelines by MoEF AQI from 1- 50 is considered good-no health impact, 51- 100 satisfactory- mild breathing issue, 101- 200 moderate- breathing discomfort, 201- 300 poor- breathing discomfort, 301- 400 very poor- respiratory illness, <400 – 500 severe illness.

The current research paper made a first attempt to deal with the Air Quality Index (AQI) in West Bengal, India. Considering Kolkata as a metropolitan city and suburban areas of 24 Parganas North, Howrah, region of West Bengal as most polluted among other districts (due to problem associated with dense air) a survey was done. The focus of the study is to view the effect of lockdown on AQI. The primary objective of the present study is to survey the AQI before lockdown and during lockdown. The results were statistically analyzed and a co-relation of the air quality parameters with the lock-down was drawn sharply. The p-value was determined to statistically draw the significance of the variables with our hypothesis. A pre-lock down and post lockdown comparison of AQI was done from March 2019 to June 2020. Since Kolkata is highest in anthropogenic activity, a detailed study was done considering the area as shown in figure 1. Industrialization, vehicle, and transport system releases toxic gases mainly in the areas of Kolkata. Efforts were made to study the air quality in mainly 5 densely polluted regions of Kolkata like Bidhannagar- 22.5797° N, 88.4143° E, Victoria- 22.5448° N, 88.3426° E, Bullygunj- 22.5280° N, 88.3659°, Jadavpur- 22.5280° N, 88.3659° E and Rabindra Sarovar- 22.5121° N, 88.3637° E. Air quality of Kolkata 22.5726° N, 88.3639° E and the suburban areas namely Howrah- 22.5958° N, 88.2636° E and 24 Parganas North- 22.6168° N, 88.4029° E were studied in detailed because these regions are high in anthropogenic activity and vehicle transports.

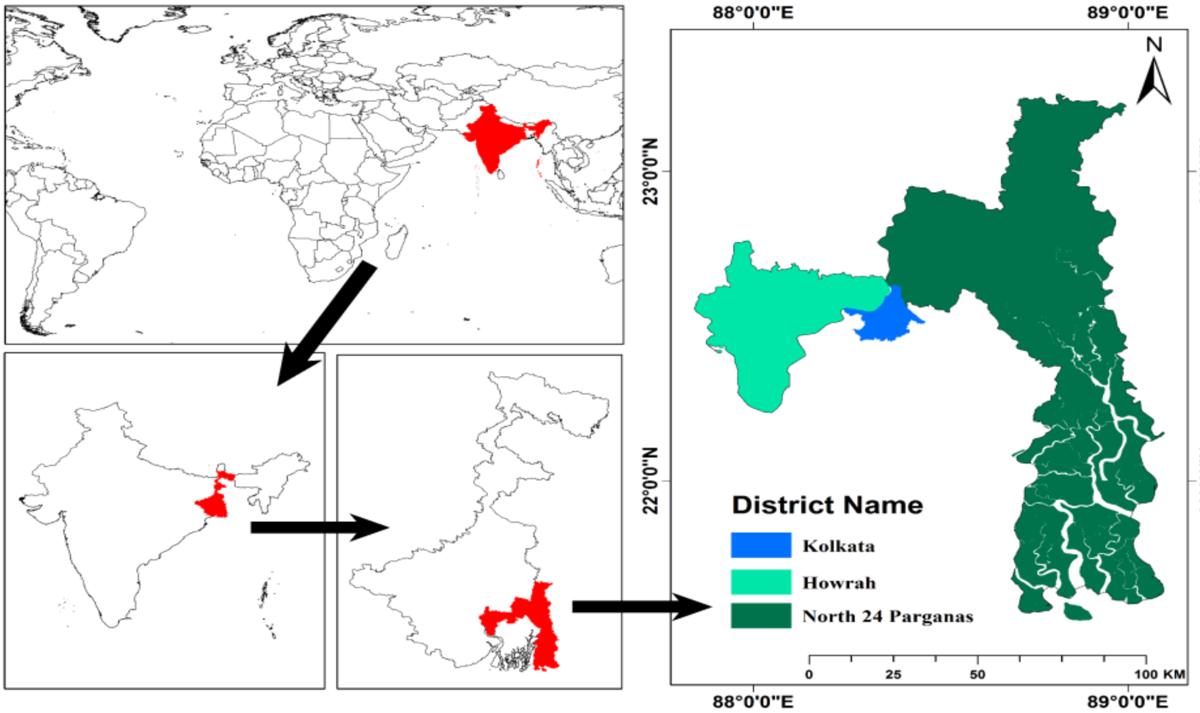


Fig. 1. Study area and sampling locations of three sites for Air Quality analysis (i) Kolkata (ii) Howrah and (iii) 24 Parganas (North)

