



Air quality fluctuation monitoring and statistical data analysis during COVID-19 pandemic in Siliguri city, India

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ABSTRACT

Introduction: Worldwide coronavirus created is a major problem for human health, food security, economy and many more. World Health Organisation (WHO) named this virus COVID-19. This virus is first detected in Wuhan, China in December 2019 and after that, it's spreading over the world. Lockdown is healing the environmental condition because major Indian metropolitan cities are recovered from different pollutants. This study is to identify the air quality trend before, during and after the lockdown in Siliguri city, the third-largest city of West Bengal and this city is also a commercial and transportation hub.

Materials and methods: The air quality data have been derived from West Bengal Pollution Control Board (WBPCB) and proceed in MS-Office and ArcGIS 10.4. The air pollutant and week air quality data have been used for monitoring the environmental situation.

Results: In this study, results show that around 70%-90% of air quality is increased during strict lockdown but again air quality is decreased after lockdown gradually. The weekly air quality graph significantly changes during lockdown but after lockdown, the graph was increased. The highest air quality shows 347 before lockdown but during lockdown it's decreased 25 on 23-24 May 2020. After lockdown public transport, industrial area and small scale industries are reopened and again the air quality increased. The highest air quality shows 353 on 14 January 2021 during unlock 8.0.

Conclusion: This pandemic taught how anthropogenic activates, like urbanization, population pressure and industrial works were endangering the environment and some caution is essential for future livelihood.

Introduction

The coronavirus or the COVID-19 is the deadly infringement spreading completed the world. This pandemic has developed a critical reason for inconveniencing. It was first determined in Wuhan, Hubei area, China in December 2019.

Afterwards, this pandemic is grabbed the world community health and challenge the health facility worldwide. Numerous countries are tried to build the vaccine to handle this deadly virus. But they can't overcome this pandemic. World Health Organization (WHO) named this virus COVID-19. COVID-19 is maximum important

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epidemic to abolish community health. As it is recognized in the name COVID-19, 'CO' stands 'corona', 'VI' for 'virus' and 'D' for 'disease', and also '19' implicates the year of its happening [1, 2]. The world has facing a huge amount of public health-related challenges and can't stop this pandemic any more. Health experts are building some strategies to protect public health in this situation. Many industries were locked during the country lockdown phases. The daily labour and small-scale industries are mostly affected during the lockdown and its cause's food scarcity in an area. Indian migrant workers have strained the global attention, with thousands worker forced to walk miles to reach their home. Most of the predictable over four million homeless people in India have had no way of creating a living since the lockdown initiated on March 25. With roads abandoned, they currently even have no habitation for begging. Many health specialists said the homeless are among the most at risk from the virus or pandemic as many previously suffer from infections such as tuberculosis, and their morbidity rates are sophisticated than for the common population.

In between 2002-2003, around 8000 people infested by Severe Acute Respiratory Syndrome (SARS) and mortality of 774 people was reported. In 2012, WHO registered the 2494 people infected and 858 killed by additional coronavirus named Middle East Respiratory Syndrome Coronavirus (MERS-CoV) and scattering about 27 countries [3, 4]. Coronaviruses are a group of Associated Ribonucleic Acid (RNA) viruses and this disease is produced in mammals and birds [5]. The common symptoms of COVID-19 in the human body are the common cold, chest pain and many more. It was first determined in Wuhan, Hubei area, China in December 2019. Subsequently, this pandemic is taken the world public health and challenge the health facility worldwide. Novel coronavirus indicates a "new pathogen of a previous know type" of the virus [6]. The acute disease was first derived in Wuhan, China in December 2019. After that, COVID-19 is spread over the world, also India does not

get relief from this. On 30th January Indian reported its first case of COVID-19 or novel coronavirus. On 30th January India reported its first case of novel coronavirus or COVID-19. By the 3rd February 2020, 3 coronavirus cases were registered; entirely all are students who just derived from Wuhan. 22 new cases were registered on 4th March 2020, where 14 Italian tourists were tested positive. The first death is conforming on 12th March 2020. A 76 years old man died in Karnataka, India. 13th March 2020 news comes from Delhi, a 60 years woman died. In two days 2 confirmed cases have come and both of them had contact with abroad at the time of return to other countries. West Bengal recorded the first case of COVID-19 on 17 March 2020 after the UK-returned student was tested positive. India has been nationwide lockdown since 25 March 2020. First phase of lockdown is 21-day from 25th March, 2020 to 14th April, 2020. Restriction in public transportation, industrial sector and human mobility are reducing the emission of pollutants. Researchers have been showed huge amount of air quality fluctuation during lockdown phases [7-11]. Government of India made a decision for protection of people from the COVID-19 pandemic by some steps like "Janta Curfew" on 22nd March from 7 AM to 9 P.M and announced the 1st phase of lockdown from 25th March, 2020 to 14th April, 2020. The main focus of government during lockdown is not only to recover the infected person also controls the growth of spreading. Government of India focuses on controlling the virus in the first stage before the stage of community spreading. It is not possible to control the spreading any more in developing and highly populated country since people don't understand the current subject. The lockdown phase was increased progressively, then the infected number is similarly increased. In the fourth stage of lockdown every day almost 5000 people were tested positive and the death comes to about 120 per day in India. In a particular region, infrastructural development, economic growth, and population pressure are increasing

