Global J. Environ. Sci. Manage. 6(SI): 31-40, Autumn 2020

Global Journal of Environmental Science and Management
(GJESM)

Homepage: https://www.gjesm.net/

SPECIAL ISSUE: COVID-19
ORIGINAL RESEARCH PAPER

The effect of COVID-19 lockdown on the air environment in India

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ARTICLE INFO

Article History:
Received 28 March 2020
Revised 30 April 2020
Accepted 18 May 2020

Keywords:
Air quality index
COVID-19 (Coronavirus)
Environmental lockdown
Lockdown
Emissions

ABSTRACT

COVID-19 is a huge tragedy for the world community. Everything in the world is affected due to this pandemic right from economy to resources where the economy of major countries of the world are facing recession and resources are surplus with no takers at all. The measures to contain COVID-19 pandemic include lockdown, social distancing, isolation, and home quarantine. Lockdown adopted by the different governments which involve non-functioning of all the industry and manufacturing units. However, as a blessing in disguise, these measures have a positive effect on the environment in terms of reduction in toxic gasses like nitrogen dioxide, aerosols, atmosphere ozone, particulate matter, and improvement in air quality. In this paper, the effect on various environmental parameters like aerosol, ozone, particulate matter, nitrogen dioxide, sulfur dioxide, carbon monoxide, and temperature on India by lockdown due to COVID-19 as a preventive measure has been analyzed. The work involves the refining and preprocessing of raw data of this year and last year of various harmful pollutants present in the environment along with satellite images from National Aeronautics and Space Administration for comparison of different parameters. It has been observed that with the above adopted measures temperature has been reduced to near about 15 degree Celsius, there is also reduction in humidity i.e. it is reduced to 40%, particulate matter (PM2.5) reaches near about normal i.e. 40 g/m^3 and carbon monoxide levels has also been reduced to 10 ppm. The main idea is to emphasize the fact that how the environment is self-healing during the lockdown. And this study will be beneficial to environmentalists and industry professionals to make the future strategy for improving the environment.

DOI: 10.22034/GJESM.2019.06.SI.04

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
31	8	0

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Note: Discussion period for this manuscript open until January 1, 2021 on GJESM website at the "Show Article.

INTRODUCTION

Economy, jobs, etc. in the whole world moving through a very disastrous phase due to the spread of novel coronavirus (COVID-19) in the world. It is a very contagious disease that became the reason to declare a global public health emergency by the World Health Organization (WHO); (Wang *et al.*, 2020a). It started in December 2019, when a case of unidentified pneumonia was reported in Wuhan, Hubei Province, People's Republic of China (PRC) (Huang *et al.*, 2020). WHO officially named the disease as COVID-19, Centers for Disease Control (CDC) of PRC named it as a novel coronavirus pneumonia (NCP) as caused by a novel coronavirus (Huang *et al.*, 2020; Tomar and Gupta, 2020; Kuiken *et al*., 2003) and named as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) by the International Committee on Taxonomy of Viruses (ICTV). There is a great challenge for the treatment of the mentioned disease due to its contagious nature, mutations, lack of vaccination, large time taken to be symptomatic and high infectivity and transmissibility (Vellingiri *et al.*, 2020; Ceylan, 2020). In India, COVID-19 was reported on 30th January 2020 (PIB, 2020) and spread to many districts of the country. The total cases reported on 28th April 2020 were 29859 with 7248 recoveries and 942 deaths (COVID-19. 2020). Preventive measures for COVID-19 includes lockdown, social distancing, washing hands frequently, etc. (WHO, 2020; Kumar *et al.*, 2020). Due to the outbreak of COVID-19, the cases are increasing day by day. Statistical analysis and characteristics of hospital medical waste under the novel Coronavirus outbreak. Due to the lockdown, human activities are limited and as a result, it affects the environment in a positive way (Isaifan, 2020; Chakraborty and Maity, 2020). A comprehensive discussion on the effects of COVID-19 is presented in (Tobas, 2020; Wang *et al.*, 2020b). There are 12.4 lakh deaths in India in 2017 due to air pollution and is a leading risk factor for deaths in the country and if pollution level is less than minimum level causing health loss then average life expectancy would have been 1.7 years higher (Balakrishnan, *et al.*, 2019). Half of these deaths in India due to air pollution in 2017 were of those aged less than 70 and as per the National Ambient Air Quality Standards (NAAQS), 77 percent of India's population has been exposed to outdoor air pollution levels above the safe limit (particulate matter PM2.5 above 40 g/m^3). The annual population-weighted mean exposure to ambient particulate matter PM2.5 in India was 89.9 g/m^3 in 2017, with Delhi recording the highest level which is much above normal with major sources as industrial emissions, construction activity, brick kilns, road dust, waste burning, agriculture stubble burning, biomass burning, and diesel generators. These types of pollutants lead to diseases like chronic obstructive lung disease, ischemic heart disease, stroke, diabetes, and lung cancer. India has a high percentage of the diseases associated with these kinds of pollutants which are fatal to humans as well as the environment. The lockdown involves the non-functioning of public transport, industrial units, production units, etc. which leads to the decrease in harmful pollutants fatal to human health and responsible for millions of fatalities every year in the world. In this study, a comprehensive discussion has been presented on the effect of COVID-19 on various environmental parameters. In this study, a comprehensive discussion has been presented on the effect of COVID-19 on various environmental parameters. The study presented in this paper has been organized and discussed as the effect of various pollutants on human health and also the related results and conclusions of the work have been presented. The study has been carried out in 2020.

