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EFFECT OF LOCKDOWN DUE TO COVID-19 PANDEMIC ON AIR QUALITY IN THE INDUSTRIAL CITY OF EASTERN INDIA

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Abstract

The lockdown due to coronavirus (COVID-19) was forced in India from March, 25 to May 3 2020 as precautionary actions in contradiction of the diffusion of infectious virus. The objective of this study is to analyse the changes in air quality between pre and during the lockdown in Asansol, the "coal mining city" of Eastern India is characterized by high pollution levels due to several industries leading to human discomfort and even health problems. Secondary data of seven parameters like CO, SO_2, NO_2, PM2.5, PM10, NH_3, and O_3 have been collected from the website of the Central Pollution Control Board, India and AQI were calculated as per the calculator provided by CPCB. The result displays a significant reduction of seven parameters from 33.31 % (SO_2) to 60.44 % (PM2.5) due to the shut down of all manufacturing units and transportation throughout the lockdown period. The air quality index (AQI) was also upgraded from a very poor to a satisfactory state during this period. Plants are the main carbon sink, so, a green belt project proposal for this polluted city has been recommended to improve air quality management. This lockdown (temporarily) showed some vaccine effect on the air quality, but this is totally against economic growth.

Keywords: COVID-19, lockdown, Air quality index (AQI), Industrial city, Eastern India

I. Introduction

Coronavirus disease 2019 (COVID-19) is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which has been identified by a group of virologists (Almeida J D, Berry D. M., Cunningham C H, Hamre D, Hofstad M S, Mallucci L, McIntosh K and Tyrrell D A J) and published in Nature, 1968. These viruses are zoonotic which are transmitted between animals and humans. It was first identified in December 2019 in Wuhan, China, and has resulted in an ongoing pandemic (Huang et al. 2020a, b; Zhou et al. 2020a, b; Zhu et al. 2020). The first confirmed case has been traced back to 17 November 2019 and 20 January 2020 WHO issued a statement saying that there was evidence of human-to-human transmission. Since the beginning, this disease has rapidly spread over China, Italy, France, Spain, Germany, the Russian Federation, UK, USA, India, UAE, Australia Brazil, Argentina, and many other countries.

The first case of coronavirus in India was observed on 30th January 2020 in the southern state of Kerala (Gautam and Hens 2020). Till now in India, the most affected cities are Mumbai, Delhi, Chennai, Ahmedabad, Pune, Indore, Kolkata, Jaipur, Jodhpur, etc. Children, older people with acute medical problems including blood sugar, high blood pressure, cancer, etc. are more serious in this disease (Arabi et al. 2019; Ashour et al. 2020; Dong et al. 2020; Zhou et al. 2020).

Because the cause of this disease is human to human transmission, so, lockdown (full or partial) was considered as an emergency measure to stop the risk of this virus, in March 2020, which decrease the pollution effective economic sectors like industry, transport, tourism, etc. (Muhammad et al., 2020; Das and Patial 2020; Paital et al. 2020). On the 19th of March, honourable Prime Minister Narendra Modi first declared a lockdown of 21 days which was started through a 'JANATA CURFEW' on 22nd March, and from 25th March 2020 lockdown started. The government decided to shut down traveling in and out of the country, all the educational sectors, restaurants, malls, temples, and other religious centers to avoid the quick spread of coronavirus (Gautam and Hens 2020).

Several types of research stated that dropping human-caused activities during COVID-19 outburst plays an important role in reducing air pollution and it was also influenced on the total ambient air quality (He et al. 2020a; Isaifan 2020). Wang and Su, 2020 observed a sharp and sudden decline in global carbon emission due to the decrease in energy footprint, slowdown of production in the industry (Muhammad et al., 2020), low public traffic (Chen et al., 2020), etc. Temporary interruption of industrial activities reduced the carbon release and also controlled the release of several other Greenhouse Gases (GHGs) and pollutants like Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), and Particulate Matters 2.5 and 10 (PM2.5, 10).

Several studies of lockdown effect on air quality have been done in megacities like Kolkata, Delhi, Chennai, and Mumbai (Mahato et al., 2020, Sharma et al. 2020; Das et al., 2021). But no such observation was done on the urban dominated industrial belt in India specially at the Durgapur-Asansol belt. These are a major source of greenhouse gases that causes temperature rise. In this context, the objective of the present paper is to assess the atmospheric CO, SO_2, NO_2, PM2.5, PM10, NH_3, and O_3 concentrations of the industrial city of Eastern India pre and during lockdown against the propagation of the COVID-19 pandemic.