urbanization process. Urban areas are mostly assumed as concentrations of people engaged in the non-agricultural activity, such as building the urban facility, increasing transportation system and many other amenities. Energy consumption, vehicular emission, and industrial emission are caused by population pressure and anthropogenic activities. The main focus of this study is to identify the air quality fluctuation during pre-lockdown, lockdown phases and unlock phases in Siliguri Municipal Corporation West Bengal. This study is some limitation like meteorological, air movement and topological influence the pollution measurement. Also, some air quality data has not been available due to lockdown and insufficient data to calculate the Air Quality Index (AQI) for the city.

Negative impact on the environment

The organic and inorganic waste is indirectly effecting by the huge amount of environmental issues, like deforestation, soil erosion, soil moisture and water pollution [12, 13]. The huge amount of medical waste can hammer the environment. Single-use gloves, surgical masks and sanitizer bottle, PPE kits are disposal huge amount worldwide. Wuhan hospital produced a massive amount of medical waste over 240 metric tons of waste per day during the COVID-19 outbreak [14]. The food packaging, online product packaging is depended on only paper or plastics. The home quarantine and lockdown policy build a huge amount of online shopping and food home delivery [15]. Waste recycling is the major challenges of this pandemic. Recycling is a communal and active route to control the pollution, save energy and conserve natural resources [16]. In India, the United Nations Industrial Development Organization (UNIDO) has been collaborating with Indian Ministry of Environment, Forests and Climate Change on the project to reduce the medical waste management in Gujarat, Karnataka, Maharashtra, Odisha and Punjab (UNIDO. 2020). Municipalities are collecting the organic and inorganic waste but in different frequencies. In some place collected

by every day, sometimes alternate days or once a week [17]. In these cases, many time people can through daily waste in nearby area or pond. That's the reason for water pollution. If store the degradable waste, this area creating an unhealthy situation. Water pollution is the effective parts of environmental changes. Water is a very common influence on the public in everyday life. If the medical waste put into the water, river, lake or sea it is more harmful for the people and reasons for the water pollution [18]. A huge amount of water was losses for hand sanitation or in medical uses during COVID-19 pandemic.

Materials and methods

Study area

Siliguri is the largest metropolitan city in North West Bengal also the fastest growing city. Siliguri is also called the gateway of North-East India and that the reason Siliguri is the hub of tourism. Anthropogenic activities like the transportation system, population growth, urbanization and industrial activities are located in Siliguri area. Siliguri have 41.9 km² areas which are distributed over 47 wards. Siliguri has around 0.5 million population and regularly increases and resulting in massive air pollution and poor ambient air quality of the Siliguri city. Siliguri city is situated between 88°25'16.47"E to 88°26'53.62"E and 26°39'57.88"N to 26°46'19.03"N. This city is situated in Mahanadi river bank at the foothills of the Eastern Himalayas (Fig. 1). After Kolkata and Asansol, Siliguri is the third-largest urban city in West Bengal. Siliguri urban area is located around 568 km from Kolkata and 500 km from Asansol. The highest elevation is 140 m and the lowest is 114 m in Siliguri. Rapid urbanization, population pressure and anthropogenic activities are causes unhealthy air quality in this area. During lockdown, the city has experienced a huge change in air quality. But after lockdown, the air quality again decreased and definitely this pandemic shows our environmental condition in every aspect of life.

