Chapter 7
COVID-19: Disaster or an Opportunity for Environmental Sustainability
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Abstract Our earth is the only planet in our solar system where life is possible due to the ecological balance between atmosphere, lithosphere and hydrosphere. Our earth is inhabited by numerous varieties of plants, animals and micro-organisms besides humans. But human beings are considered as one of the most intelligent living organisms who has been exploiting the nature for his own benefit and disturbing the ecological balance of our ecosystem. Industrialization and globalization although are considered the primers in development of human civilizations but have gradually increased the carbon footprints and have generated many environmental problems like change in climate, extinction of many varieties of flora and fauna, pollution, etc. The development of science and technology has become a part and parcel of our lives today and we cannot sustain without them. The onset of corona pandemic in the world has clearly depicted the harm done by man to the environment. Clear sky, fresh air, calm surroundings, cleaner rivers, reduced waste, repairing of ozone hole, early monsoons, increase in wildlife sightings, undisturbed habitat for marine life, reduction in greenhouse gas emissions and particulate matter, etc., were some of the most visible changes noticed during the lockdown due to coronavirus which acted as an opportunity for repairing our Mother Nature. But COVID-19 pandemic has also brought many problems like unemployment, psychological problems, economic crisis, massive cuts in agriculture and fishery exports levels, generation of recyclable waste, rise in clinical waste, etc. The estimation of deaths due to coronavirus is difficult but according to world health organization (WHO) due to ailments caused by air pollution about 3 million people die each year which is more than the coronavirus toll to date. No doubt that the effects of the lockdown will be short-lived and economic activities resumption will again increase emission levels and it will wipe out all gains. Industries will make up their lost time by increasing production and pollution level will return to its pre-pandemic stage. Governments will face a shortage of resources to invest in clean energy which will increase the use of fossil fuels. So, need of the hour is to maintain improvements achieved due to lockdowns permanently and develop technologies that are eco friendly which can help in environmental sustainability. Some of the methods for environmental sustainability are

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electrification of transport, partial lockdowns in emergency situations, work from home wherever possible, use of clean energies, forests conservation, waste management, etc. No doubt, coronavirus is life threatening disaster but it has given us an opportunity to understand and differentiate between our needs and luxuries at individual levels leading to environmental sustainability at various levels such as community, state and global levels. This outbreak has given us a vision of a better future that we all want to have. COVID-19 has made people realize the harm our earth has been bearing and also the mechanism by which things can be sequenced for attaining the goals of sustainable development.

**Keywords** Coronavirus · Lockdown · Environmental sustainability · Industrialization · Pollution · Clean energy · Sustainable development

### 7.1 Introduction

The word Environmental Sustainability is concerned with the protection and maintenance of resources present in the environment for future generations. In the last century, there has been rapid industrialization which has been depleting our natural resources at a rapid speed and if we continue to consume these resources at the same pace it will difficult that we could preserve these resources for our future. So, it’s the high time we all should realize the importance of ‘Environmental Sustainability’ so that our coming generations are not deprived of the valuable resources. Since the last few decades’ policies are being framed by governments at national, regional and local level in achieving the goals of environmental sustainability before the situation gets worse [29].

With the progress in science and technology, non-renewable sources like fossil fuels are being consumed at a rapid speed leading to its depletion. So, it’s a high time we must shift to renewable sources of energy like solar, wind, hydro and geothermal energy so that we can conserve the non-renewable sources of energy. Besides conserving the resources it is important to conserve the biodiversity, protect ecosystem and control pollution to maintain equilibrium in nature. The major motives of environmental sustainability are briefly represented in Fig. 7.1.