II. Materials and Methods

a. Study site

This industrial region is situated in West Bengal (The western part of Burdwan district) in the Eastern part of India. The prime industries in this region which are supported by coal, iron, and steel are Steel plants of the Steel Authority of India Limited (SAIL) and Indian Iron and Steel Company (IISCO). Asansol (Fig. 1) is known as a 'coal mining city' because the whole area sits on coatings and coatings of coal. Besides the Steel and Coal-based industries, the region also consists of some other heavy industries, such as

Durgapur Chemicals, Durgapur Thermal Power Station, Burnpur Cement Limited (BCL), Dishergarh Power Supply, Damodar Valley Power Corporation, Joy Balaji Sponge Iron Private Limited, Shyam Gel Limited (Power Divisions), etc. So, the air is highly polluted in this region in a normal situation (Banerjee et al. 2005, 2006; Dey 2013) due to industrial development, reconstruction, and suburbanization, which causes respiratory troubles in the human population.

b. Data sources and analysis

During the study period, seven parameters (CO, SO_2, NO_2, PM2.5, PM10, NH_3, and O_3) have been measured to calculate the deviation of air quality between pre (January 1, 2020, to March 24, 2020) and during (March 25, 2020 – May 3, 2020) lockdown period. The secondary data of the seven selected parameters have been obtained from the website of Central Pollution Control Board (CPCB), Govt. of India, and AQI (Air Quality Index) was calculated according to the calculator provided by CPCB. To measure the associations between air pollutants, Pearson's correlation was executed for seven parameters (CO, SO_2, NO_2, PM2.5, PM10, NH_3, and O_3).

III. Results

The quality of air has been shifted significantly because of lockdown which is echoed in Table 1 and Fig. 2, 3. Air quality index (AQI) also exhibited that after the application of lockdown, the pollutant level reduced from poor or very poor quality to satisfactory condition (Table 3 and Fig. 4). For example, CO level declined from 0.83 to 0.49 mg/m^3 (-40.96%), SO_2 decreased from 17.47 µg/m^3 to 11.65 µg/m^3(-33.31%), NO_2 decreased from 35.70 µg/m^3 to 15.04 µg/m^3 (-57.87%), PM2.5 decreased from 79.98 µg/m^3 to 31.64 µg/m^3(-60.44%), PM10 decreased from 148.85 µg/m^3 to 72.54 µg/m^3(-51.27%), NH_3 decreased from 31.10 µg/m^3 to 18.15 µg/m^3 (-41.64 %) and on the other side, there was a slight increase in O_3 concentration from 24.05 µg/m^3 to 25.96 µg/m^3 (+7.94 %) which was expected to be primarily due to the decrease in the concentration of NO_2 and particulate matter (PM2.5 and PM10).

The correlations between different air pollutants concentrations during the study period are shown in Table 2. The daily average concentration of PM2.5 (24 hrs) is extremely correlated with SO_2 (r = 0.42), NO_2 (r = 0.64) and CO (r = 0.74). Same results have been found in the daily average concentration of PM10, which is also highly correlated with the daily average concentration of SO_2 (r=0.54), NO_2 (r=0.62), NH_3 (r=0.47) as well as 8 h average concentration of CO (r = 0.74). In this result NO_2 is also significantly correlated with CO (r = 0.67) and NH_3 (r = 0.70). Sharma et al., 2020 recommended that the augmented control of transportation and industrialization in these zones is the main control factor for the decrease of pollutants concentration.

IV. Discussion

Fast industrial development and urban development play a great role in air pollution in the Durgapur-Asansol belt. To stop spreading the coronavirus, these factories, transportations, and other human-made activities were completely locked on, and from 25th March 2020, that give rise to the decrease of CO, SO_2, NO_2, PM2.5, PM10, NH_3, and O_3 release. A similar result was also observed by Mandal and Pal (2020) studying stone quarrying and crushing dominated study area from Eastern India.

