COMPARATIVE ANALYSIS ON AIR AND WATER QUALITY IN PARTS OF INDIA: BEFORE AND DURING LOCKDOWN DUE TO COVID -19

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ABSTRACT

Due to the pandemic caused by SARS-CoV-2(Severe acute respiratory syndrome corona virus2) commonly known as Corona virus, a nationwide lockdown came into effect in India from 24th March midnight, 2020, which slowed down the movement of vehicles, operation of industries etc. Due to this reason a drastic change in the environment occurred and it caused the reduction of pollution level in the environment. In the present study, observations have been made to understand the positive impacts of lockdown in India. Studies have shown that after the implementation of lockdown, the level of the various major constituents of air pollution such as particulate matter ($PM_{2.5}$, PM_{10}, etc.), NO_2, CO and ozone etc.in the air has reduced substantially. The air quality index data have clearly shown the difference in level of air pollution between the year 2019 and 2020. The study was mainly focused on comparison of air quality parameters such as particulate matter, NO_2, CO and ozone etc as well as the water pollution parameters such as Biochemical oxygen demand, chemical oxygen demand and dissolved oxygen for the River Yamuna and it was observed that there was substantial amount of positive change in pollutants after lockdown compared to what was prior to lockdown. The observations are carried out in a time frame manner such as before lockdown and after lockdown and results have been found with a huge difference in reduction of air pollution as well as water pollution.

KEY WORDS : COVID 19, Air pollution, air quality index (AQI), Particulate matter, Biochemical oxygen demand (BOD), Chemical oxygen demand (COD), dissolved oxygen (DO)

INTRODUCTION

The air pollution control is becoming very necessary to overcome the adversely effects of air pollution. The air quality data and statistical models for the past few years show the uncontrollable change in air quality (Mahato *et al.,* 2020; Guttikonda *et al.,* 2014 and Shehzad *et al.,* 2020). Some of the mega cities of India like Delhi, Bengaluru, Thane, Mumbai and Jaipur, Rajasthan etc. have shown large scale urbanization in the past few years. In the publication, Nature of air pollution, for emission sources and its management in Indian cities, it was reported that 695,000 premature deaths occurred in 2010 due to the rise in particulate matter and ozone pollution. Among all the pollutants present in air, $PM_{2.5}$ (particulate matter of size less than 2.5 micrometers diameter) has the most severe effects as its size is very minute to enter in the lungs and blood stream. Other major pollutants which cause serious health hazards are PM_{10}, NO_2, CO and ozone etc. (Shehzad *et al.,* 2020 and Indian Institute of Tropical Meteorology).

Now if we talk about the present worldwide pandemic situation caused by SARS-CoV-2 (severe acute respiratory syndrome corona virus2) commonly known as Corona virus, it is reported that the virus has originated from Wuhan city in

China (Shehzad *et al.,* 2020). Corona virus disease (COVID-19) is an infectious disease. In India, our Honorable Prime Minister, addressed the nation for the implementation of Janta curfew on 22 March, 2020 (Source: Times of India). On 24th March evening, Honorable Prime minister put forward a nationwide lockdown for 21 days starting from 24th March mid night for selective limited movement of the population as a precautionary measure to curve the spread of the virus and for the wellbeing of the country at large. After that, four phases of lockdown continued, which lead to the substantial control of the virus spread among the population and eventually the lockdown helped in drastically reduction of the air pollution level in the country. Cities like Delhi, Mumbai etc. witnessed a huge amount of improvement in air quality due to less pollution (Susanta *et al.,* 2020 and Dutheil *et al.,* 2020).

Air Quality Standards in India

The major pollutants present in air those are responsible for air pollution such as particulate matter, nitrogen dioxide, sulfur dioxide, carbon monoxide, ozone etc. are taken into consideration for the computation of air quality index. The table below shows the AQI index and its various ranges (Susanta *et al.,* 2020). For example, the value ranges between 0-50 for a good air quality index. Similarly, other values depict different standards for AQI as shown in Table 1.

The nationwide lockdown has directly or indirectly contributed to the reduction in pollution of environment at a huge scale. In May, 2014, WHO ranked New Delhi as the most polluted city of the world? The air quality Index was reported to be 200 and sometimes it went off the measurable scale. The value of 200 itself is 25% higher above the unsafe level as per the Air Quality Standards in India.

During lockdown period, the value has fallen several times below 20. Reports have shown that in New Delhi, the concentration of $PM_{2.5}$ has become 71% less during lockdown period (Dutheil *et al.,* 2020).