With the onset and spread of COVID-19, the life of every individual on this earth changed beyond recognition and within days. Corona has posed a threat to the life of human beings throughout the world and has gradually caused an economic crisis at many places. But it has also taught the human beings how nature and environment have been adversely affected by human activities. The lockdown imposed in different parts of the world due to which nature had bloomed to its fullest whose impact can be seen directly on the air quality index, water in the rivers, the climate change and liberated wildlife. People learned to stay indoors with minimum resources with the tourism industry coming almost to a halt and affecting the livelihood of many. So, it is important to discuss both the positives and negatives of the corona pandemic so that we can adapt to some good practices and ignore the ones that can pose a
threat to our health. COVID-19 has changed everything in few days and beyond imagination. People are stuck in different places due to lockdowns and it has greatly impacted the economies of different countries. This pandemic has resulted in loss of human lives and governments are trying to prevent the spread of this virus to protect against further death loss. Transportation is shut and most of the trains and flights are being cancelled so that people do not come out without any purpose and to avoid human to human contact during travel [46]. On the other side the natural world has shown signs of improvement due to human absence and coronavirus lockdowns have optimistically impacted our environment. There is an improvement in quality of air, liberated wildlife, etc. [10].

The major source of disaster in the twenty-first century is novel coronavirus and to find out the drugs to prevent and cure is a foremost need of the hour [54]. World Health Organization in March, 2020 declared coronavirus a global pandemic: a disease prevalent in the whole world affecting large number of people. This virus transmits through respiratory droplets and human contact [74]. COVID-19 can be transmitted in a healthy person from an infected person through internal or external body parts such as saliva, cough, sneeze, etc., and also through objects that have virus [50] and when the whole world is without a vaccine for corona the only alternative is to break transmission chain [2]. Globally, as of 24 July 2020, there are 15,296,926 confirmed COVID-19 cases [72] and the same can be seen in Fig. 7.2.

COVID-19 pandemic has been impacting the institutions, businesses, industries and people around the world posing a threat to the economic development of a country and also posing a threat in achieving the UN Sustainable Development Goals (SDGs) [37]. Moreover, lockdown due to COVID-19 has resulted into miserable consequences leaving the world at standstill. But the quality of our environment has bolstered in terms of air quality as air pollution reduced massively during the lockdown, water in the rivers at several places were found much cleaner than past years and wildlife flourished to its fullest with reduced human intervention. The
precautions in form of quarantines during COVID-19 worked as a forerunner and a surprising turnaround in the realm of environmental sustainability [46]. So, it is important to discuss both the pros and cons of the coronavirus to attain the goals of environmental sustainability.

### 7.2 Positive Impact of Coronavirus on Environment

COVID-19 has killed millions of people throughout the world which has forced people to stay indoors [77]. To avoid contamination of the lethal virus among each other many nations of the world had imposed lockdowns. But this lockdown has proved to be a boon for our environment leading to improvement in water and air quality, decreased noise pollution and enriched biodiversity. The environment around us started transforming in palpable ways due to coronavirus lockdowns and the most noticeable effects are clean air, water, a reduced amount of waste, the wildlife that came out of hiding and decreased noise levels [15]. Some of the positive impacts of coronavirus on environment are given below:

#### 7.2.1 Impact on Atmosphere (Air)

Air forms an important part of our biosphere. Life on earth has been made possible due to the presence of air. Our atmosphere is a mixture of several gases like oxygen, carbon dioxide, carbon monoxide, nitrogen and other inert gases whose quantity is fixed. But man, in order to satisfy his needs, has exploited the environment leading to increase in the greenhouse gases causing atmospheric pollution and change in climate. Air pollution has been a source of various respiratory disorders and diseases in human being. Sometimes the severity is so high that it can lead to the death of the
individual. 98% of cities of low-income countries fail to meet air quality standards set by WHO [47]. ‘Cleaner air is one of the goals of environment sustainability’. The air quality is mainly deteriorated due to the presence of aerosols also known as PM$_{2.5}$ which leads to cardiovascular and pulmonary diseases [11].

**Impact and Reasons for Improvement in Quality of Air**

The modifiable sources of air pollution can be modulated either by changing the source intensity or activity levels such as electricity generation, traffic and cooking. Regulations in respect of air pollution targets typically on factors that can reduce emissions rather than on the activities that can be altered. The closures observed in industries, factories, decrease in traffic on roads and other modifiable factors due to COVID-19 provided a new opportunity to quantify and observe the impact in real time situation [67]. In India, the lockdown was imposed from 24 March to 14 April 2020 due to which air pollution decreased significantly within few days [40]. Industries like textile, pharmaceuticals, leather and electronics along with high population index make Mumbai and Delhi as the cities which are most polluted in the world. Almost all places of public gathering such as shopping complexes, schools, cinemas, educational institutions, restaurants were closed, industrial and manufacturing units shut, transportation and travelling services by air, road and rail were stopped and people were asked to work from home during nationwide lockdown affecting the economy negatively [35].