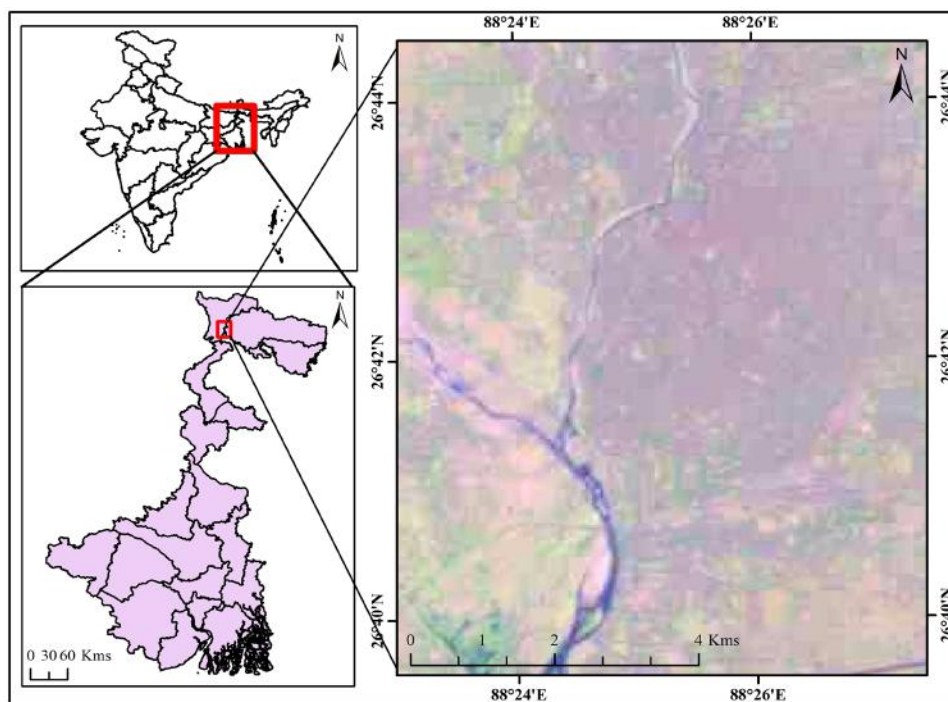


Fig. 1. Location map of Siliguri city, West Bengal, India

The Central Pollution Control Board (CPCB) data shows that $PM_{2.5}$ and PM_{10} are the primary threats for the city due to motorized vehicles, industrial activities, urbanization and constriction. NO_2 also cross the National Ambient Air Quality Standard (NAAQS) violation limit for human health [19]. In this study, we identify the air quality fluctuation during COVID19 pandemic and mapping the lockdown data is more suitable for human health. This study is future helpful for future planning of this city.

Data sources

The main focus of this study is to identify the fluctuation of air quality over Siliguri, West Bengal. Pre-lockdown, 4th phases of lockdown and unlock phases has been experienced huge fluctuation of air quality. Ward no-32, Bapupara have one air quality monitoring centre in Siliguri Municipal Corporation. The air quality data from 1 February 2020 to 24 March 2020 (before lockdown), 25 March 2020 to 31 May 2020 (Lockdown periods) and 1 June 2020 to 31 January 2021 data were used to calculate the variation in awareness and evaluate the relative

change of air quality from pre-lockdown, lockdown and unlock phases. The West Bengal Pollution Control Board (WBPCB), under the guidance of the National Air Quality Monitoring Program (NAMP), regularly monitoring the urban towns and industrials areas air quality (Table 1) in India [20]. The network involves 308 air quality monitoring station covering 115 cities/towns in 25 states in 4 union territories in India [21]. The daily seven pollutants are observing in the monitoring station for air quality assessment. Particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxides (NO_2), sulphur dioxide (SO_2), ammonia (NH_3) on 24 h interval and ozone (O_3), and carbon monoxide (CO) have been taken into consideration on an 8 h interval for air quality monitoring (Table 2). The Central Pollution Control Board online portal data is used for air quality monitoring in Siliguri municipal corporation area. The air quality data are also verified from different sources like AQI-India under the Central Pollution Control Board and state air quality monitoring station is West Bengal Pollution Control Board (WBPCB) [22].

Table 1. Range and categories of Indian AQI (IND-AQI) [22, 23]

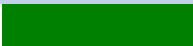





| AQI | Class | Colour code | Impacts on human health |
|---------|--------------|---|---|
| 0-50 | Good |  | Minimum health impact |
| 51-100 | Satisfactory |  | Minimum breathing trouble to sensitive people |
| 101-200 | Moderate |  | Breathing discomfort to the people with lungs, asthma and heart 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 |

Table 2. Projected breakpoints for Air Quality Index (AQI) scale 0–500 [25]

| | P.M ₁₀ | P.M _{2.5} | NO ₂ | O ₃ | CO | SO ₂ | NH ₃ |
|-----------------------|-----------------------------------|-----------------------------------|-----------------------------------|----------------------------------|--------------------------------|-----------------------------------|-----------------------------------|
| AQI category (range) | 24-h ($\mu\text{g}/\text{m}^3$) | 24-h ($\mu\text{g}/\text{m}^3$) | 24-h ($\mu\text{g}/\text{m}^3$) | 8-h ($\mu\text{g}/\text{m}^3$) | 8-h (mg/m^3) | 24-h ($\mu\text{g}/\text{m}^3$) | 24-h ($\mu\text{g}/\text{m}^3$) |
| Good (0-50) | 0-50 | 0-30 | 0-40 | 0-50 | 0-1.0 | 0-40 | 0-200 |
| Satisfactory (51-100) | 51-100 | 31-60 | 41-80 | 51-100 | 1.1-2.0 | 41-80 | 201-400 |
| Moderately (101-200) | 101-250 | 61-90 | 81-180 | 101-168 | 2.1-10 | 81-380 | 401-800 |
| Poor (201-300) | 251-350 | 91-120 | 181-280 | 169-208 | 11-17 | 381-800 | 801-1200 |
| Very Poor (301-400) | 351-430 | 121-250 | 281-400 | 209-748 | 17-34 | 381-1600 | 1200-1800 |
| Severe (401-500) | 430+ | 250+ | 400+ | 748+ | 34+ | 1600+ | 1800+ |

Data analysis

The AQI is a quantity of the accumulative result of different pollutants attentiveness on the quality of air in different places, but the alteration of the air quality measurement method which is called as National Air Quality Index (NAQI) is established on the maximum operator approach to escaping the uncertainty [24]. The calculation of sub-indices for the different pollutant and then the combination of divide standards (sub-indices), which is be contingent upon the Indian NAAQS are the dual phases for AQI calculation. The EPA-US method for AQI is used by the Central

Pollution Control Board to detect the AQI. The maximum value of sub-indices is taken for the air quality index.