II. Methods

a) *Survey of air quality index (AQI) and pollutants*

The survey and data of air particulate matter PM_{10}, $PM_{2.5}$, and other related parameters like SO_2, NO_2, CO, O_3, and NH_3 were analyzed. Data were collected before and after lockdown from the Central pollution control board (CPCB) of India. A comparative analysis was done to check the pre lockdown and lockdown period. Pre-lock down data was recorded from March 2019 to 4th March 2020. Lockdown data was recorded from 22nd March 2020 to June 2020. All the data were statistically analyzed and significance was drawn at $P< 0.05$ as a cut-off. For air quality analysis, daily based data of air pollution were collected from the central pollution control board (CPCB) of India (https://app.cpcbccr.com/AQI_India/). The EPA guidelines and guidelines of MoEF (CPCB) were followed during the survey of air quality index. The particle sizes, particulate matter (P.M $_{25}$ and P.M $_{10}$), greenhouse gases like Carbon monoxide- CO, Ozone gas, and other polluting gases like Sulphur dioxide- SO_2, Nitrogen dioxide- NO_2, and Ammonia- NH_3 were analyzed before lockdown and during the lockdown.

b) *Statistical analysis*

Statistical analysis of all data sets of air quality was performed in SPSS version 25. Two statistical data sets (Pre- lockdown, and lockdown) of all the variables were compared in both cases. The mean values of paired samples (before lockdown and lockdown) were compared and correlation was established by Student's paired't' tests. The significance of the test results was validated at p-value < 0.05 during statistical analysis.

III. Results and Discussions

The particulate matter 2.5 is more harmful than particulate matter 10. When the level of these particles increases and penetrate deeply into the lungs, one can experience several health impacts like breathing problem, burning or sensation in the eyes, etc. Nitrogen dioxide and sulfur dioxide are part of a group of gaseous air pollutants produced as a result of road traffic and other fossil fuel combustion processes. Its presence in air contributes to the formation and modification of other air pollutants, such as ozone and particulate matter, and acid rain. Exposure to high concentrations of ammonia in the air causes immediate burning of the eyes, nose, throat and respiratory tract, and, may also result in blindness, lung damage, or death. Inhalation of lower concentrations can cause coughing, nose, and throat irritation. An air quality index was prepared; the values were statistically calculated and represented below in table 1, table 2, and table 3. The dendrogram in figure 2 explains the variation of air quality parameters among five different cities of Kolkata, West Bengal showing both pre-COVID-19 outbreak and outbreak lockdown phase (*= $p < 0.05$; *= $p < 0.05$). The dendrogram in figure 3 explains the variation of air quality parameters among Kolkata, Howrah, and 24 Parganas North. The QGIS interpolated maps of Kolkata in figure 4(a) to 4 (j) and of suburban areas in figure 5 (a) to 5 (j) states the differences of AQI index of PM $_{2.5,}$ PM_{10}, SO_2, NO_2, and NH_3 present in the air during lockdown period.

The number of vehicle transport and anthropogenic activity is highest in Kolkata. The AQI and survey report suggests that during COVID- 19 lockdown the quality of air has improved massively. The air quality has improved day by day from moderate/ poor level to good (AQI > 50) (as represented in table 1, table 2, table 3, figure 2, and figure 3). The QGIS interpolating maps in figure 4 (a) to 4 (j) and 5 (a) to 5 (j) shows the reduction of $PM_{2.5}$, PM_{10}, $SO_{2,}$ NO_2, and NH_3 during the COVID- 19 lockdown phase in comparison to pre- lockdown phase. The spatiotemporal variation of air quality parameters among five different cities of Kolkata shows both pre-COVID-19 outbreak and outbreak lockdown phase differences, as represented in figure 2. The spatiotemporal variation of the metropolitan city of Kolkata and sub-urban areas of Howrah and 24 Parganas North shows pre-COVID-19 outbreak and outbreak lockdown phase variation, as represented in figure 3. Statistical calculations using Students paired "t" test revealed the significance of test results at $P < 0.05$ (shown in table 1). The percentage reduction of NH_3 was 91 %, $PM_{2.5}$ 85.2, SO_2 85 %, PM_{10} 75 %, Ozone/ Co < 50 % and NO_2 27 % in Kolkata. Table 2 and table 3 suggest significance of test parameters at $P < 0.05$, percentage reduction was NH_3 96.1, %, $PM_{2.5}$ 91.1, SO_2 89.5 %, PM_{10} 79.5 %, and NO_2 54.1 % in Howrah and percentage reduction was NH_3 96.2, %, $PM_{2.5}$ 95.1, SO_2 94.3 %, PM_{10} 81.4 %, and NO_2 68.9% in 24 Parganas North. The AQI of West Bengal in terms of the cleaner atmosphere may be graded as 24 Parganas North (AQI- 28) > Howrah (AQI- 32) > and Kolkata (AQI- 38). In the Kolkata area, AQI was as high as 200 ppm in Bullygunj, 145 in Victoria, 120 in Jadavpur, 125 in Rabindra Sarovar, and 110 in Bidhanangar before lockdown. After lockdown, the AQI came to a safer limit. AQI was found lowest in Rabindra Sarovar- 30 < Bidhannagar- 34 < Victoria- 38 < Jadavpur- 40 < Bullygunj- 41.