According to Central Pollution Control Board, a remarkable improvement in the water quality of River Yamuna has been noticed during the lockdown period. Different locations were selected and samples were taken for testing by the Delhi Pollution Control Committee, and results showed that the water quality was improved by 33%, when compared to the results obtained before lockdown
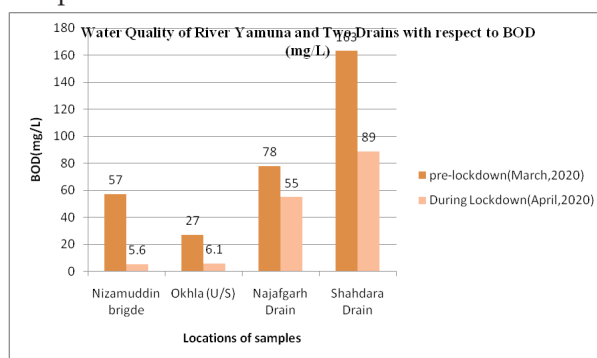
Fig. 1. BOD values of River Yamuna and Two Drains (Pre-Lockdown and Lockdown)
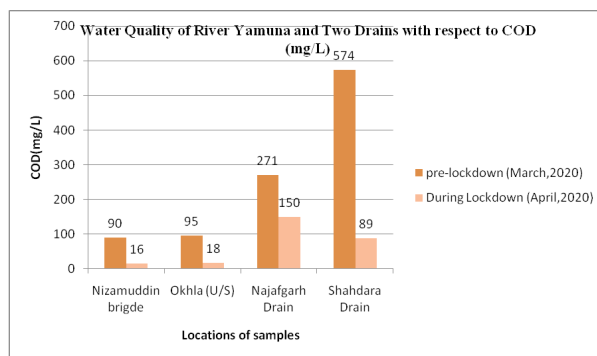
Fig. 2. COD values of River Yamuna and Two Drains (Pre-Lockdown and Lockdown)

Table 1: Air Quality Index and its ranges.

AQI	Remark	Color 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

started. The results obtained by this study depicted that there was a significant improvement in DO, i.e., dissolved oxygen, BOD, i.e., Biochemical oxygen demand and COD, i.e., Chemical oxygen demand in the river water when similar parameters were compared to the data of pre-lockdown period. Table 2, 3 and 4 shows the comparison of BOD, COD and DO value of some places from where samples of river water were taken between year 2019 and 2020 (Dutheil *et al.*, 2020).

Comparison of AQI for different cities of India

As per the data obtained, the AQI (air quality index) of different cities in India, year 2020 have shown drastic improvement when compared to past few years (Gautam *et al.*, 2020). The figures below (from Figures 5 to 12), shows the comparison of air quality index of four different cities of India, namely Delhi, Mumbai, Bangalore and Rajasthan for the year 2019 and 2020 respectively. Figures 5 and 6 depicts the AQI data for Delhi for the year 2019 and 2020. Analysis reveals that data obtained in 2019 is 190 but the result obtained in the year 2020 was found to be 160. Similarly, Figure 7 and 8 represents studies for Bengaluru. As observed in the figures, data obtained in 2019 is 126 but the result obtained in the year 2020 was found to be 54. Relevant studies for Mumbai and Jaipur can be observed from the set of Figures 9, 10 and 11, 12 respectively. The set of figures (5 to 12) below clearly summarizes the improvement of air quality after the lockdown has started.

Effects of pollution on human health

Air pollution may cause severe health problems
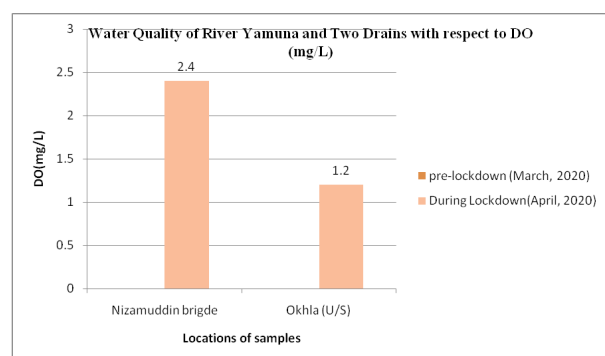
Fig. 3. DO values of River Yamuna and Two Drains (Pre-Lockdown and Lockdown)

Table 2. BOD value for Yamuna River for the year 2019 and 2020

Location	BOD (mg/L)	
	Monitoring year 2019	Monitoring year 2020
ITO Bridge	28	22
Nizamuddin Bridge	20	16
Agra Canal, Okhla Bridge	24	16
Agra Canal (Jaitpur)	23	17

Table 3. COD value for Yamuna River for the year 2019 and 2020

Location	COD (mg/L)	
	Monitoring year 2019	Monitoring year 2020
ITO Bridge	88	32
Nizamuddin Bridge	68	42
Agra Canal, Okhla Bridge	68	42
Agra Canal (Jaitpur)	64	48

Table 4. DO value for Yamuna River for the year 2019 and 2020

Location	DO (mg/L)	
	Monitoring year 2019	Monitoring year 2020
ITO Bridge	0	2.3
Nizamuddin Bridge	0	2.3
Agra Canal, Okhla Bridge	0	4.8
Agra Canal (Jaitpur)	0	4.2