The study area map is designed in Geographical Information System (GIS) environment. ArcGIS 10.5 is used to study map generation. The air quality index data has been derived from the Central Pollution Control Board online portal and then estimate the pre-lockdown, lockdown and unlock phase's situation. The different phases data used for graph (bar graph, line graph) generation for visual interpretation of air quality. Microsoft Excel is also used for pollutant data graphically representation.

Results and discussion

During pre-lockdown (1 February to 24 March 2020), highest AQI shows 347 and lowest is 45 for the date of 7 February and 25 February respectively (Fig. 2). Throughout lockdown, the highest AQI shows 228 and lowest 25 for

the date of 7 April and 22-23 May 2020 (Fig. 3). The unlock phases air quality showing the highest value 372 and lowest 18 which is 11 January 2021 and 17 August 2020 respectively (Figs. 4-6). The weekly and daily air quality data also show that the fluctuation of AQI in Siliguri city.

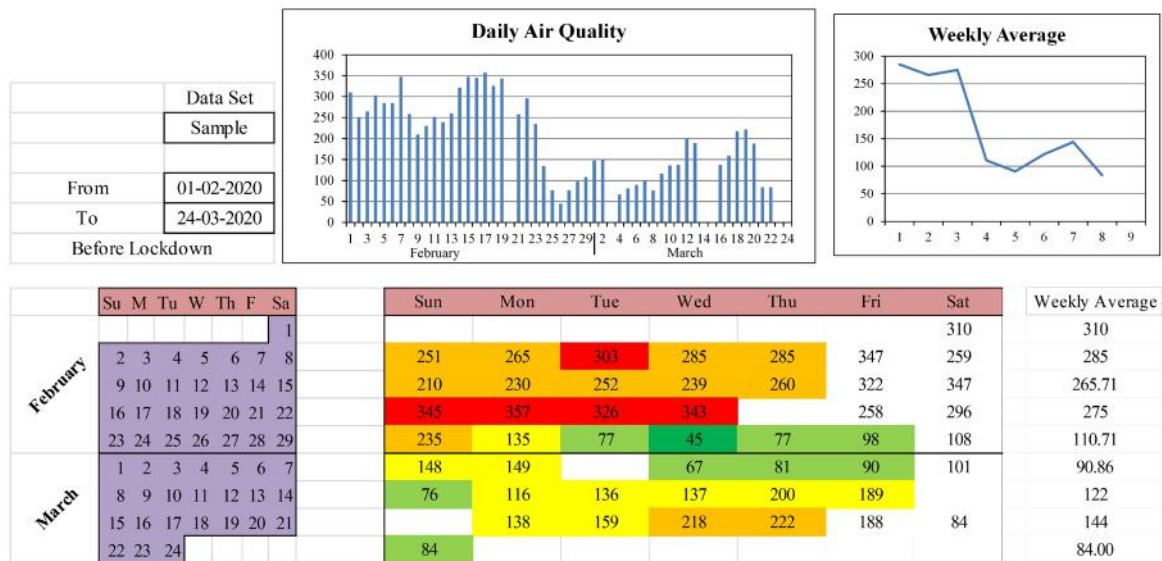


Fig. 2. Status of air quality in daily basis from 1st February to 24th March 2020 (Pre-lockdown phase)