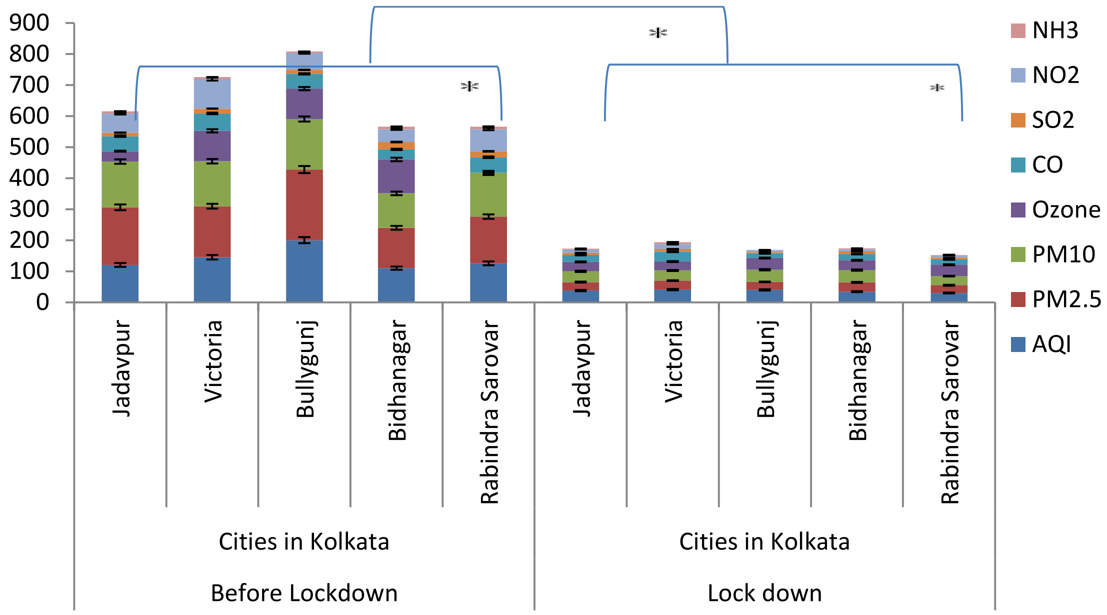


Fig. 2. Spatiotemporal variation of air quality parameters among five different cities of Kolkata, West Bengal showing both pre-COVID-19 outbreak and outbreak lockdown phase, unit of measurement, parts per million (ppm) (*= p < 0.05; *= p < 0.05)