Fig. 4. Yamuna river covered with foam due to pollution before lockdown (left), Clear water of Yamuna river after lockdown; Photo taken on April 7, 2020 (Source: Planetcustodian.com)
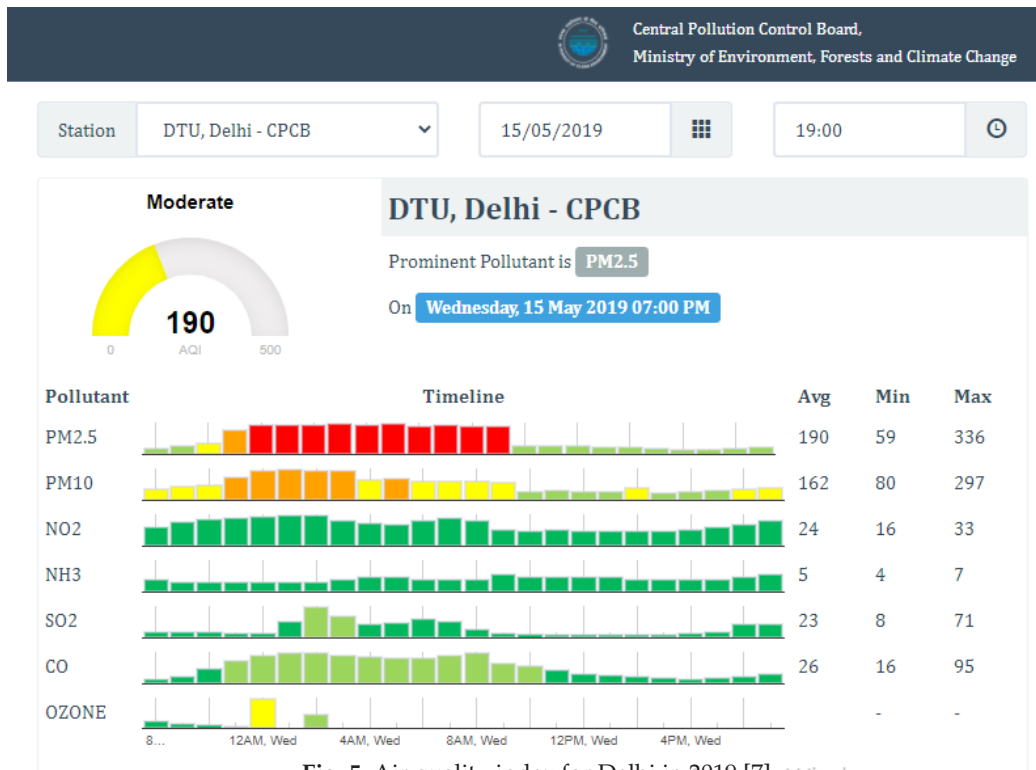
Fig. 5. Air quality index for Delhi in 2019 [7]

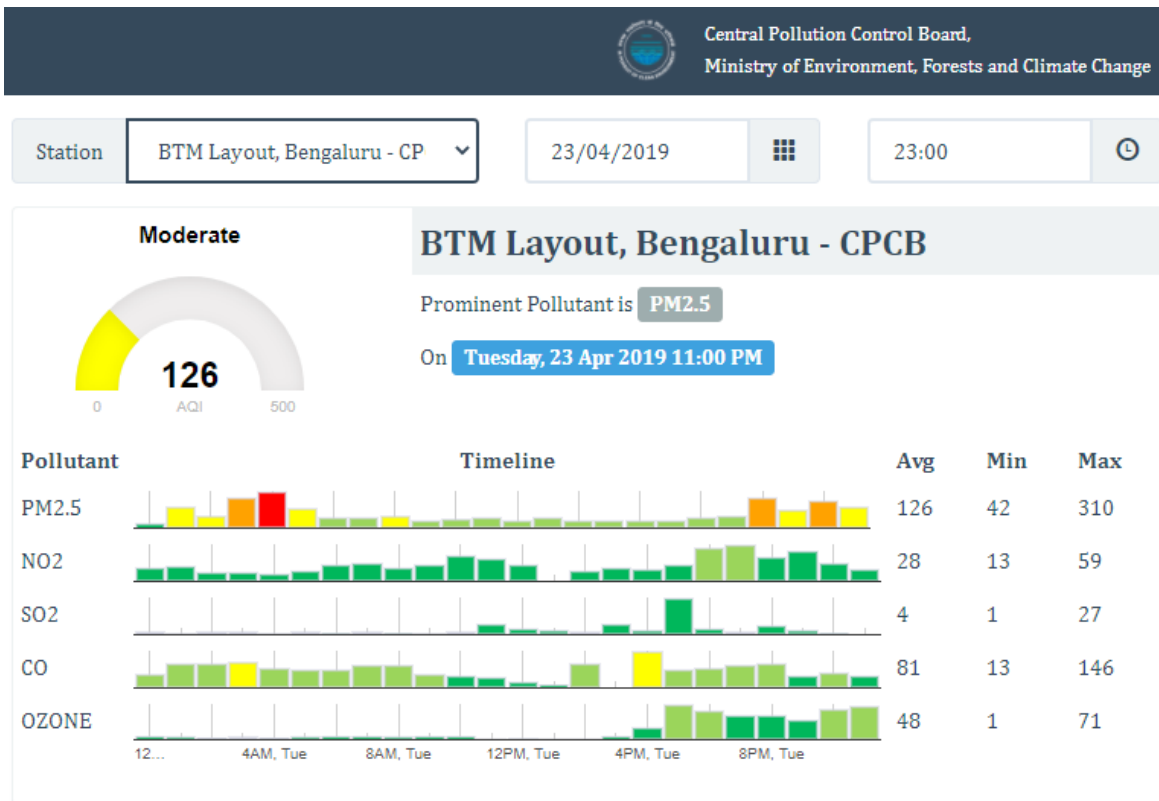**Fig. 6.** Air quality index for Delhi in 2020 [7]