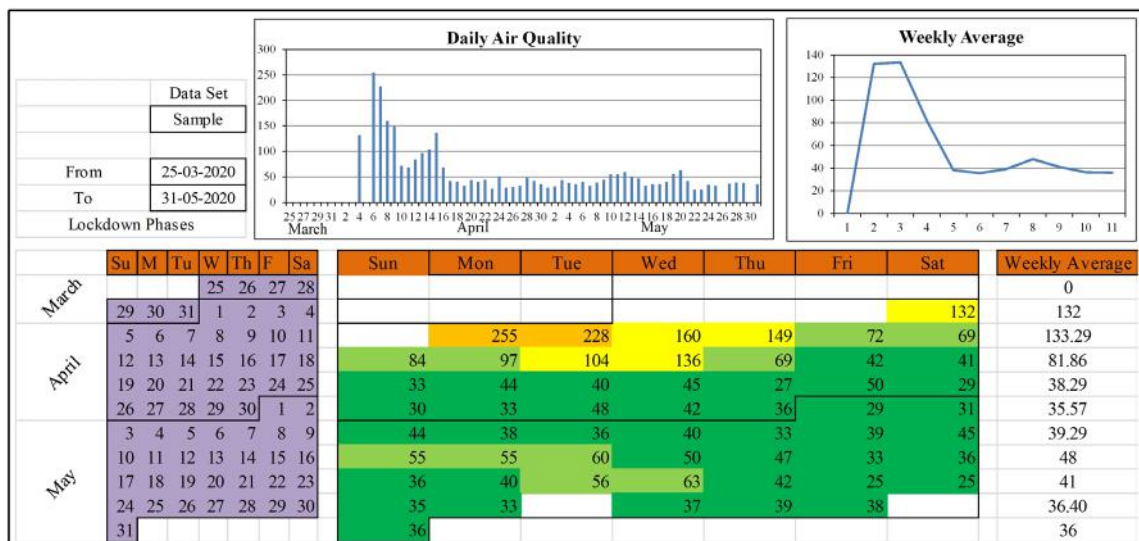


Fig. 3. Status of air quality in daily basis from 25th March to 31st May 2020 (During Lockdown)

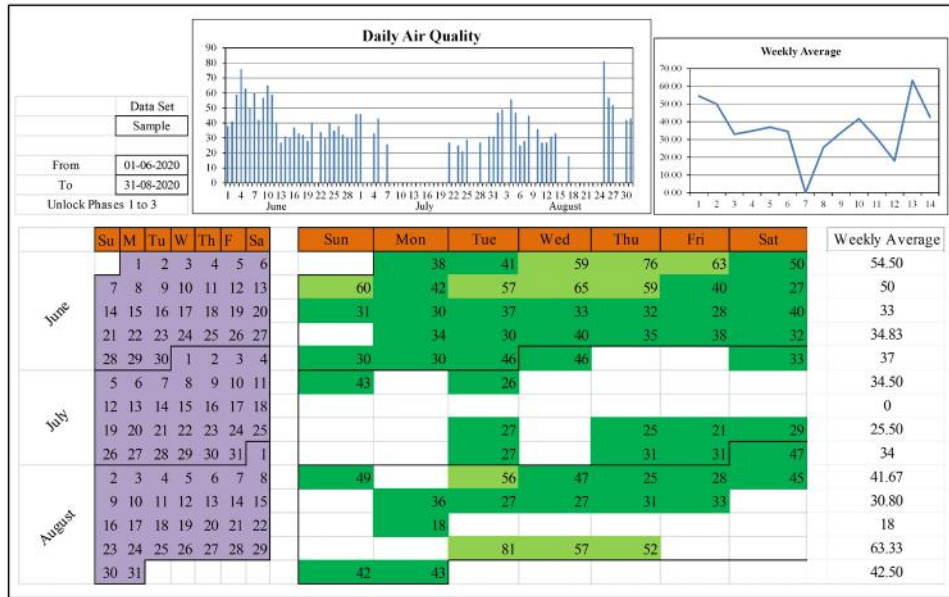


Fig. 4. Status of air quality in daily basis from 1st June to 31st August (Unlock 1.0 to 3.0)

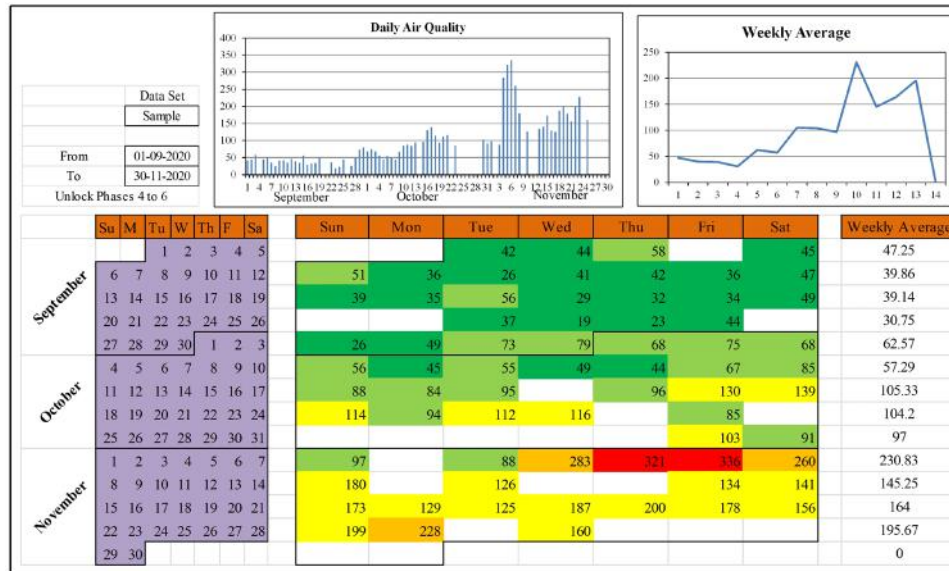


Fig. 5. Status of air quality in daily basis from 1st September to 30th November (Unlock 4.0 to 6.0)