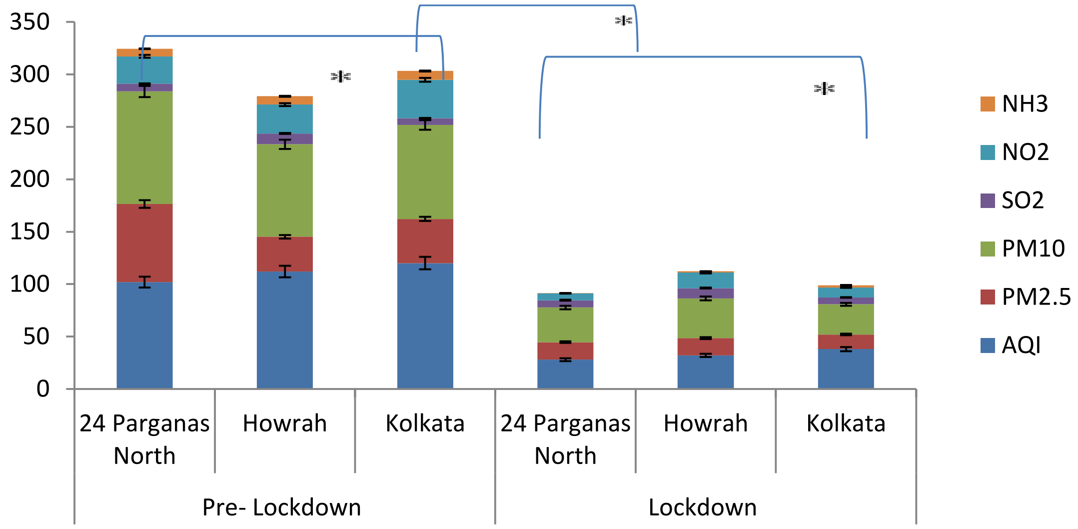
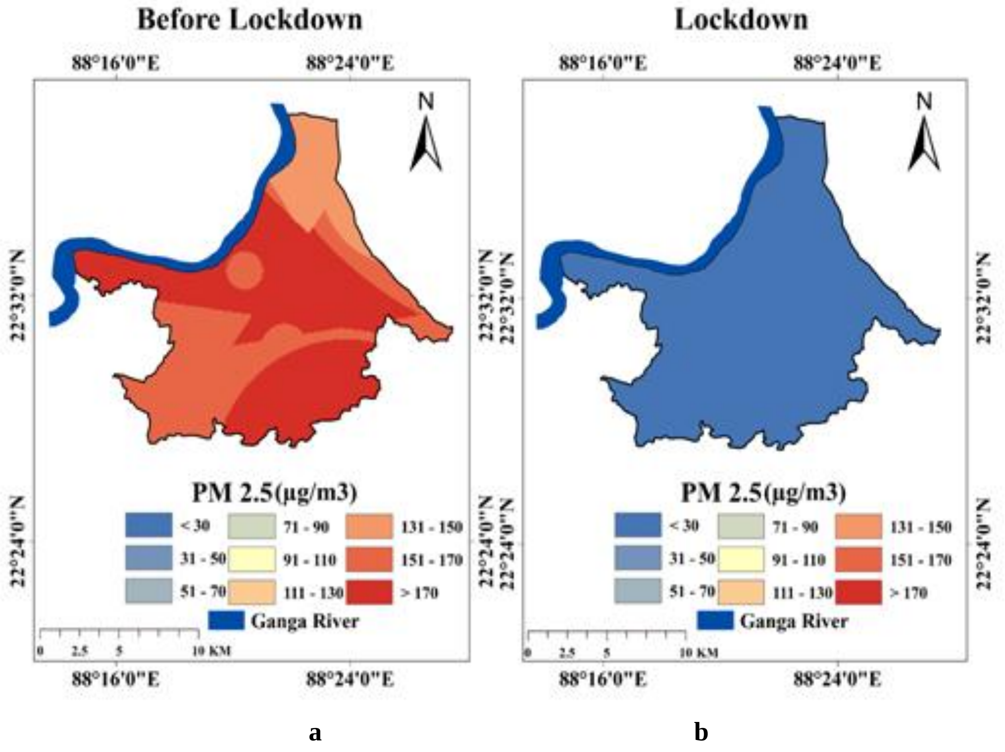
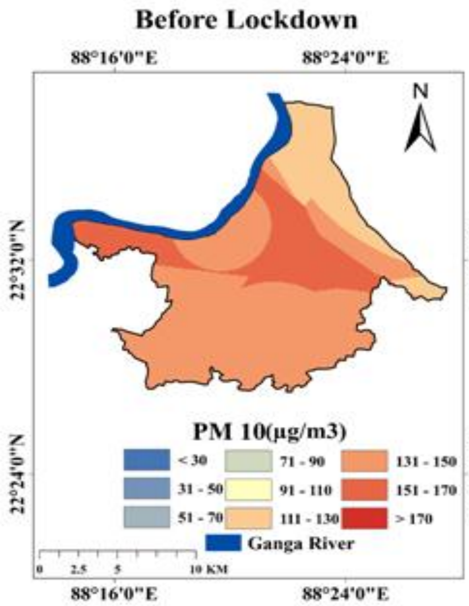
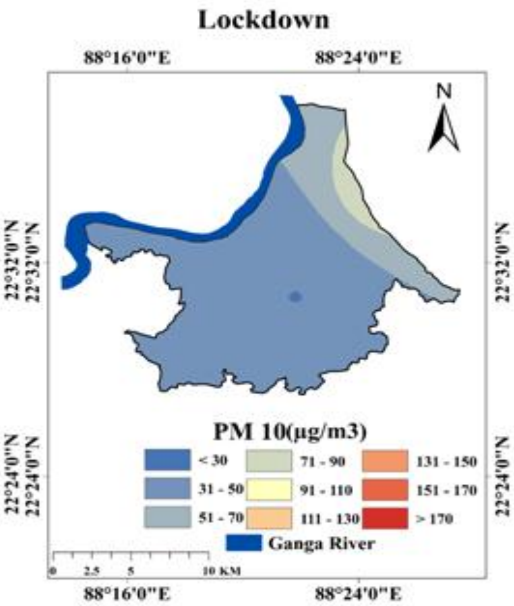


Fig. 3. Spatiotemporal variation of air quality parameters of the metropolitan city of Kolkata and Suburban areas of Howrah and 24 Parganas North, West Bengal showing both pre-COVID-19 outbreak and outbreak lockdown phase, unit of measurement, parts per million (ppm) (*= p < 0.05; *= p < 0.05)

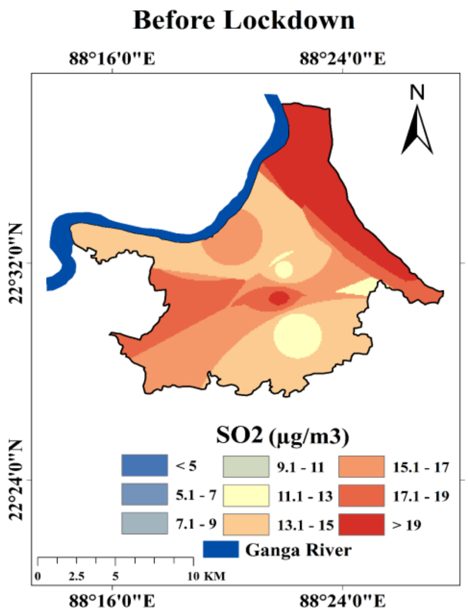



Before Lockdown
88°16'0"E
88°24'0"E
N
22°32'0"N
22°24'0"N
PM 10(µg/m3)
< 30
31 - 50
51 - 70
71 - 90
91 - 110
111 - 130
131 - 150
151 - 170
> 170
Ganga River
0 2.5 5 10 KM