MATERIAL AND METHODS

The method involves the preprocessing of raw data of this year and the last year of various harmful pollutants present in the environment. Some of the comparisons have been made with the data in picture form available from NASA and other data has been refined or preprocessed for comparison of different parameters. The various kinds of pollutants are fatal to human health as shown in Fig. 1 (Wanner, 1990; Nurul *et al.*, 2014; Myhre *et al*., 2013). The main idea is to emphasize the fact that how the environment is impacted by the lockdown and description of various pollutants harmful to human health and the environment.

Aerosol

Atmospheric aerosols have highly variable size and chemical compositions and are suspended in the form of liquid, solid, or mixed particles. Due to the product of numerous sources and varying formation mechanisms, there is variability in the size and composition of aerosols that are either emitted directly

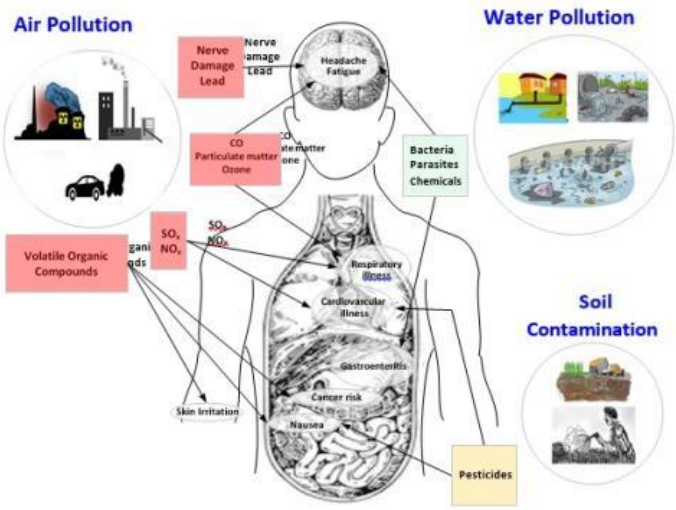


Fig. 1: Effect of various pollutants on human health

to the atmosphere or produced in the atmosphere. The main sources are biomass burning, combustion processes, plant/microbial materials, etc. The health impacts of aerosols include asthma, bronchitis, chronic irritation, inflammation of the respiratory track, etc. (Nature, 2013; NASA, 1996).

Ozone

Ozone can be good or bad depending upon where it is found and occurs both in the Earth's ground level and upper atmosphere (EPA, 2020). The upper atmospheric ozone is called stratospheric ozone and shields us from sun ultraviolet rays by forming a protective layer but partially destroyed by manmade chemicals. However, ground-level ozone is a harmful air pollutant and affects both human health and the environment. It is created by chemical reactions between volatile organic compounds and oxides of nitrogen but not emitted directly into the air. It is produced when pollutants emitted by vehicles, power plants, refineries, chemical plants, chemically react in the presence of sunlight and transported to the long distances by wind and can reach even in rural areas. It can trigger a variety of health issues like throat irritation, chest pain, coughing, airway inflammation, reduce lung function, harm lung tissue, and worsens bronchitis, emphysema, and asthma patients (Nuvolone *et al.,* 2018).