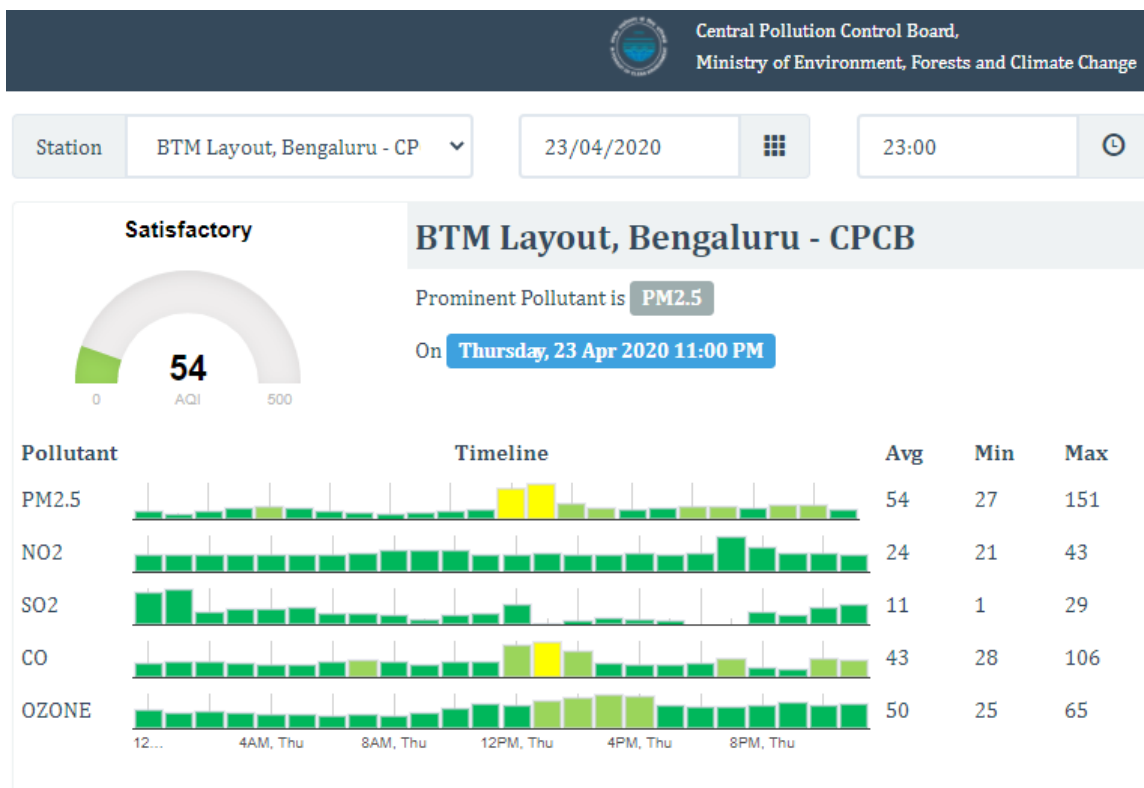Fig. 7. Air quality index for Bengaluru in 2019 [7]

Fig. 8. Air quality index for Bengaluru in 2020 [7]