The emission of CO, SO_2, NO_2, O_3 concentrations is the greatest environmental problem for developed countries (Sharma and Dhar 2018). NO_2 is produced from the burning of fossil fuels, like diesel, thermal power generation, industrial emissions, automobile exhaust, and shipping (Burnett et al., 2004; Tobias et al., 2020; He et al. 2020c; Sharma et al. 2020) and it causes many health hazards, acid rain, nitrate aerosols (Biswas et al., 2019). According to a report by European Space Agency (ESA) and the National Aeronautics and Space Administration (NASA) recommends that quality of the environment enhanced the release of NO_2 reduced up to 30% (Source: ESA, 2020a and NASA Air Quality Analysis, 2020). NH_3, CO, and SO_2 are vital indicators of air poisons that are connected to coal consumption, petroleum, and chemical fuel releases. PM2.5 and PM10 derived from road traffic, industrial exhaust emission, construction works, and road dust was significantly attenuated during the progression of lockdown. As per Lal et al., 2000, O_3 is a negligible pollutant that is released from sunlight and nitrogen oxides (NOx) and volatile organic compounds (VOCs). A decreasing trend in O_3 was observed pre lockdown phase, while during the lockdown, O_3 showed an increasing tendency was also observed by Hasnain et al., 2021 at China due to the enhancement of solar radiation in the summer, because of the emissions of isoprene and biomass burning (Lu et al., 2018). As per Islam et al. 2020, O_3 increased during the lockdown phase in Bangladesh, and Mahato et al. 2020 found the same in Delhi, India. Li et al., 2020 found that the release of NO_2, SO_2, and PM2.5 reduced in the air than the preceding years at Yangtze River delta region in China and Kerimray et al. 2020 observed that CO, NO_2, and PM2.5 levels decreased by 49%, 35% and 21% accordingly than the before-lockdown period in Almaty, Kazakhstan. France, Spain, Italy, and Germany displayed better-quality air throughout the lockdown period because of limited automobile activities and partly locked industries, etc. (Muhammad et al. 2020; ESA 2020b). Even in Wuhan City, China 30% reduction of NO_2 was also found in 2020 than 2019 (He et al. 2020b). Otmani et al. 2020 observed a decrease in the concentration of PM10, NO_2, and SO_2 in Salé City, Morocco by 75%, 96%, and 49% respectively during the lockdown period.

Like other international countries, good air quality was also noticed in India on 24th March 2020 (Mahato et al. 2020; Gautam 2020a; CPCB, 2020; Mate et al. 2020; Mitra et al. 2020; Lau et al. 2020). Sharma et al. 2020 also observed notable positive changes of air quality (CO_2, SO_2, NO_2, O_3, PM2.5, and PM10) during March and April 2020 and also reported AQI across 22 cities of India showing upgrading by 15 - 44%. Das et al. 2021 experienced that the air quality of the Indian megacities has also improved by 50% after lockdown. Mahato et al., 2020 worked on the air quality of different parts of Delhi and have witnessed that, the concentrations of PM10 and PM2.5 were reduced in maximum level (>50%) and satisfactory result in AQI in comparison to the pre lockdown phase. A similar outcome has been found by Bera et al. 2020 in Kolkata, West Bengal, where the pollutants like CO, SO_2, NO_2, PM2.5, and PM10 are significantly reduced throughout lockdown related to the earlier three years. The long-term lockdown system reduces materialistic consumption and energy usage as per Jribi et al., 2020. Eroglu, 2020 noted a significant decrease in the use of coal consumption during lockdown months than in the past years. As the country was passing through the lockdown phase, the industrial and transport activities were paused, reduces the concentration of CO, SO_2, NO_2, NH_3, PM2.5, and PM10 in the atmosphere of an industrial and most polluted city like Asansol, which is also a part of Raniganj Coalfield area.

Lockdown is good from the environmental point of view for air quality, but, in the case of the economic development of a country, it is not advisable. Plants act as a sink (Kaur and Nagpal, 2017) of carbon, and to reduce pollution, the plantation is the only solution along with the use of alternative energy. Salih et al. 2017 identified some plant species (*Ficus bengalensis* -Banyan, *Psidium guajava* - Guava, *Mangifera indica* - Mango, *Hibiscus rosa-sinensis* - China rose, *Bougainvillea spectabilis* - Bougainvillea, *Neolamarkia cadamba* - Kadam/ Burfower tree, *Ficus religiosa* - Peepul, *Cascabela thevetia* - Yellow oleander, *Cassia siamea* - Cassod tree, *Ricinus communis* - Castor oil plant, *Eucalyptus globus* - Southern blue gum, *Azadirachta indica* - Neem) which has high absorption capacity of specific pollutants. Choudhury and Banerjee 2009 specified as per APTI (Air Pollution Tolerant Index) standards of few plants like *Mangifera indica* (Mango), *Azadirachta indica* (Neem), *Ficus benghalensis* (Banyan), *Psidium guayava* (Guava), *Eucalyptus* (Eucalyptus), *Alstonia scholaris* (Chattiyan), *Butea monosperma* (Palash), *Moringa oleifera* (Sajina), *Dalbergia sisoo* (Sissoo), *Artocarpus heterophylus* (Jackfruit), *Hibiscus rosasinensis* (Jaba), *Calotropis gigantia* (Akanda), *Ricinus communis* (Bheranda), *Murraya paniculata* (Kamini), *Citrus aurantium* (Nebu), *Aegle marmelos* (Beal), *Ixora coccinea* (Rangan), *Nerium indicum* (Karabi), *Tamarindus indicus* (Tentul), *Thevetia peruviana* (Korubi) and *Tabernaemontana divaricata* (Tagar) are tolerant species in Asansol district and can be used as a pollution suppressor in this area.