Particulate matter

Particulate matter (PM) is a pollutant consist of a mixture of solid and liquid particles suspended in air and has manmade and natural sources. The main sources of PM are combustion engines, solid-fuel households, and industrial fuels, and other industrial activities like mining, manufacture of cement, building, etc. Also, PM is these are formed in the air through chemical reactions of gaseous pollutants and are the products of atmospheric transformation of nitrogen oxides and sulfur dioxide. PM is disastrous to health and can cause asthma, cardiovascular and respiratory diseases, etc. (WHO, 2013).

Nitrogen dioxide

Nitrogen dioxide (NO_2) is emitted from the combustion of fossil fuels and is a highly reactive pollutant. The main source of NO_2 is traffic pollution and NO_2 is highly lethal for a human exposed to long and short-term exposure. Annually 4.6 million people die worldwide due to the problems associated with NO_2 emissions which may cause cellular inflammation, bronchial hyperresponsiveness, and respiratory problems (Muhammad *et al.,* 2020; Latza *et al.,* 2009). The continuous exposure of NO_2 with as little as 0.1 ppm in the air over a period of one to three years increases the medical issues like bronchitis, emphysema and affects the performance of lungs (Boningari and Smirniotis, 2016).

Sulfur dioxide

The main source of sulfur dioxide (SO_2) is an industrial activity, e.g. thermal power generation, mineral ores, industrial activities that burn fossil fuels, motor vehicle emissions, etc. (Biersteker, 1976; Chen *et al.,* 2012). Health issues caused by SO_2 include cough, shortness of breath, bronchitis, fatigue, etc. and causes the rainwater acidic due to sulphuric acid formation (EPA, 2020).

Carbon monoxide

The main sources of carbon monoxide are vehicles, lanterns, furnaces, grills, gas ranges, water heaters, and clothes dryers, etc. and having high risk when equipment is having poor ventilation and placed in an enclosed area (Atimtay *et al.,* 2000). It is observed that one-third of carbon monoxide-related fatalities occur when the victim is asleep. When inhaled carbon monoxide passes to the bloodstream through the lungs, it attaches to the hemoglobin molecules, and as a result, oxygen can't move on that molecule. If the exposure continues then it will be fatal for vital organs like the brain, heart as blood gradually loses its ability to carry enough oxygen to meet your body's needs (Harvard, 2019).

RESULTS AND DISCUSSION

The effect of lockdown on various environmental parameters has been discussed. First, the major countries of the world have been discussed, and then the parameters related to India. First, the effect of the emission of NO_2 has been discussed. NO_2 is emitted from cars, trucks, thermal power plants, and other industrial facilities and can aggravate respiratory conditions in people with asthma. Its long-term exposure can lead to increase susceptibility to respiratory infections. NO_2 is the main ingredient of summertime smog as it can transform into ground-level ozone. Fig. 2 shows that there is a decrease in NO_2 levels from January 2020 to February 2020 in China due to the closure of business and factories with less vehicles on the road (NASA, 2020). Similar observations have been made in the Northeast United States where there is a drop in 30% of NO_2 emissions as shown in Fig. 3 (NASA, 2020). Thus, there is a considerable decrease in the level of pollution in major economies of the world. Now in the subsequent paragraphs, the situation of various environmental parameters in India has been discussed.