(Humbal *et al.*, 2019; Kagaya *et al.,* 2020; Muhammad *et al.*, 2020 and Sharma *et al.*, 2020). Persons suffering from cardiac or lung related diseases may require medical assistance due to increase in severity of symptoms. Again, the symptoms also depend on the type of exposure a person is exposed to, its severity of exposure and also the health condition of an individual. The negative impacts of air pollution increase the severity in health condition. During low air pollution a healthy person may show no degradation in health where as a person suffering from pre- existing diseases may show severe health problems. In some cases, it is observed that healthy people those who work outside may face difficulty in breathing in cases when air pollution level becomes very high. The group of people those are prone to face problems due to deterioration of air quality are the persons who are suffering from respiratory problems such as asthma, chronic

obstructive pulmonary disease (COPD), bronchitis and lung cancer. The group of people suffering from heart diseases face similar problem due to increased level of air pollution. People with diabetes are also sensitive to air pollution. People with no such diseases may also cause problems as air pollution may cause the initial source of such diseases. In case of infants and children, air pollution may cause serious health issues as their body remains in tender stage (WHO, 2020; Dutheil *et al.*, 2020; Singhal *et al.*, 2020 and Tosepu *et al.*, 2020). Children playing outdoor games are more susceptible to air pollution, which may cause health hazards.

Effect of Particulate Matter

Various studies have shown that the existence of particulate matter in air causes serious health hazards which are experienced worldwide. Particulate matter mainly causes problems to the
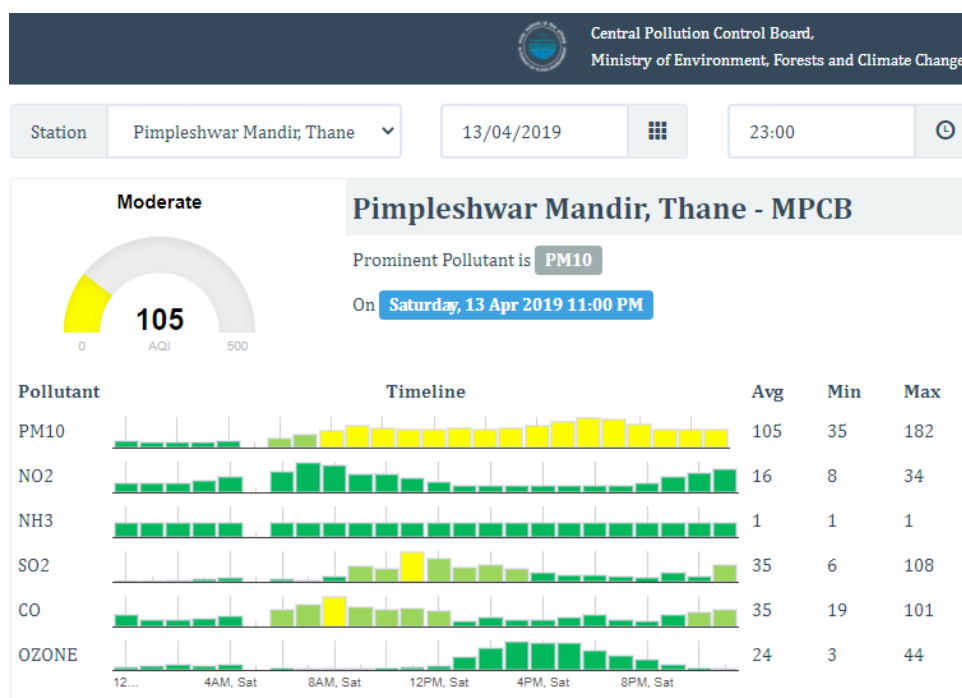

Fig. 9. Air quality index for Thane, Mumbai in 2019 [7]

Table 5. Indian national ambient air quality standards (MoEF Gazette, 2009)

Pollutants (mg/m³)	Time- weighted Average	Concentration of Pollutants in Ambient Air	
		Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area
Ozone (O₃	8 h *	100	100
Carbon Monoxide (CO)	8 h *	02	02
Nitrogen Dioxide (NO₂)	24 h *	80	80
Particulate Matter (size less than 10 μm) (PM₁₀)	24 h *	100	100
Particulate Matter(size less than 2.5 μm) (PM₂.₅)	24 h *	60	60

group of people mainly suffering from respiratory as well as cardiac diseases. The proneness to health problems may vary from person to person depending on immunity, genetics, age etc. The various adverse effects of particulate matter are found by various studies but its range to predict below which it causes no health hazards are not introduced yet. In most of the air quality monitoring stations PM_{10} is used for generating data. PM_{10} denotes the particle mass which enters through the respiratory tract and causes problems in breathing. PM_{10} includes both fine particles as well as coarse particles. The coarse particles are produced mainly due to construction activities or by road dusts etc. (Wang *et al.,* 2020) whereas the fine particles are formed due to combustion activities. The combustion of wood, paddy straw etc. produces large amount of particulate matter of fine size such as $PM_{2.5}$.

Effect of Ozone gas (O_3)

The reaction between Oxides of nitrogen and volatile organic compounds in presence of sunlight produces ozone. Exposure to the high concentration of ozone may cause chronic diseases. The increased level of concentration of ozone is causing severe health hazards. The increase in level of ozone concentration is mainly due to human activity such as deforestation, construction as well as due to hot weather. Person with pre-existing respiratory

problems as well as healthy people, both are susceptible to the adverse impact of ozone. According to evidences obtained from time series the death due to increased level of ozone concentration is found to be 5%-9%.