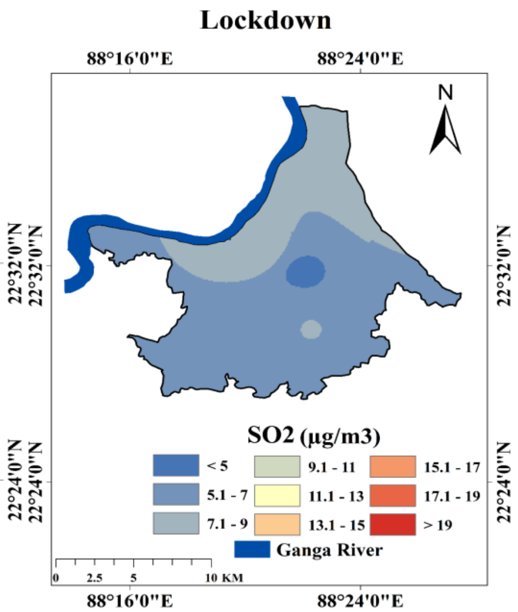
c


Lockdown
88°16'0"E
88°24'0"E
N
22°32'0"N
22°24'0"N
PM 10(µg/m3)
< 30
31 - 50
51 - 70
71 - 90
91 - 110
111 - 130
131 - 150
151 - 170
> 170
Ganga River
0 2.5 5 10 KM

d


Before Lockdown
88°16'0"E
88°24'0"E
N
22°32'0"N
22°24'0"N
SO2 (µg/m3)
< 5
5.1 - 7
7.1 - 9
9.1 - 11
11.1 - 13
13.1 - 15
15.1 - 17
17.1 - 19
> 19
Ganga River
0 2.5 5 10 KM

e


Lockdown
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N
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SO2 (µg/m3)
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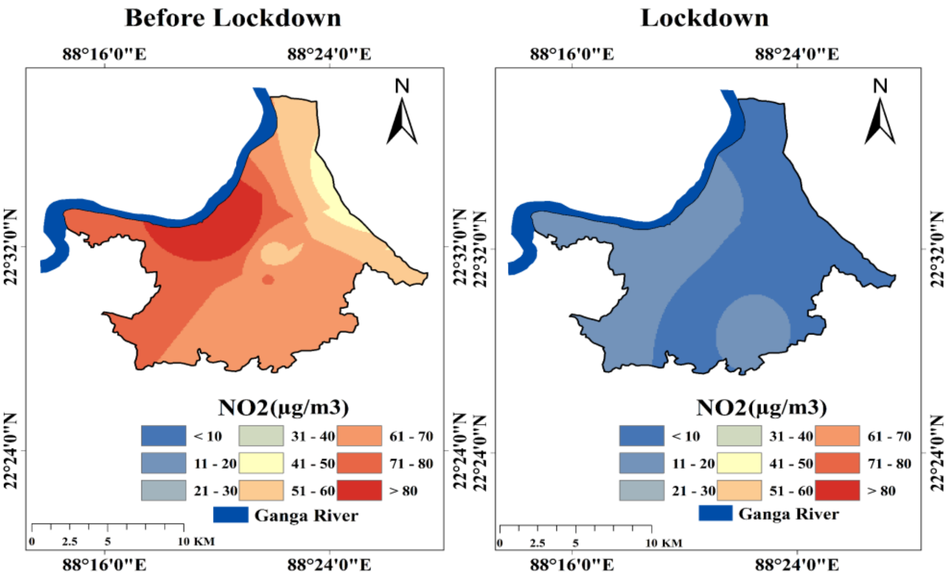
15.1 - 17
17.1 - 19
> 19
Ganga River
0 2.5 5 10 KM