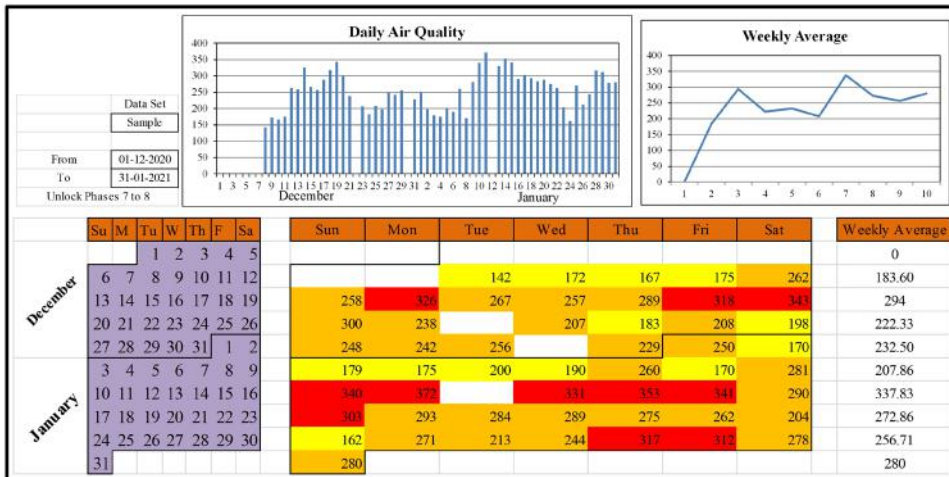


Fig. 6. Status of air quality in daily basis from 1st December 2020 to 31st January 2021 (Unlock 7.0 to 8.0)

Air quality data analysis

Pre-lockdown

According to the Central Pollution Control Board, the mean concentration of $PM_{2.5}$ and PM_{10} was very high and it overstepped the NAAQS in Pre-lockdown phase (1 February 2020 to 24 March 2020). Traffic congestion and industrial activities are more responsible for this. Others pollutants like SO_2 , O_3 , NH_3 , NO_2 , CO and Ozone are within the permissible limit. During pre-lockdown NO_2 cross 100 which shows that NO_2 is the primary threat for Siliguri city after $PM_{2.5}$ and PM_{10} before lockdown period (Table 2). Due to unavailability of pollutant data some data are missing but available data shows that the fluctuation of air quality in Siliguri city.

During lockdown period

Lockdown period (25 March 2020 to 31 May 2020) experienced a drastic change in the reduction of the pollutants. $PM_{2.5}$ and PM_{10} and

NO_2 are the main threat for Siliguri city but the trend line is lower than pre-lockdown phase (Fig. 7). $PM_{2.5}$ data in February month is showing high but during the lockdown, it's reduced. Main source of SO_2 is power plants and large industries, which is come from fossil fuel. In the industrial and power plant activities, Siliguri city is facing low concentration of SO_2 but during the lockdown, SO_2 is further reduced (Fig. 7). The primary source of NH_3 is agricultural activities and animal husbandry. In Siliguri city, NH_3 is below the permission limit (Fig. 7). CO and Ozone concentration also fluctuate during the lockdown period. The lockdown results in the massive change over the mean concentration of all pollutant. The average $PM_{2.5}$ and PM_{10} and NO_2 are reducing during the lockdown. In the fourth phases of lockdown (Table 3) air quality is more healthily for human life. During the third phase of lockdown, some restricted movement is started like intra-city public bus transport, cabs and four-wheeler with a limited passenger. Those days NH_3 and SO_2 show negligible changes.

Table 3. Timetable of nationwide lockdown and unlock phases

| | Phases | Date |
|----------|-----------|---------------------------------|
| Lockdown | Phase 1 | 25 March- 14 April 2020 |
| | Phase 2 | 15 April - 3 May 2020 |
| | Phase 3 | 4 May - 17 May 2020 |
| | Phase 4 | 18 May 31 May 2020 |
| Unlock | Phase 1.0 | 1 June- 30 June 2020 |
| | Phase 2.0 | 1 July - 31 July 2020 |
| | Phase 3.0 | 1 August - 31 August 2020 |
| | Phase 4.0 | 1 September - 30 September 2020 |
| | Phase 5.0 | 1 October - 31 October 2020 |
| | Phase 6.0 | 1 November - 30 November 2020 |
| | Phase 7.0 | 1 December - 31 December 2020 |
| | Phase 8.0 | 1 January - 31 January 2021 |