Effect of Nitrogen Dioxide (NO_2)

Ozone oxidizes NO to produce NO_2. $PM_{2.5}$ which is a major constituent of air pollution is formed by tropospheric ozone and nitrate aerosol which possesses nitrogen dioxide. The existence of nitrogen oxide in air is mainly due to transportation activities, operation of power plant, sewage disposal system etc. The elevated rise in NO_2 concentration in air mainly causes bronchitis symptoms, basically nitrogen dioxide attacks the respiratory systems in human. Persons living in urban area are more prone to health problems created by nitrogen dioxide.

Effect of Sulfur Dioxide (SO_2)

Studies which deal with asthmatic problems have shown that people exposed to a high level of SO_2 in air experiences severe respiratory and pulmonary problems after a period of 10 minutes of exposure. SO_2 possesses fine particle and some other related substances.

Effect of Carbon Monoxide (CO)

Carbon monoxide is a toxic gas, which has no colour and no odour. As it is neither visible nor can be smelled, it is more dangerous and may cause serious
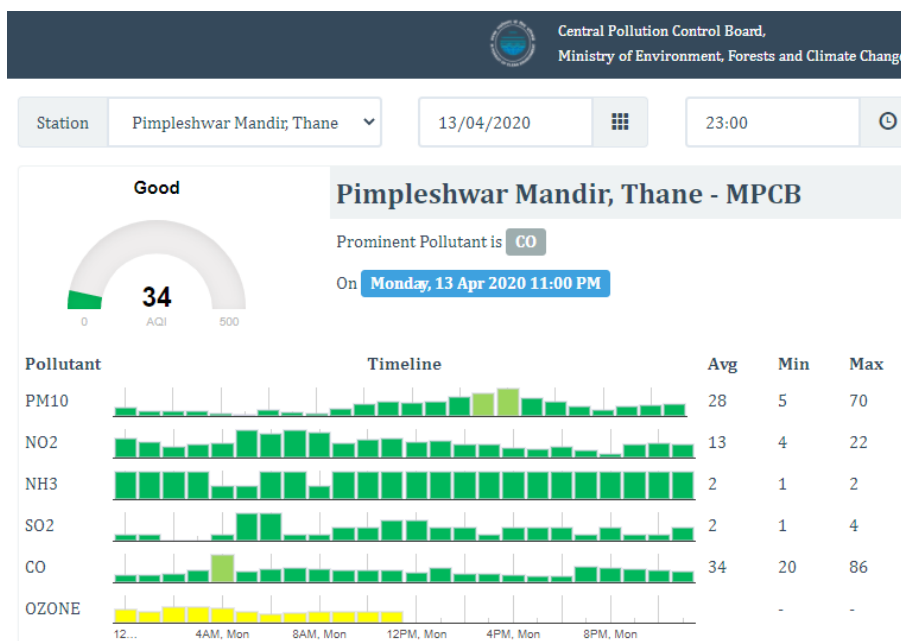

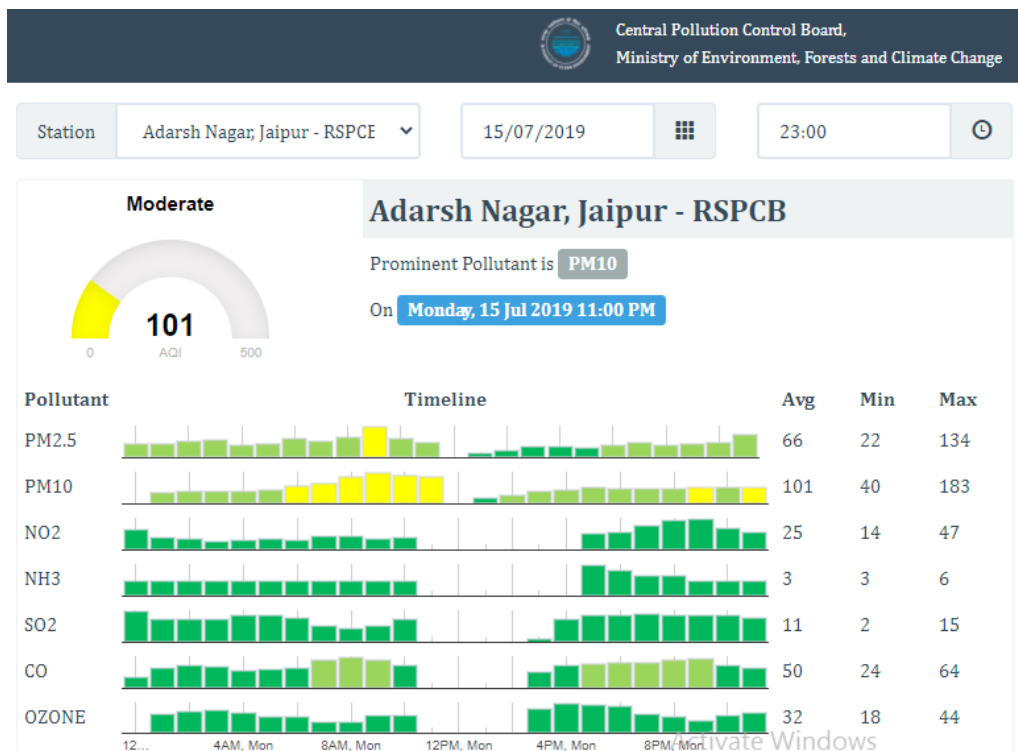**Fig. 10.** Air quality index for Thane, Mumbai in 2020 [7]