V. Conclusion

This study considers the healthier vision of COVID-19 and how to present lockdown affects several parameters like CO, SO_2, NO_2, PM2.5, PM10, NH_3, and O_3 which is responsible for air pollution. The upgrading of air quality unlocked our eye to the magnitude of damage triggered by unregulated anthropogenic actions in the city. There is a chance after the lockdown period the environmental pollution can be returned so human determination towards saving the environment can do an eternal effect. The strict application of conservation-related regulations along with mass awareness should be done to bring back the city atmosphere.

VI. Acknowledgement

The authors are thankful to the Central Pollution Control Board (CPCB), Govt. of India, for providing essential data connected with air quality variations in Asansol of pre and during lockdown period. The authors would also like to acknowledge the European Space Agency (ESA), USA, and National Aeronautics and Space Administration (NASA).

Table 1. Emission level of selective pollutants (monthly average) present in air pre and during lockdown in Asansol City

	CO (mg/m^3)	SO_2 (µg/m^3)	NO_2 (µg/m^3)	PM2.5 (µg/m^3)	PM10 (µg/m^3)	NH_3 (µg/m^3)	O_3 (µg/m^3)	AQI
Pre lockdown (Jan 1 - March 24)	0.83	17.47	35.70	79.98	148.85	31.10	24.05	177.26
During lockdown (March 25 - May 3)	0.49	11.65	15.04	31.64	72.54	18.15	25.96	72.64
Net variation (Pre and during lockdown)	-0.34	-5.82	-20.66	-48.34	-76.31	-12.92	+1.91	-104.62
Percentage of variation	-40.96	-33.31	-57.87	-60.44	-51.27	-41.64	+7.94	-59.02

Table 2. Correlation between different air pollutants

	SO_2	**PM10**	**PM2.5**	**NO_2**	**NH_3**	**O_3**	**CO**
SO_2	1						
PM10	0.54213506	1					
PM2.5	0.419505768	0.970734874	1				
NO_2	0.216473155	0.625318066	0.6441298	1			
NH_3	-0.09558842	0.474475928	0.5757579	0.70285951	1		
O_3	-0.01747704	0.173946554	0.1756631	0.1487088	0.240263	1	
CO	0.292987905	0.738711321	0.7434538	0.6666152	0.517972	0.109648	1

Table 3. Data of AQI between pre and during lockdown periods as per CPCB standards

JAN	**MON**	**TUES**	**WEDS**	**THURS**	**FRI**	**SAT**	**SUN**	**MON**	**TUES**	**WED**	**THURS**	**FRI**	**SAT**	**SUN**	**AVG**
			1	2	3	4	5			278	178	79	92	79	**141.20**
	6	7	8	9	10	11	12	150	289	315	264	169	269	107	**223.29**
	13	14	15	16	17	18	19	231	334	301	308	237	302	169	**268.86**
	20	21	22	23	24	25	26	101	226	310	256	159	207	200	**208.43**
	27	28	29	30	31			219	310	278	278	132			**243.40**