f



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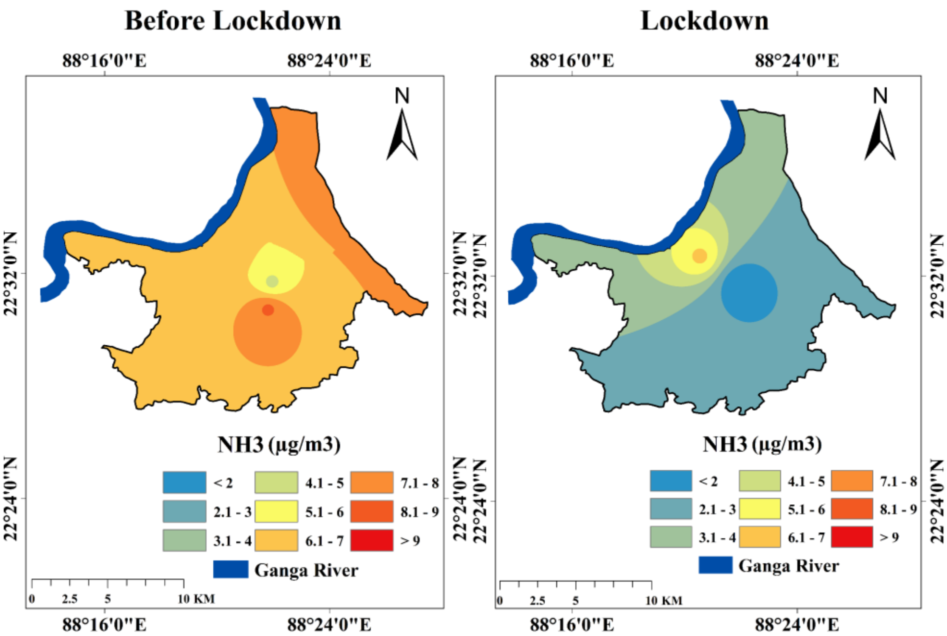
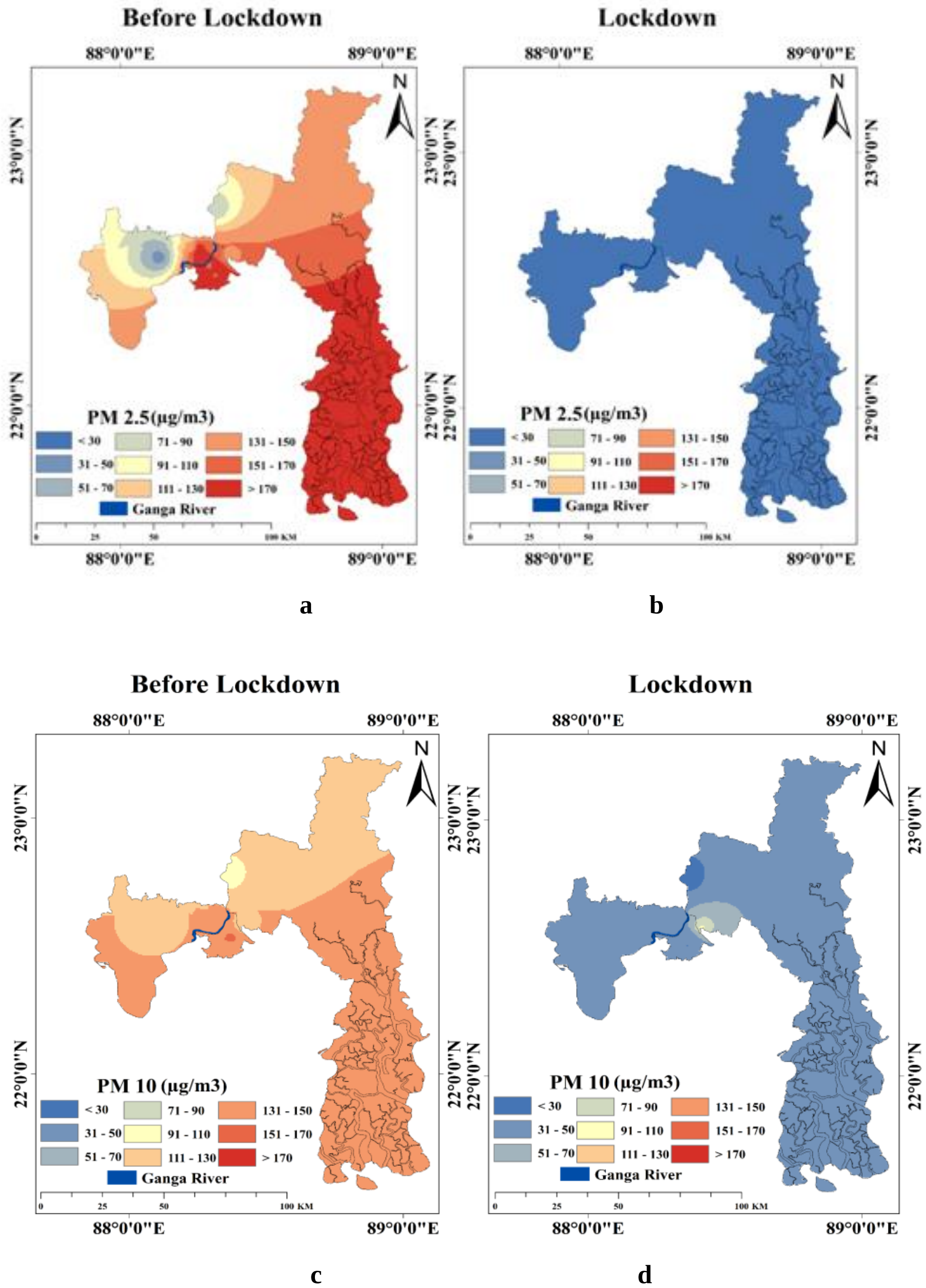
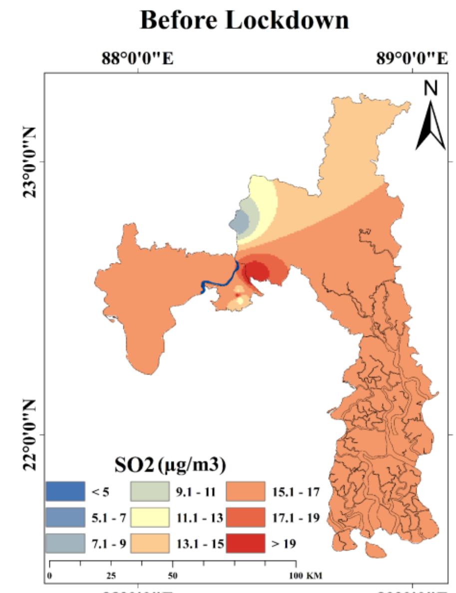


i j

Fig. 4 (a to j). QGIS Interpolated maps showing variations in air quality parameters during COVID- 19 lockdown in the metropolitan city of Kolkata. Figure 4 (a), 4 (c), 4 (e), 4 (g) and 4 (i) indicates before lockdown and figure 4 (b), 4 (d), 4 (f), 4 (h), 4 (j) indicates lockdown phase