Fig. 11. Air quality index for Jaipur, Rajasthan in 2019 [9]
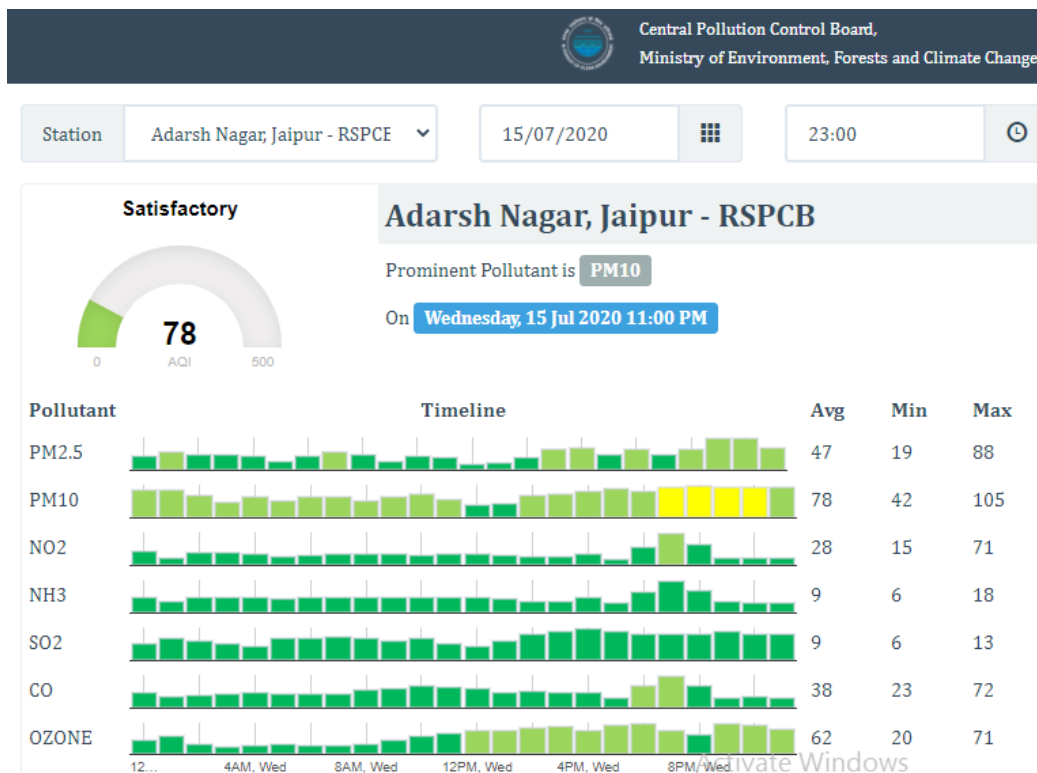

Fig. 12. Air quality index for Jaipur, Rajasthan in 2020 [9]

health hazards. The high level of exposure of carbon monoxide causes problems such as headaches, nausea etc. The effect of carbon monoxide gas may vary person to person depending upon the severity to exposure, immunity of the person etc. Unvented kerosene, leaking furnaces, stoves, generators etc. are the main source of the carbon monoxide production. Lack of oxidation during gas combustion may cause production of CO in indoor air. The gas emitted from bus, truck auto etc. are the main source of carbon monoxide in open air. Health issues such as fatigue, chest pain is observed in case of lower concentration and dizziness, nausea etc. (Holshue *et al.*, 2020) are seen to be caused due to higher concentration. Severe exposure to carbon monoxide may cause death too.