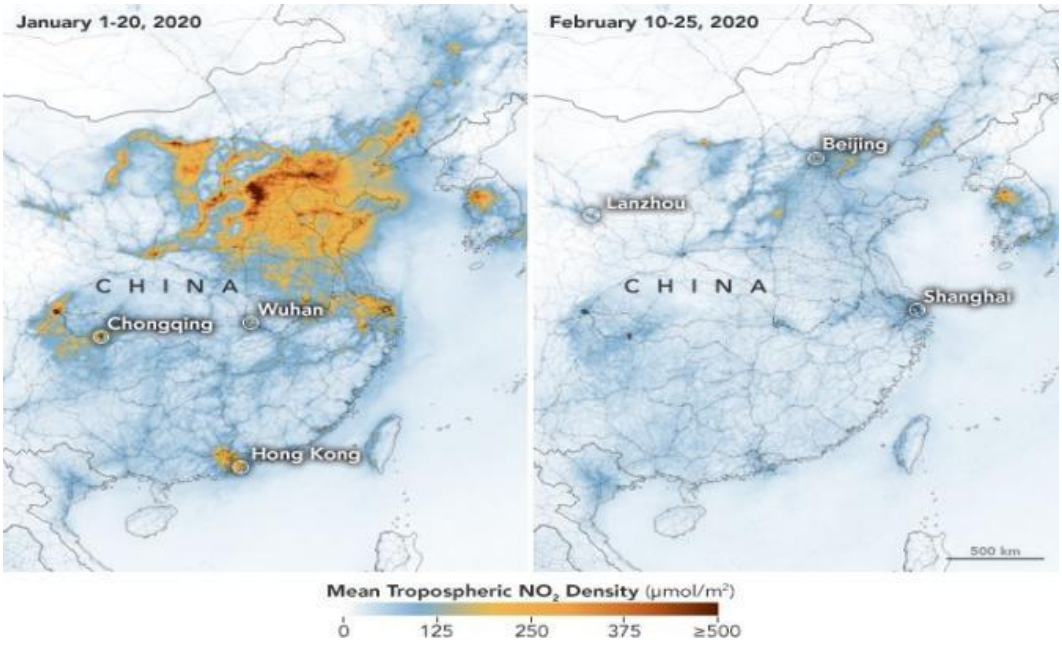


Fig. 2: Mean NO_2 density in China of January 2020 and February 2020 (NASA, 2020)

Effect of lockdown on environment in India

India has a high disease burden and high mortality due to air pollution. A large number of deaths in the whole of India is attributed to the problems associated with air pollution. With the spread of COVID-19 in India, the measure adopted was a lockdown and the whole of the activities in the country comes to halt. In this dressing time, some of the parameters are showing rejuvenation i.e. nature is rejuvenating. The major effect that can be visualized is the reduction in temperature and humidity as compared to 2019, shown in Fig. 4a and b respectively. Since Delhi is one of the most polluted cities in the country, so it is taken as a representative case. From Fig. 4a and b, it is observed that there is a considerable reduction in the temperature and humidity in Delhi after the lockdown i.e. 25th March 2020.

Fig. 5a and b show the NO_2 emissions in Delhi from December 2019 to April 2020. From these figures, it is observed that there is a reduction in NO2 emissions in Delhi due to restrictions on traffic movement and industries. There is also a reduction in Aerosol levels as shown in Figs. 6 and 7. Similar results have been observed in the case of carbon monoxide, sulfur dioxide, ozone, and particulate matter as shown in Fig. 8a, b, c, and d respectively. From Fig. 8a, it has been observed that from the start of the lockdown period, there is a reduction in the quantity of carbon monoxide in the atmosphere as compared to the same time in the previous year.

The same reducing trend is observed in the case of sulfur dioxide as shown in Fig. 8b. Lower atmospheric ozone, which is fatal to health and environment is also reduced during this period as compared to

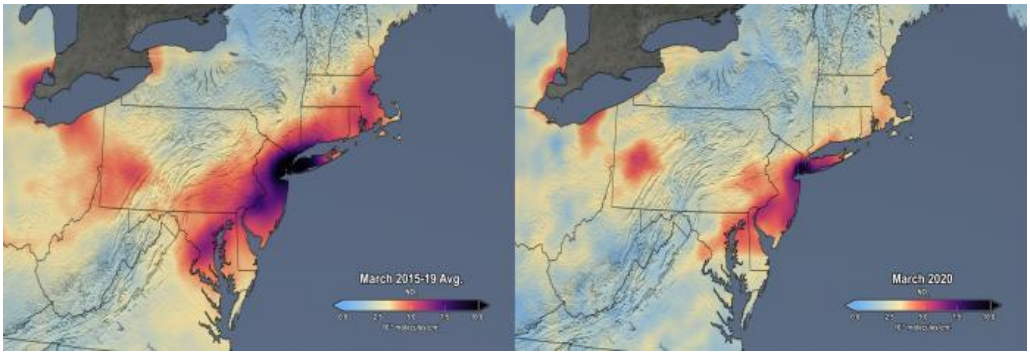


Fig. 3: (a) NO_2 levels in US in March 2015-19 (b) NO_2 levels in US in March 2020 (NASA, 2020)