FEB						1	2						153	114	**133.50**
	3	4	5	6	7	8	9	125	189	168	152	173	268	191	**180.86**
	10	11	12	13	14	15	16	131	167	165	257	273	132	160	**183.57**
	17	18	19	20	21	22	23	194	240	249	257	180	260	168	**221.14**
	24	25	26	27	28	29		104	89	99	140	144	270		**141.00**
MAR							1							320	**320.00**
	2	3	4	5	6	7	8	236	257	73	107	95	53	63	**126.29**
	9	10	11	12	13	14	15	92	99	105	116	107	43	72	**90.57**
	16	17	18	19	20	21	22	102	119	118	134	117	140	82	**116.00**
	23	24	25	26	27	28	29	101	100	118	78	77	58	64	**85.14**
	30	31						86	101						**93.50**
APRIL			1	2	3	4	5			103	90	90	92	90	**93.00**
	6	7	8	9	10	11	12	92	103	112	82	60	78	75	**86.00**
	13	14	15	16	17	18	19	94	87	87	74	78	43	43	**72.29**
	20	21	22	23	24	25	26	52	43	43	54	71	55	47	**52.14**
	27	28	29	30				47	55	84	48				**58.50**
MAY					1	2	3					48	76	94	**72.67**

AQI	***REMARK***	***COLOUR CODE***	***POSSIBLE HEALTH IMPACTS***
0-50	Good		Minimal impact
51-100	Satisfactory		Minor breathing discomfort to sensitive people
101-200	Moderate		Breathing discomfort to the people with lungs, asthma and heart diseases
201-300	Poor		Breathing discomfort to most people on prolonged exposure
301-400	Very Poor		Respiratory illness on prolonged exposure
401-500	Severe		Affects healthy people and seriously impacts those with existing diseases

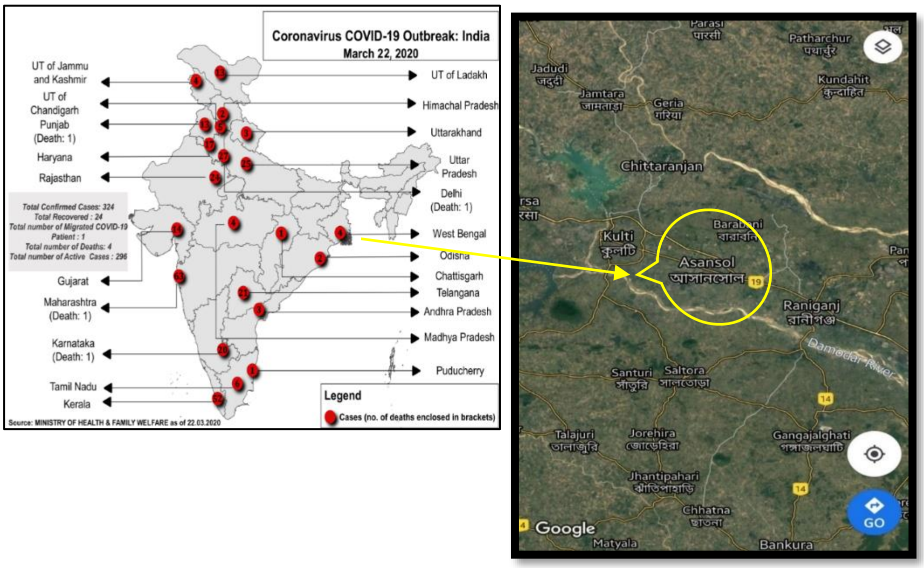

Fig.1. Geo-location of the study area

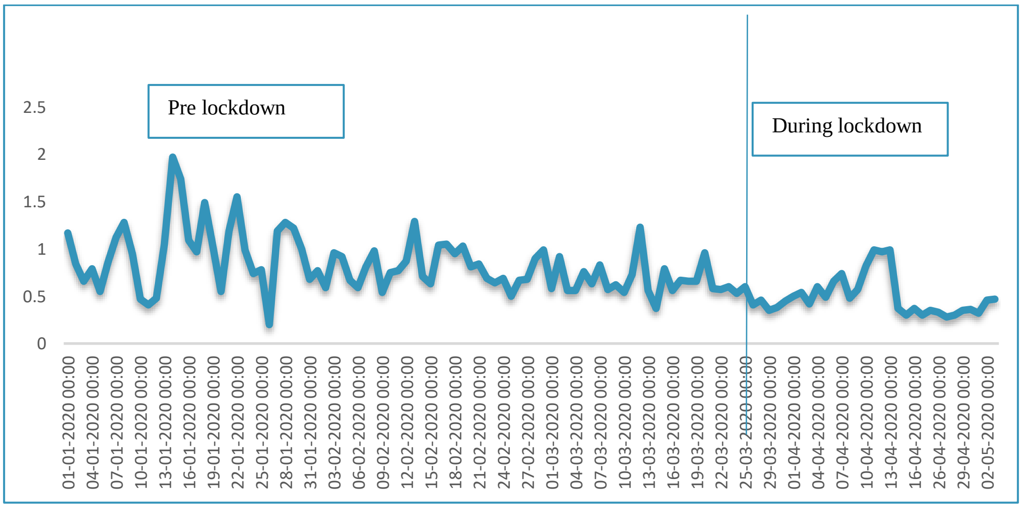

Fig. 2. The changing trend of atmospheric CO (mg/m^3) during study period (8 hrs average)