As industrial activities were closed, flights and other modes of transport restricted, there was decrease in air pollution and emission of gases causing greenhouse effect. There was decrease in carbon in atmosphere basically due to lessening in fossil fuel burning emissions. Decrease in levels of nitrogen dioxide (NO$_2$) by 40% was found in cities of Asia and Europe as compared to same period in 2019, 30% in New York and 60% in UK. Delhi has witnessed a reduction of over 70% in PM$_{2.5}$ levels while US has witnessed a 33, 22 and 19% drop in PM$_{2.5}$ concentrations in Los Angeles, New York and Seattle, respectively, during lockdown in the month of March–April, 2020 [34]. The major source of nitrogen dioxide is road transport and power plants which were almost shut due to coronavirus. Another reason for improvement in air quality was the reduction in human activities [15]. There was also reduction in particulate matter (PM) or aerosol levels after the COVID-19 lockdown. Also reduction in waste and crop residue burning was found which improved the air quality. Factories, markets, shops and places of worship closure, public transport and construction work suspension have improved the air quality [53]. The air traffic dropped by 60% globally which has lead to reduction in greenhouse gas emissions which has a great impact on today’s climate change [27]. The improvement in air quality index (AQI) across India is given in Table 7.1 [7].

Air pollution was reduced in Bangkok due to lockdown otherwise schools were forced to close down few months back due to air pollution [45]. Some indirect benefits were also seen due to improvement in the quality of air because of coronavirus and lockdowns. Gradual repair of the ozone hole was also noticed because of reduction in greenhouse gases and particulate matter in the upper atmosphere due to lessening of air traffic. Upcoming monsoons were also impacted by lockdown [15]. It has
Table 7.1  Comparison of air quality index as of 15 April 2019 and 15 April 2020 in cities of India [7]

| S. No. | Name of the city | April 15/year | Air quality | Index value | Prominent pollutant |
|--------|------------------|---------------|-------------|-------------|---------------------|
| 1      | Delhi            | 2019          | Poor        | 250         | PM10, PM2.5         |
|        |                  | 2020          | Moderate    | 138         | O3                  |
| 2      | Agra             | 2019          | Moderate    | 200         | PM2.5               |
|        |                  | 2020          | Satisfactory| 95          | PM2.5               |
| 3      | Bengaluru        | 2019          | Moderate    | 113         | PM2.5, PM10         |
|        |                  | 2020          | Good        | 50          | O3, PM10, CO        |
| 4      | Faridabad        | 2019          | Poor        | 242         | PM2.5               |
|        |                  | 2020          | Moderate    | 169         | O3, PM10            |

been opined that virus can bond with pollution particles due to which virus can remain longer in the air. So, cleaner air can aid in flattening the coronavirus curve reducing the burden on the health care [34]. There was increase in visibility as a result of clean air due to lockdowns. Some of the reports of improved visibility have been reported such as people of North India were able to see Dhauladhar Mountain range after 30 years which were not visible to them due to air pollution [10]. Due to coronavirus, companies are allowing employees to work from home which has resulted into decline in vehicles on roads [45].

There was decrease in surface temperature by 3–5 °C at the middle catchment of Dwarka river basin of Eastern India due to stoppage of activities such as stone crushing due to lockdown [41]. The positive effect of lockdown on air quality has been reported in some online studies during 2020.