Before Lockdown
Lockdown
88°0'0"E
89°0'0"E
23°0'0"N
22°0'0"N
N
PM 2.5(µg/m3)
< 30
31 - 50
51 - 70
71 - 90
91 - 110
111 - 130
131 - 150
151 - 170
> 170
Ganga River
0
25
50
100 KM
a
b
Before Lockdown
Lockdown
PM 10 (µg/m3)
c
d


Before Lockdown
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89°0'0"E
23°0'0"N
22°0'0"N
N
SO2 (µg/m3)
< 5
5.1 - 7
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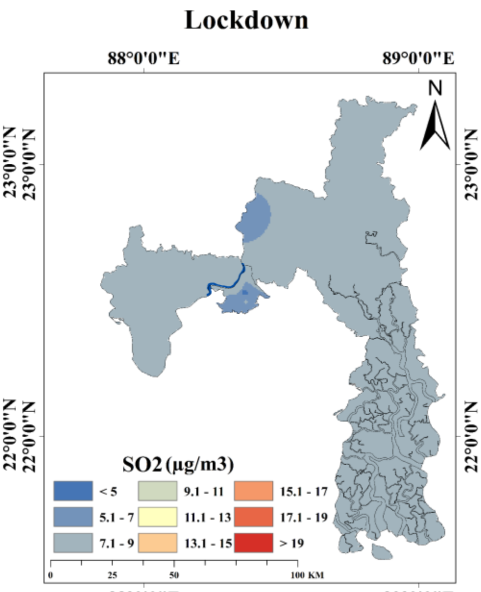
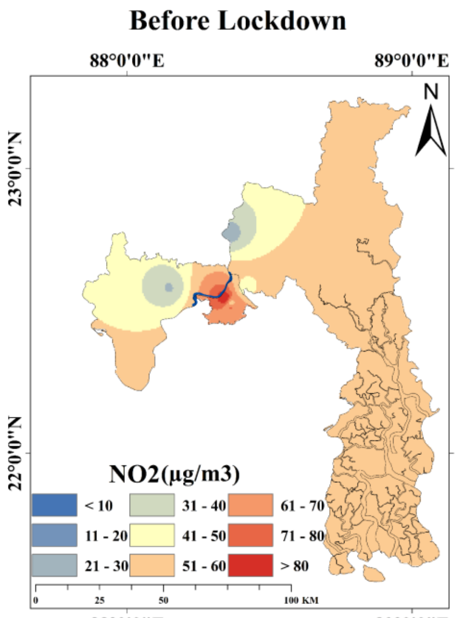
9.1 - 11
11.1 - 13
13.1 - 15
15.1 - 17
17.1 - 19
> 19
0 25 50 100 KM

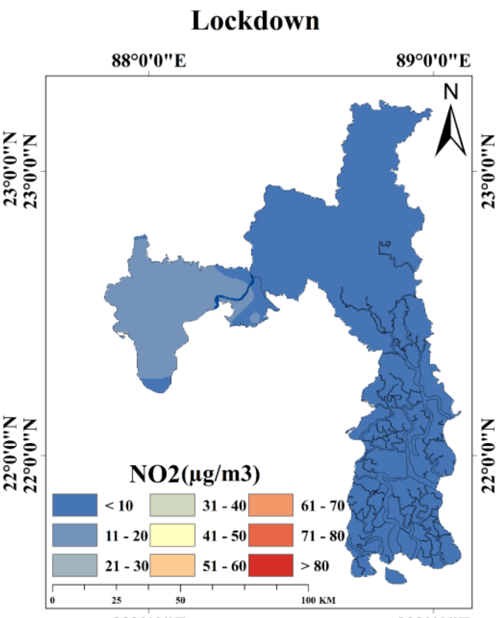
e


Lockdown
88°0'0"E
89°0'0"E
23°0'0"N
22°0'0"N
N
SO2 (µg/m3)
< 5
5.1 - 7
7.1 - 9
9.1 - 11
11.1 - 13
13.1 - 15
15.1 - 17
17.1 - 19
> 19
0 25 50 100 KM