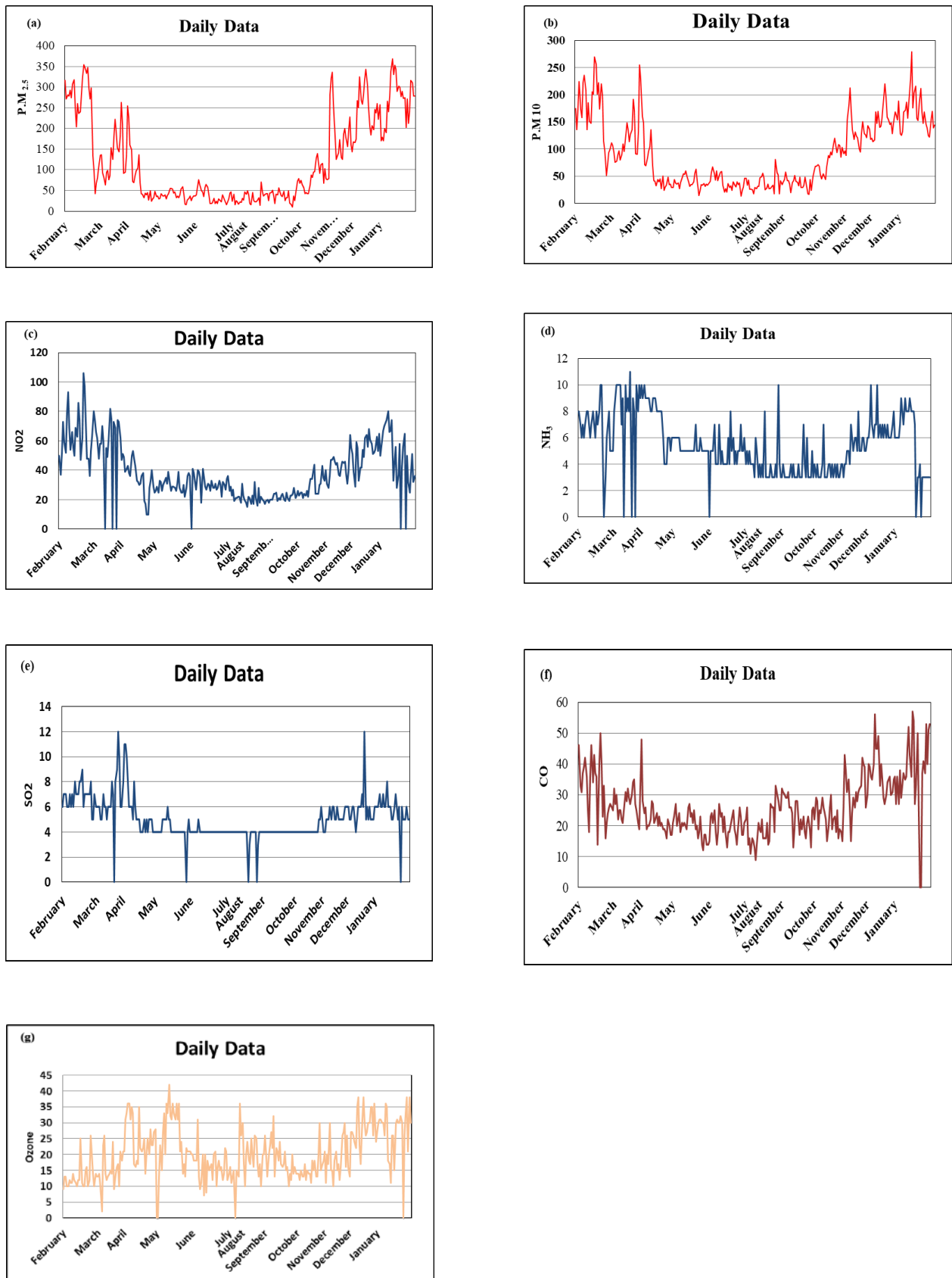


Fig. 7. Daily different Air pollutant measurement of Siliguri City, West Bengal, India. (February 2020 to January 2021)

Unlock phases

The unlock phase is started on 1 June 2020 and it is continuing to date. The concentration of pollutants is limited during the first unlock phase. But after that, the pollutant is cross the NAAQS permissible limit. The industry, public transport and private cars are started and those activities again triggered the pollutant. The Siliguri city is the transportation commercial hub and also the truism spot. After lockdown, express train is started and during unlock, 6 people also move for a tour of many other activities with some restriction. $PM_{2.5}$, PM_{10} and NO_2 and other pollutant are significantly increased and it's more harmful to human health.

Weekly data analysis

Weekly air quality data is showing the actual

air quality variation in Siliguri city (Fig. 8). Pre lockdown air quality is very high from 1 February 2020 to 24 March 2020. During lockdown only second and third week experienced high air quality but after then air quality is decreased in Siliguri city. The mainly fifth and eleventh week is very low air quality. All through strictly lockdown (25 March 2020 to 31 Ma 2020) is reduced the environmental vulnerability and transportation system, industrial area and many activities can stop by the government for control the spreading of COVID-19 pandemic in India. Unlock phases are started on 1st June 2020 and unlock 1 to 3 Siliguri area has experienced healthily air quality but in unlock 4 to 6, air quality is a huge change after week 8. Then same cases resulting in unlock phases 7 to 8, which are situated from 1st December 2020 to 31st January 2021.