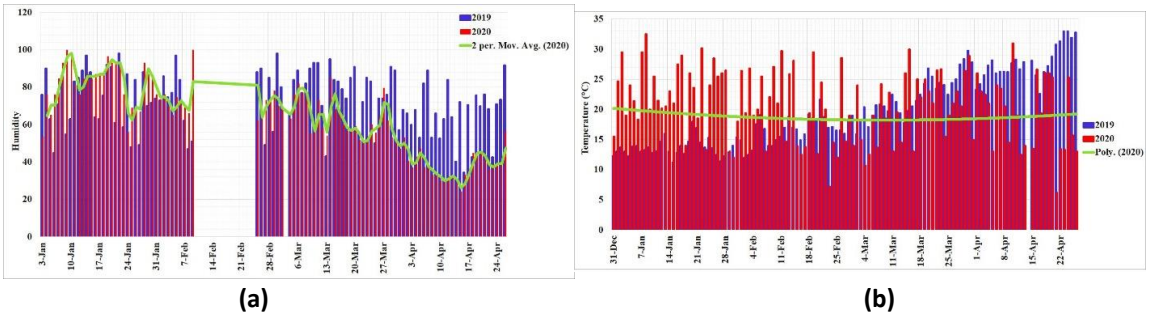
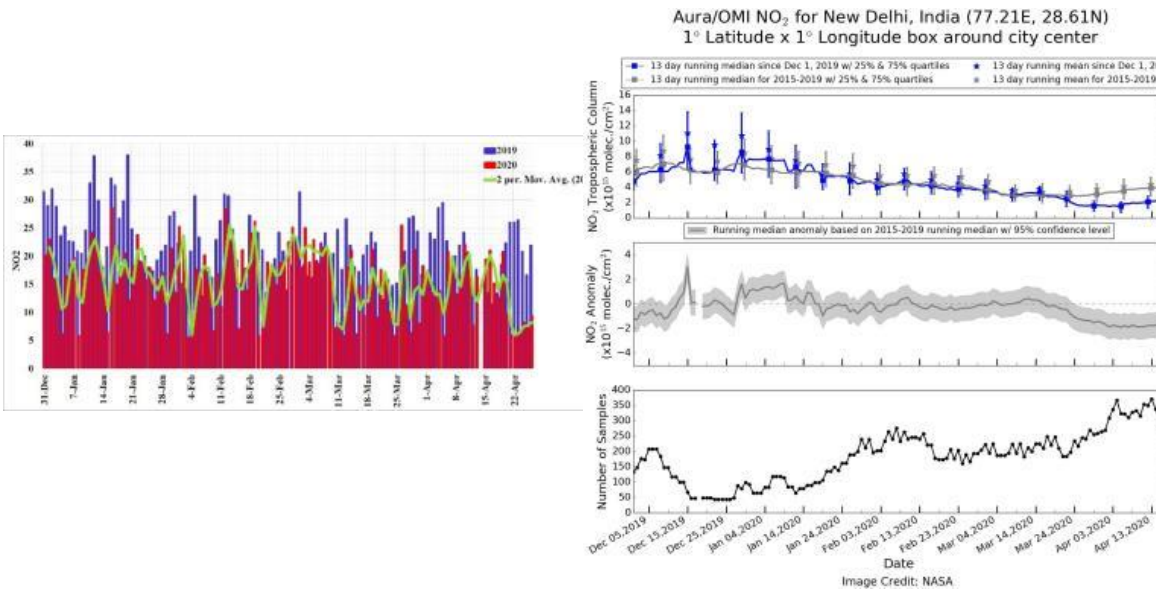


Fig. 4: (a) Humidity in Delhi 2019-2020 (b) Temperature in Delhi 2019-2020 (Platform, 2020)



(a) **(b)**

Fig. 5a: NO_2 levels in Delhi (b) NO_2 levels in Delhi (c) NO_2 levels in Bangalore (d) NO_2 levels in Chennai (NASA, 2020)