Defining Air Quality Index for India

Central Pollution Control Board (CPCB) of the Indian Ministry of Environment and Forest has set various air quality standards for the reference as well as regulation of urban air quality. The standards are made by particularly taking into consideration the Air (prevention and control of pollution) Act (1981), the Environmental Protection Act (1986) etc. In the official Gazette 2009, revision has been made for the air quality standards by the Ministry of Environment and Forests. The revised Indian National Ambient Air Quality Standards considering the criteria pollutants are shown in the table below. The standards are been made by considering the highest percentage over different averaging period of time (Muhammad *et al.*, 2020). The standards for residential as well as industrial areas are kept same. The standards are made for the easy understanding of the general public about the serious health hazards caused by various pollutants (Susanta *et al.*, 2020). For the awareness of the general public, air quality indices are made from past few years as per the US Environmental Protection Agency (EPA). The air quality index (AQI) is basically used for caution and to make the general public aware of the serious health issued caused by these pollutants. The AQI becomes more when the pollution as well as population increases. The AQI is obtained from monitoring station or a model which gives the concentration of pollutants. AQI is described by ranges and each range has a colour code, such as green colour is used for good AQI. Equation 1 is used for the conversion of concentration of pollutant to an AQI number (US Environmental Protection Agency, 1998).

In the Table 5, 98% of the time the values shall be within the satisfactory range and 2% of the time it may exceed the range but it should not exceed on two consecutive days

To convert from concentration to AQI following function is used worldwide

$$I = \frac{I(high) - I(low)}{C(high) - C(low)}\big(C - C(low)\big) + I(low) \quad ..(1)$$

Where,

I = AQI

C= Concentration of pollutants

C (low) = Breakpoint concentration that is $\leq$ C

C(high) = Breakpoint concentration that is $\geq$ C

I (low) = Index breakpoint corresponding to C(low)

I(high) = Index breakpoint corresponding to C(high).

The AQI concept is used for the studies of pollution level in India. A project sponsored by CPCB, New Delhi, studies has been carried out to find the Indian Air Quality Index (IND-AQI) for pollutants such as sulfur dioxide (24-h avg), nitrogen dioxide (1-h avg), carbon monoxide (24-h avg and 1-h avg), ozone (24-h avg and 1-h avg) and
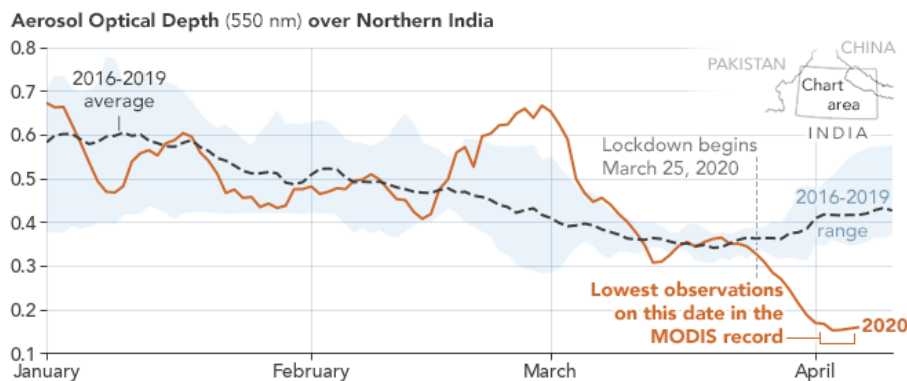

Fig. 13. Aerosol Optical Depth (AOD) over Northern India [8].

PM$_{10}$ (24-h avg). The representation of the average AQI has been done by taking the maximum average of the sub-indices of the various criteria pollutants of a particular location.

Figure 13 describes that, according to data provided by NASA satellites there is a huge fall in the AOD data due to the implementation of lockdown. As per the study, the AOD value is found to be lowest during lockdown when compared with the past 20 years data (Humbal *et al.*, 2019).

CONCLUSION

Though the lockdown due to the outburst of Covid-19 pandemic caused serious problems to the society mainly to the lower income group of people but in a bigger picture the nature has replenished itself naturally from the serious issue of pollution, because fortunately we have given an opportunity to the nature to cleanse itself by this implementation of lockdown. Though the lockdown caused losses in economy of the country but it has improved the sustainability of the environment leading to a better future of the planet. Effect of various air pollutants has been analyzed thoroughly in this study which showed significant desired results for a sustainable environment. In this study, megacities of India like Delhi, Mumbai, Hyderabad and Guwahati (from Northeast) is considered to compare the air quality changes. As per the data obtained from CPCB, Ministry of Environment, Forest and Climate Change, the air quality index data for the year 2019 in for Delhi was 190, whereas it was found to be 160 in the year 2020 for the same. Similarly for Bengaluru the air quality index data was 126 and for the year 2020 it was 54, which is a huge difference in pollution level. Likewise, studies have been carried out for another two cities in India, Mumbai and Jaipur and the results were found to be more satisfactory when compared with the previous year's data. Similarly dissolved oxygen in the Yamuna River was found to have more than the values obtained prior to lockdown. According to data provided by NASA satellites there is a huge fall in the AOD data due to the implementation of lockdown. As per the study, the AOD value is found to be lowest during lockdown when compared with the past 20 years data.

ACKNOWLEDGMENTS

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