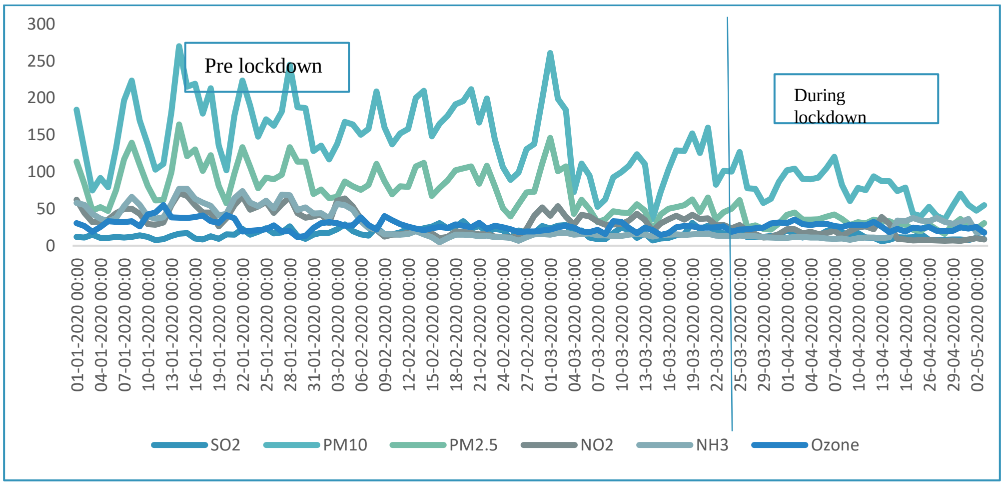

Fig. 3. The changing trend of atmospheric SO_2 ($\mu g/m^3$), NO_2 ($\mu g/m^3$), PM2.5 ($\mu g/m^3$), PM10 ($\mu g/m^3$), NH_3 ($\mu g/m^3$) and O_3 ($\mu g/m^3$) during study period (24 hrs average)

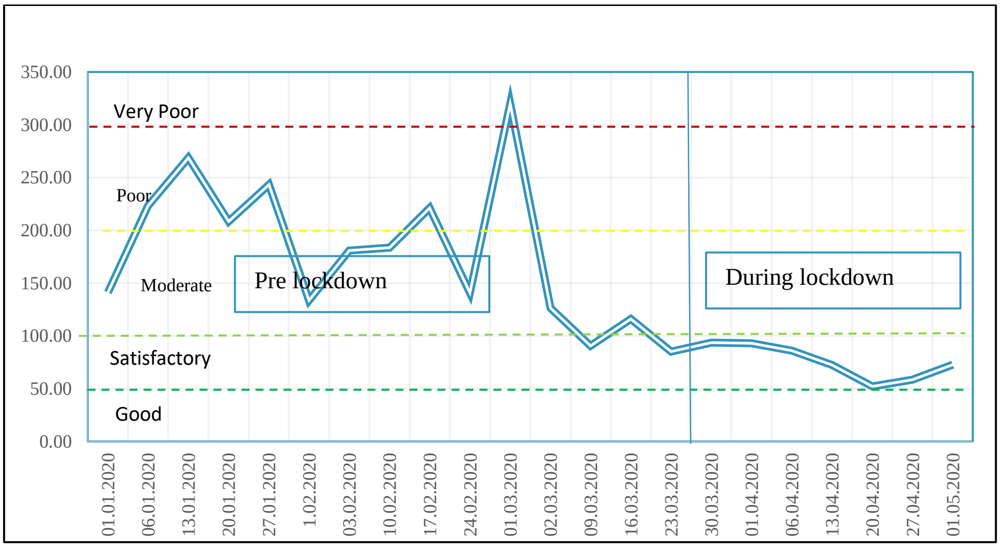

Fig. 4. Change of AQI between pre and during lockdown periods

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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