Review of Studies Comparing the Quality of Air during Pre-COVID and Post-COVID

Tanzer-Gruener, Robinson and Presto, 2020 in their study at urban and suburban Pittsburgh found that concentrations of carbon monoxide and nitrogen dioxide during March 2019 and March 2020 reduced by 57 and 43% [67]. Mahato et al. (2020) studied the air quality data in Delhi and found that air quality improved significantly during lockdown, PM$_{10}$ and PM$_{2.5}$ concentration reduced by more than 50%, nitrogen dioxide by 52.68% and carbon monoxide by 30.35% during lockdown phase. Thus, if the pollution source is attenuated the environment can heal itself in a suitable time period [40]. Kumari and Toshniwal (2020) investigation on three indian cities of Mumbai, Delhi and Singrauli located in western, northern and eastern part on the air quality during lockdown from the period 1 March 2020 to 15 April 2020 analysed the concentration of key air pollutants such as PM 2.5, PM 10, sulphur dioxide and nitrogen dioxide during pre and post lockdown phases from the data obtained from Central Pollution Control Board (CPCB) online portal concluded that air quality can be improved significantly if we strictly execute the pollution control plans as the concentration of pollutants reduced alarmingly during lockdown phase [35]. He et al. (2020) stated that lockdown in China imposed in one-third of their cities by
restricting economic activities and personal mobility during COVID-19 improved the air quality remarkably and brought down the PM 2.5 concentration by 25% which is capable of averting premature deaths due to air pollution [28]. Marlier et al. (2020) in their study quantified the changes in the concentration of air pollution in China for the month January and February of 2019 and 2020. There was a reduction of 48% in PM$_{2.5}$ concentrations, 11% in sulphur dioxide and 49% in nitrogen dioxide during a 3 week period after the Lunar New Year (LNY) in 2020 compared to 2019 which was mainly due to measures taken for quarantine and decrease in transportation, industrial pollution and economic activity during COVID-19 [42]. Cadotte (2020) compared air quality of February 2019 and 2020 in six cities Shanghai, Wuhan, Milan, Hong Kong, Seoul and Kyoto where restrictions were imposed due to COVID-19 and found decline in major air pollutants indicating that air quality can be improved through change in policy by the government [6]. Almond et al. (2020) in their study concluded that COVID-19 had indefinite impacts on pollution in China. The improvement in air quality was much less than that expected near the epicentre of the pandemic, i.e. province of Hubei but the concentration of ozone increased in both absolute and relative terms [1]. Kuzemko et al. (2020) found that the emission level recorded in April, 2020 was as low as 10 years ago with Carbon dioxide emissions showing reduction of 17% in April 2020 as compared to April 2019, due to reduction in transport [36]. Connerton et al. (2020) studied the air pollution effects caused due to social distancing and quarantine policies in four megacities: Paris in France, New York and Los Angeles in the United States, Sao Paulo in Brazil by analysing the levels of air pollutants such as O$_3$, CO, NO$_2$ and PM$_{2.5}$ during 2015–2019 and for the month of March 2020 and found that statistically significant reduction in their levels. This is beneficial for cleaning the air and decreasing the deaths caused by COVID-19 epidemic by reducing pressure on health equipment and hospitals [12]. Bekbulut et al. (2020) found that particulate matter levels are 3% higher and ozone levels are lowered by 4% than expected after 6 weeks of passing of orders for stay at home. Further nitrogen dioxide is associated with traffic and showed 30% lower concentration during post-COVID [5]. Chen et al. (2020) in their study across United States found non-uniform reductions of carbon monoxide (CO) up to 37% and nitrogen dioxide (NO$_2$) by 49% during the early phase of lockdown (15 March–25 April 2020) in comparison to a pre-lockdown mainly due to decrease in transportation, potentially benefiting the health of the public [9]. Rodríguez-Urrugo and Rodríguez-Urrugo (2020) in their study on 50 capital cities which are most polluted in the world according to the WHO found that particulate matter PM$_{2.5}$ decreased by an average of 12% measured before and after the quarantine period [55]. Saadat, Rawtani and Hussain (2020) stated that COVID-19 pandemic caused the drop in water pollution and improvement in air quality in some parts of the world mainly due to change in the life style of the people and shutting down of businesses in order to control the virus [57]. Tracker (2020) stated that emissions reductions will not be sustained unless recovery packages are implemented by the government to enable low carbon societies and economies [70]. Shrestha et al. (2020) investigated the six air pollutants between February, March 2019 and 2020 in 40 cities and found PM$_{10}$ and PM$_{2.5}$ levels lower than in 2019 for the month of February and March 2020.
in many cities. The air quality improved after lockdown in Delhi, Bangalore, Beijing including major trade centres of the world at Paris, Sydney, Tokyo, Seoul, London and New York but once the situation is back to normal the level is likely to rise again [63]. Shakil et al. (2020) in their critically analysed 57 studies published in nine journals for the month of May 2020 concluded air pollution reduced significantly because of lockdown [61]. Sarfraz, Shehzad and Shah (2020) in their study from January 2020 to April 2020 in India studied the usefulness of COVID-19 on air pollution by the execution of data from CPCB online portal and European Space Agency (ESA) and found improvement in air quality in India with a substantial decrease in Nitrogen Dioxide (40–50%) in Mumbai and Delhi as compared to last year [58]. Masum and Pal (2020) in their study on Chittagong city in Bangladesh found that except NO2, all other pollutants PM_{10}, PM_{2.5}, NO2, SO2 and CO showed statistically significant decreasing trend due to lockdown [43]. Kanniah et al. (2020) illustrated in their study that due to shut down of industrial and anthropogenic activities, aerosol optical depth (AOD) over sea decreased notably by 27–30% in the troposphere along with reductions in other air pollutants in Malaysia [33].