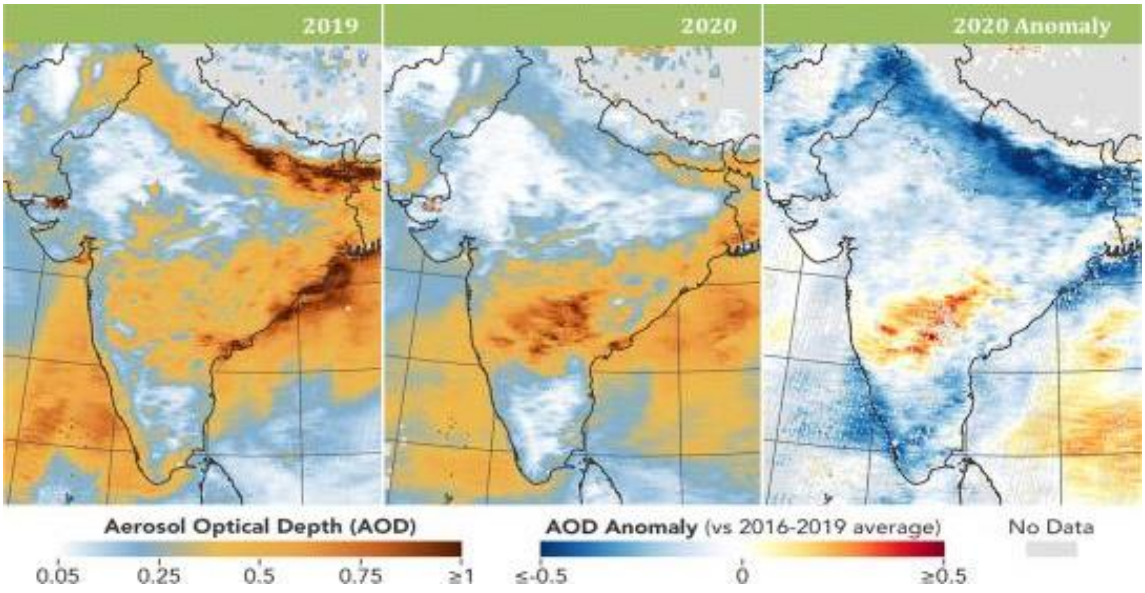


Fig. 6: Aerosols levels over India from 2016 to 2020 (NASA, 2020)

2019 as shown in Fig. 8c and similar decreasing trends are observed in harmful particulate matter during this period, as shown in Fig. 8d. From the above figures and analysis, it has been observed that there is a considerable effect of lockdown on various environmental parameters and consequent decrease in the parameters associated with that. It can be said that in this distressing time, nature is in self-healing mode.