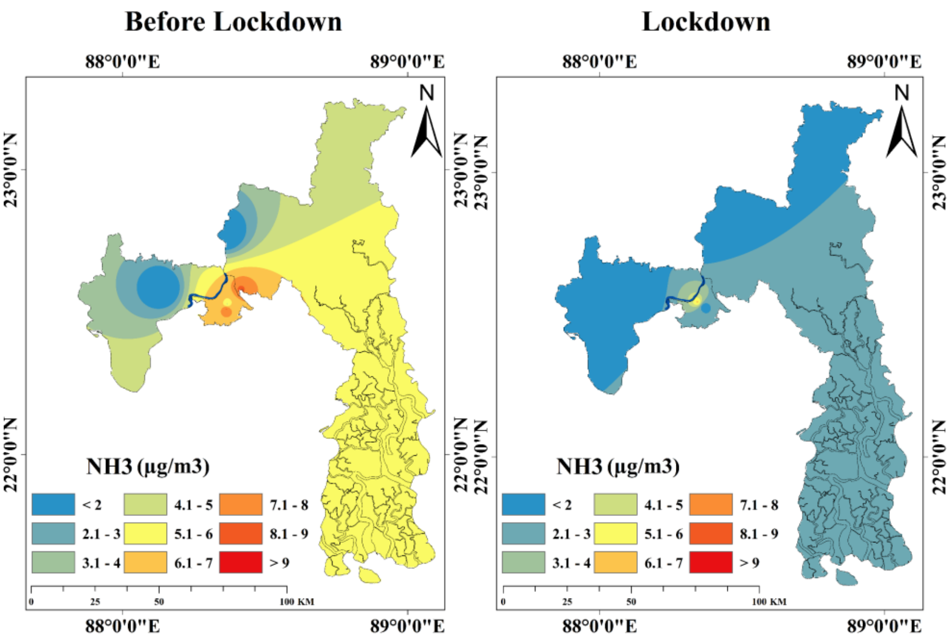
f


Before Lockdown
88°0'0"E
89°0'0"E
23°0'0"N
22°0'0"N
N
NO2(µg/m3)
< 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
71 - 80
> 80
0 25 50 100 KM

g


Lockdown
88°0'0"E
89°0'0"E
23°0'0"N
22°0'0"N
N
NO2(µg/m3)
< 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
71 - 80
> 80
0 25 50 100 KM

h



i j

Fig. 5 (a to j). QGIS interpolated maps showing variations in air quality parameters during COVID- 19 lockdown in suburban areas of Howrah and 24 Parganas North. Figure 5 (a), 5 (c), 5 (e), 5 (g) and 5 (i) indicates before lockdown and figure 5 (b), 5 (d), 5 (f), 5 (h), 5 (j) indicates lockdown phase

Table 1. Summary of Air Quality Index report of Kolkata

Parameters (ppm)	Overall Air Quality index				
	A.M*	**"t"**	**Sig. (2 tailed)**	**Percentage progress (%)**	**AQI Remark**
$PM_{2.5}$	27.28±7.0	8.641	0.001	85.22	Good
PM_{10}	33.84±6.67	7.520	0.002	75.83	Good
Ozone	33.24±9.06	1.726	0.160	51.66	Good
CO	21.24±4.36	7.63	0.002	55.92	Good
SO_2	6.92±0.06	6.07	0.012	85.53	Good
NO_2	9.4±1.01	6.07	0.004	27.22	Good
NH_3	2.84±0.16	5.97	0.004	91.24	Good

- **A.M*= Arithmetic mean with standard deviation, t= Student's T-test, degree of freedom in all cases were (n-1= 9) and Sig.= significance at p< 0.05**

Table 2. Summary of Air Quality Index report of Howrah

Parameters (ppm)	Overall Air Quality index				
	A.M*	**"t"**	**Sig. (2 tailed)**	**Percentage progress (%)**	**AQI Remark**
$PM_{2.5}$	16.52±3.14	8.551	0.001	91.11	Good
PM_{10}	37.77±8.71	4.770	0.020	79.52	Good
SO_2	9.90±2.38	6.53	0.001	89.59	Good
NO_2	14.78±5.33	6.67	0.010	54.10	Good
NH_3	1.62±0.10	5.42	0.001	96.15	Good

- **A.M*= Arithmetic mean with standard deviation, t= Student's T-test, degree of freedom in all cases were (n-1= 9) and Sig.= significance at p< 0.05**

Table 3. Summary of Air Quality Index report of 24 Parganas North

Parameters (ppm)	Overall Air Quality index				
	A.M*	**"t"**	**Sig. (2 tailed)**	**Percentage progress (%)**	**AQI Remark**
$PM_{2.5}$	16.64±4.25	8.42	0.001	95.12	Good

PM_{10}	33.12±11.22	7.22	0.010	81.43	Good
SO_2	6.89±1.88	6.09	0.001	94.34	Good
NO_2	6.59±2.59	8.52	0.009	68.99	Good
NH_3	1.02±0.12	5.02	0.001	96.24	Good

- **A.M*= Arithmetic mean with standard deviation, t= Student's T-test, degree of freedom in all cases were (n-1= 9) and Sig.= significance at $p< 0.05$**

IV. Conclusion

It is understood from the test results that with limitation to industrialization, agricultural activity, and anthropogenic activity; an improvement in air quality may be achieved. The lockdown phase, initiated from 22nd March 2020 completely ceased all the industrial operations and movements of vehicle transports that ultimately upgraded the air quality of Kolkata. Limited industrialization, construction work drastically improved air quality. Though there is no direct impact of air quality improvement with quality improvement of water yet there may be some indirect impacts. Air pollutants such as SO_2 and NO_2 may lead to excess amounts of acid in lakes and streams and can damage trees and forest soils. Nitrogen and sulfur in the atmosphere may settle down in the aquatic system and can harm fish or other aquatic life when deposited on surface waters (Kjellstrom 2006).

During the lockdown, there was daily human activity to mass balance that resulted in less release of harmful pollutants in the air. The concentration of air pollutants in the atmosphere reduced 4 folds in Kolkata than before. Cessation of transport and industrial activities had a good impact on the air quality of West Bengal. COVID- 19 lockdown of three months had an overall good impact on the reduction of pollutants in the air. Improvement in air quality has benefited ecology, environment, society, and mankind.

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