**Review of Studies linked with Air Pollution and Morality during COVID-19**

Wu et al. (2020) studied the increasing danger of COVID-19 deaths in United States by studying factors such as population density and size, age distribution, behavioural and socio-economic variables of smoking and obesity and concluded that during coronavirus increase of only 1 µg/m³ in PM_{2.5} leads to 8% rise in the death rate [75]. Conticini et al. (2020) stated that the high level of pollution is an important co-factor for the high level of deaths in Northern Italy due to COVID-19 [13]. Frontera, et al. (2020) analysed the association between COVID-19 outbreak and air pollutants with the number of patients, rate of transmission and death number in Italian regions. The most polluted regions required ICU admission due to more severe form of COVID-19 along with the highest number of people showing morality in comparison to other regions as the virus can remain viable for some hours in aerosol [23]. Isphording and Pestel (2020) studied the severity of spreading of COVID-19 in Germany with air pollution and found positive effects of PM_{10} concentration and air pollution on the death in elderly patients due to COVID-19 [32]. Tian et al. (2020) stated that long-term exposure to PM_{2.5} is directly linked with COVID-19 mortality [69]. Najmi et al. (2020) in their study compared the air quality status in Marrakech and Casablanca, two large cities from Morocco during the lockdown and before the pandemic and found drop in air pollutants benefitting the health of the humans and reducing the rate of morality [48].

Thus, COVID-19 pandemic has proved to be a *‘blessing in disguise’* which can help earth to revive and improve air quality [35] which has been supported by many research studies conducted in different parts of the world [1, 5, 6, 9, 12, 13, 23, 28, 32, 33, 35, 36, 42, 43, 48, 55, 57, 58, 61, 63, 69, 75]. Further it has been found that places where the air pollution was high, deaths rate due to COVID-19 also enhanced [13, 23, 32, 48, 69, 75]. In India, the concentration of sulphur dioxide between April 2019 and April 2020 decreased by around 40% [19] as shown in Fig. 7.3, the data obtained from ESA, Copernicus Sentinel 5-P Satellite.
The darker shades of red and purple indicate greater concentrations of sulphur dioxide in the atmosphere, while the black dots indicate the locations of the large, coal-fired power plants. Notably over New Delhi compared to the previous year, sulphur dioxide concentrations have dropped significantly.

Delhi and Mumbai saw a drop of 40–50% in nitrogen dioxide concentration in comparison to the same time of last year, i.e. 25 March–20 April 2019 and 25 March–20 April 2020 as shown in Fig. 7.4 [20].

Like India, there was a drastic decrease in the concentration of air pollutants in European countries specifically in cities of Paris, Madrid, and Milan as shown in Fig. 7.5 from the images obtained from ESA, Copernicus Sentinel 5-P Satellite [21].