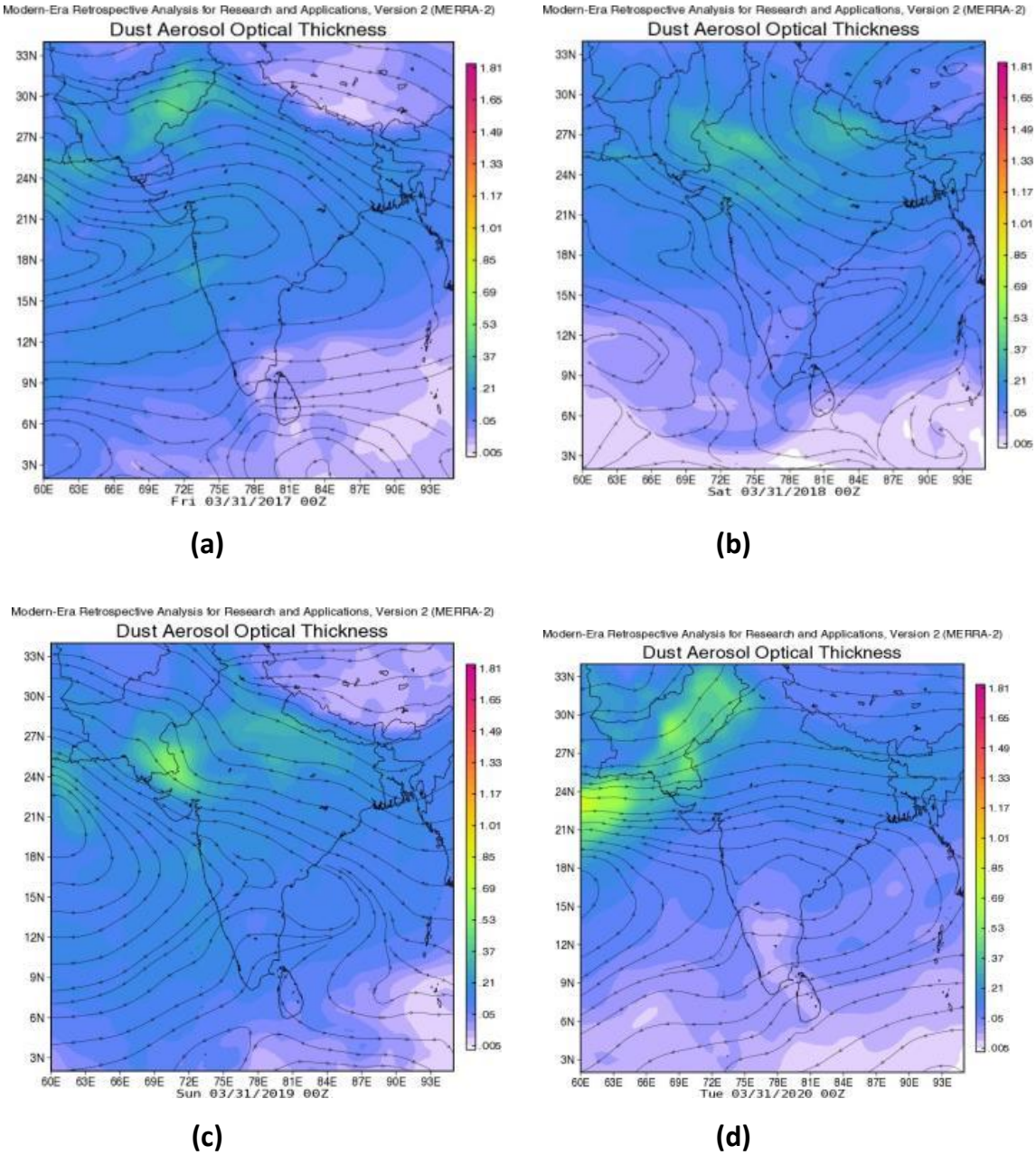


Fig. 7: (a) Dust aerosol optical thickness in India for March 2017 (b) Dust aerosol optical thickness in India for March 2018 (c) Dust aerosol optical thickness in India for March 2019 (d) Dust aerosol optical thickness in India for March 2020 (NASA, 2020)