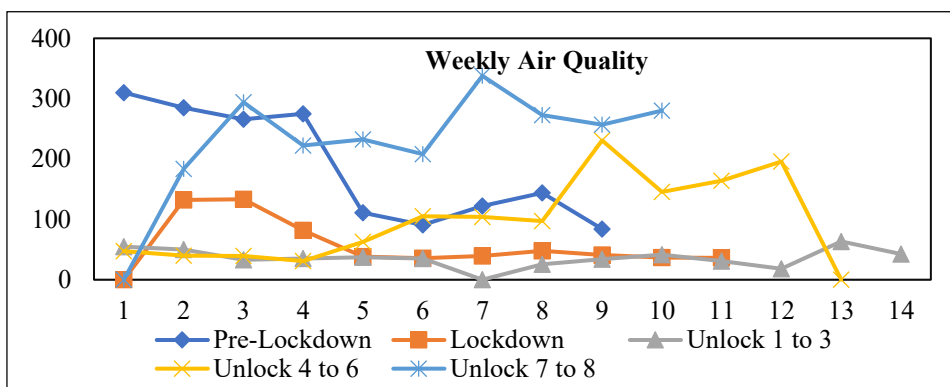


Fig. 8. Weekly average air quality in different phases of Siliguri city(January 2021)

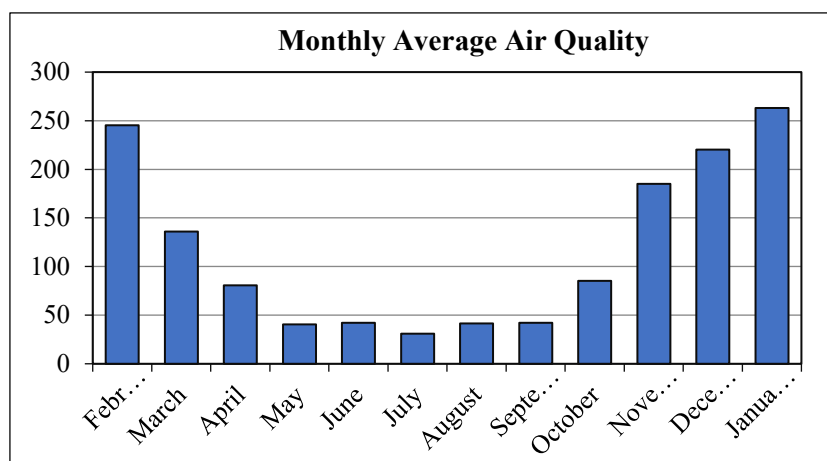


Fig. 9. Monthly Air Quality of Siliguri City, West Bengal, India

The monthly air quality data is more fluctuated, which is cross 200 in February. But during the lockdown and unlock 1.0 to 5.0, monthly air quality is healthily for human and also good the air quality is shown (Fig. 9). After unlocking 5.0, anthropogenic activities again triggered the pollutant and air quality is reducing same as pre-lockdown time.

Conclusion

As a developing country, India has increased the built-up area, industrial activities and transportation system due to population pressure. The huge populated country, India has 121 million people located with 382/km² [26]. This huge amount of population during coronavirus can't stop spreading. The Government of India takes an initial step for battle with this pandemic. This study is to identify and monitor the air quality and pollution for Siliguri city during COVID-19 pandemic. In India, the condition is the same as in the world. The most inhabited country is affected in COVID-19 in the time of 30th January 2020. There is not the same condition as in the preliminary phase. Progressively the affected statistics are increased and the government is fighting with them. Central and state government are working together against COVID-19 pandemic for people health. This study is to identify the lockdown is better for increasing the health of air quality. The metropolitan environment is more harmful due to industrial activities, public transportation and its cause's poor health condition of those areal people. Unhealthy air quality is increased the health-related problem like Asthma, heart disease, lung cancer and respiratory diseases such as emphysema. Also, air pollution can cause long-term damage to people's brain, nerves, kidneys, and liver.

Huge air quality fluctuation is observer during this pandemic. This is a proper time to think about our environmental issue and how to overcome it. Otherwise the megacities like Delhi, Kolkata, Durgapur and Siliguri are facing huge air pollution on their industrial activities and transportation system. Those activities are increased environmental polluted emission and it's more harmful to human health. During the last 100 years, people are not facing any epidemic or pandemic like COVID-19. This pandemic shows that how to protect our mother earth properly. If people do not maintain their activities

and some proper guideline they are facing more epidemics is future like COVID-19. This research indicates that human activities are more harmful for the environment and sustainable livelihood. This time is the more vital point of changing the human mind and activates for future generation to give a proper healthy life. If the human cannot maintain the so-called development and activities, they are definitely facing numerous epidemics in future.

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Competing interests

On behalf of all authors, the corresponding author states that there is no financial or non-financial interest to disclose.

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Ethical considerations

The named authors are aware of the journal policy and the authors are declaring that the manuscript or figures are not being previously published in any format or any language elsewhere. The original manuscript is only submitted to the Journal of Air Pollution and Health.

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