The concentration of air pollutants though was found to decrease during lockdown but gradually will increase during the unlock period. The risk of COVID-19 infection is found to increase with air pollution, therefore the use of alcohol-based sterilizers and masks have been strongly suggested. The master plan must be adapted by international and national bodies during post lockdown to revive the Mother Nature. Many times ecological disturbances on the planet such as endemic and pandemic are created by the human activities for which man has to repent [75].
7.2.2 Impact on Hydrosphere [Water]

Hydrosphere constitutes the total amount of water on our planet earth. Water is an essential part of our lives and no living organism on this earth can imagine its life without water. But gradually man for his desires has exploited and polluted water to such an extent that it has made other species of plants and animals endangered and time is not far away when we could read about these organisms in books only. The corona lockdown has given an insight into human beings to realize the amount of harm it has done to the environment. The coronavirus has shown some positive impact on the quality of water of different water resources. The quality of river water has improved due to decreased effluents released in the rivers. In river water total dissolved solids (TDS) level reduced by two times [41]. The water of River Ganga is fit for consumption after certain treatment [45]. There are also reports of clearer water of River Ganga in Uttar Pradesh due to shut down of industries due to coronavirus. Fishes were seen near the Varanasi Ghat step which is not a common sight due to fewer crowds. The water of Yamuna River has also appeared clearer due to absence of toxic foam formed due to detergents, chemicals and sewerage of industries. The decrease in religious activities and lesser cremations can also be one of the reasons. The reduced tourism and the reduced number of motorboats have led to cleaner waterways [18]. In Venice, waterways are benefitted due to lack of boat traffic as visit of tourists to this place has been reduced due to lockdown. Lack of
boats means lack of churning of muddy floors of canal [34]. This has improved the clarity of the water which in turn provided a clear view of marine animals like fish, crabs, etc. [10]. Various studies that have reported the improvement in quality of water due to COVID-19 lockdown are discussed below:

**Review of Studies Comparing the Quality of Water during Pre-COVID and Post-COVID.**

Lokhandwala and Gautam (2020) stated that lockdown declared due to COVID-19 in India has improved the quality of air, environment and water with rivers showing a positive sign towards restoration [39]. Yunus et al. (2020) illustrated that it was for the first time in modern history that the activity of people, movement of vehicles and industries were all halted due to a pandemic. In the last two decades the increased anthropogenic and industrial activity has polluted the biosphere, atmosphere and hydrosphere and with the shut down imposed our environment has definitely shown improvement. By using remote sensing images, quantitatively improvement was seen in the longest freshwater lake known as Vembanad Lake in India in terms of suspended particulate matter (SPM) which decreased by 15.9% on average in surface