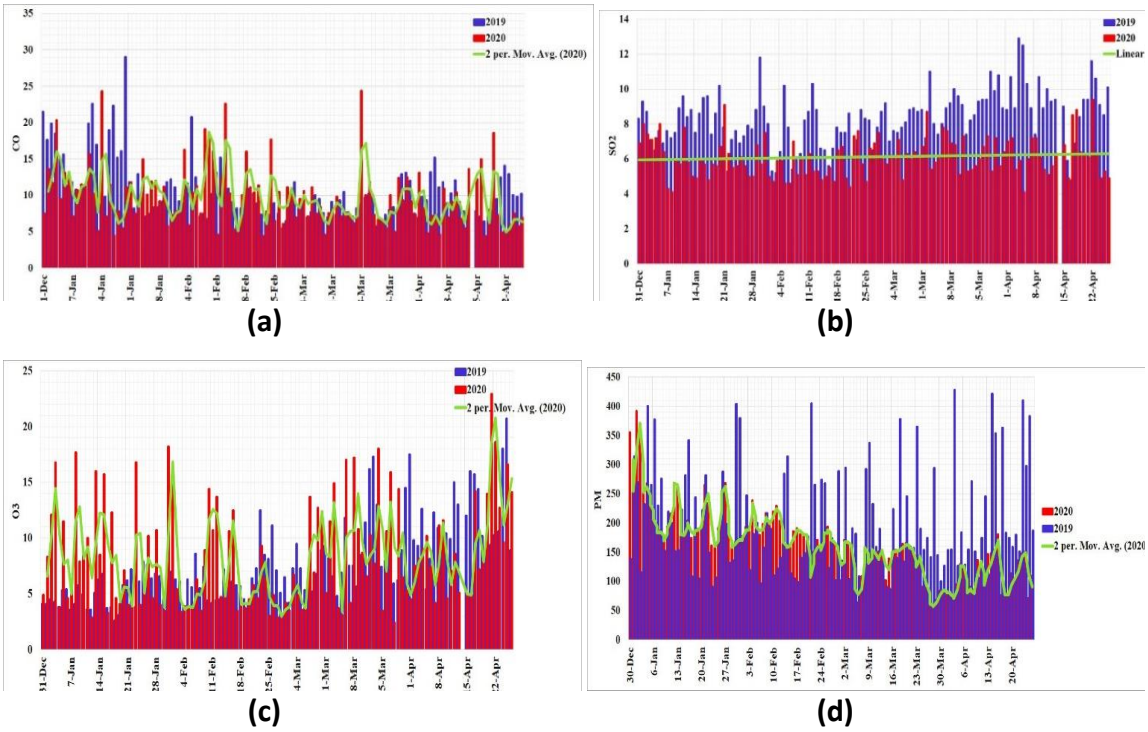


Fig. 8: (a) Carbon monoxide emissions in Delhi 2019-20 (b) Sulhur dioxide emissions in Delhi 2019-20 (c) Ozone emissions in Delhi 2019-20 (d) Particulate Matter in Delhi 2019-20 (Platform, 2020)

CONCLUSION

COVID-19 is a pandemic that affected the whole world and put the lives of millions at risk. It is the unprecedented tragedy that struck the world in a century and with different mutations, contagious, and no vaccination at all. Everything in the world is affected right from economy to resources as the economy of major countries of the world is in recession with large resources and few buyers for that. Millions of people lose their jobs and source of livelihood in this unprecedented tragedy. The measures to contain COVID-19 are to prevent the flow of the virus through humans due to its contagious nature and for that measures adopted are lockdown, social isolation, etc. Lockdown is the non-function of schools, colleges, markets business establishments, factories, public transport. Due to the lockdown, the movement of people is restricted and very few vehicles on the road. However, as a blessing in disguise, there is one thing that is healing and rejuvenating, i.e. nature. Environmental pollution is the major source of ailments and deaths all over the world. A large population of the world dies due to the diseases associated with air pollution. Therefore, in this distressing time nature is in self-healing mode as many of the harmful pollutant in the world are minimum levels. Inthis paper, the effect on environmental parameters due to the lockdown as a preventive for COVID-19 has been analyzed for India. Due to the lockdown, throughout the India, a significant reduction in the emissions like nitrogen dioxide, carbon monoxide, sulfur dioxide, ozone and particulate matter has been observed from the results. In this time, nature is rejuvenating as there is a considerable decrease in harmful pollutants which are fatal to human health and environment. This study is beneficial to the policymakers and environmentalists and medical professionals to analyze and access the effect of various factors on the reduction of pollutants so that future infrastructure and policy can the planned accordingly to accommodate it.

AUTHOR CONTRIBUTIONS

N. Gupta performed the literature review, visualization, manuscript text and manuscript edition. A. Tomar performed the conceptualization, data collection, methodology, data analysis, reviewing and editing the manuscript. V. Kumar performed the literature review and helped in manuscript preparation.

ACKNOWLEDGMENT

The author would like to acknowledge the NASA online publication of air quality data and reports. The authors would also like to acknowledge the efforts made by World's Air Pollution for providing historic data sets and COVID-19 related data. The data in this paper were based on World's Air Pollution COVID-19 datasets.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

ABBREVIATIONS

CDC	Centers for disease control
CO	Carbon monoxide
COVID-19	Coronavirus
ICTV	International committee on taxonomy of viruses
NCP	Novel coronavirus pneumonia
NO_2	Nitrogen dioxide
PM	Particulate matter
PRC	People's Republic of China
SARS-CoV-2	Severe acute respiratory syndrome coronavirus
SO_2	Sulfur dioxide
WHO	World Health Organization

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HOW TO CITE THIS ARTICLE

Gupta, N.; Tomar, A.; Kumar, V., (2020). The effect of COVID-19 lockdown on the air environment in India. Global J. Environ. Sci. Manage., 6(SI): 31-40.

DOI: 10.22034/GJESM.2019.06.SI.04

url: https://www.gjesm.net/article_39821.html