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**Fig. 7.5** Nitrogen dioxide concentration over France and Italy during March 2019 and March 2020. Source https://www.esa.int/ESA_Multimedia/Images/2020/03/Nitrogen_dioxide_concentrations_over_France & https://www.esa.int/ESA_Multimedia/Images/2020/03/Nitrogen_dioxide_concentrations_over_Italy. Copyright contains modified Copernicus Sentinel data (2019–20), processed by KNMI/ESA
Patel, Mondal and Ghosh (2020) stated that despite of various plans for restoration, the River Yamuna in Delhi as one of the dirtiest rivers in India due to unabated rise in pollution. Lockdown imposed due to COVID-19 pandemic nationally provided a ray of hope. The impact on water quality of Yamuna was analysed using a satellite images and combination of measurable parameters. There was an improvement of 37% during the lockdown in Class C Water Quality Index estimates of nine stations. Similarly Chemical Oxygen Demand and BOD values were reduced by 39.25 and 42.83% and Faecal coliform decreased by over 40% in comparison to the pre-lockdown phase. Further 20 major drains were analysed and depicted reduced contaminant and effluent loads. Thus, if polluting actions and contaminants that are deleterious are regulated appropriately it is possible that our rivers can recover with better water quality [52]. Garg et al. (2020) affirmed that the quality of water in Ganga has improved during vide country-wide lockdown and this change was studied through Sentinel-2 multispectral remote sensing data in terms of turbidity at Varanasi, Haridwar, Prayagraj and Kanpur and observed that at each stretch of the river the turbidity in the river has reduced drastically [24]. Dhar et al. (2020) in their analysis on dissolved oxygen (DO) along the stretch of River Ganga in 6 sites during 2nd, 9th, 16th and 23rd April 2020 (COVID-19 lockdown period) in comparison to the data of 2015–2019 saw a decrease in dissolved oxygen (DO) providing congenial environment for flourishing of aquatic biodiversity and improving the water quality during lockdown [16]. Dutta et al. (2020) stated that due to the eight week nationwide lockdown in India rejuvenation of Ganga River has taken place due to negligible discharge of industrial waste and agricultural runoff. Further 60% excess rainfall than the normal was observed in the Ganga basin diluting the pollutants with 82.83% more than the average water storage in past ten years, reduction in Total coliform and nitrate (NO₃⁻) concentration, Faecal coliform and biological oxygen demand (BOD) and an increase in dissolved oxygen (DO) [17]. Selvam et al. (2020) conducted the study on 22 groundwater samples from the coastal industrial city of Tuticorin in Southern India to describe the biological and chemical changes of water by taking samples before 10 and 11 February 2020 and during the lockdown (19 and 20th April 2020) and found significant reductions in metals due to decrease in wastewater discharge from thermal power plants, metal-based industries and seafood-based industries and also reduction in faecal coliforms, total coliform and NO₃ due to decrease in organic sewage from the fishing industries and conclude that by seizing of anthropogenic activities groundwater can quickly revive [59]. Chakraborty et al. (2020) in their study on three station of lower Gangetic delta region found that there was a significant increase in the dissolved oxygen (DO) during COVID-19 lockdown in comparison to the level of dissolved oxygen of the last thirty years (1984–2019) [8]. Arif, Kumar and Parveen (2020) confirmed a highly positive change in nature’s behaviour during lockdown period due to Corona pandemic giving an opportunity for earth’s hydrosphere, atmosphere and biosphere to rejuvenate and studied the water quality of Yamuna River in Delhi one of the most polluted river of India and found a very impressive recovery in lockdown [2].
Thus, various studies have proved that the quality of the water in rivers, underground water has improved due to lockdown which has made the aquatic life to flourish to its fullest due to increase in dissolved oxygen [8, 16, 17, 21, 24, 52, 59, 76].

7.2.3 Impact on Nature and Wildlife

The coronavirus has made people to stay indoors and animals are encouraged to move freely due to the empty parking lots, quiet streets and parks. There is news from all over the world regarding the returning of many species to their natural habitats [18]. There were reports of liberated wildlife too [10]. A Nilgai was seen walking on the road in Noida (UP) and in Kerala’s Kozhikode, a Malabar civet, was seen which is an endangered animal [18]. Herd of marauding goats were seen in Welsh seaside, deers were seen roaming in Japanese city, boars were seen in Barcelona city, Spain, wild puma was found in city of Santiago, Chile, orcas whale was seen in parts of a Vancouver fjord in North America [10]. The lockdowns have also resulted in undisturbed habitats for marine life. The environment due to lockdown has also favoured situation for olive ridley turtles to lay eggs in Odisha’s Gahirmatha beach and Rushikulya’s rookery [18].

There are increased moles clambering sightings over ground near footpaths that are well-walked and many rare birds in Britain. Wild flowers are blooming in large number due to reduction in mowing. It is indirectly beneficial for wild plants, bees, birds, bats, butterflies, bugs as they are dependent upon them [10]. This pandemic is allowing animals to thrive even amidst the margins of urbanized existence [18].

Similar findings have also been reported in some online studies which are discussed below:

Review of Studies Related to Nature and COVID-19

Newsome (2020) studied the effect of COVID-19 on tourism industry globally and in wildlife destinations by using online resources and found that there is a loss of 75 billion jobs in hospitality industry and general tourism due to shutdown. But still the environment has got time to recover and the impact is positive due to economic, social and environmental sustainability [49]. Rutz et al. (2020) illustrated that in urban environments nature appears to have changed due to the lockdown imposed due to COVID-19 with many people reporting dolphins in the harbour of Trieste, Italy, pumas in downtown Santiago, Chile and jackals in broad daylight in urban parks in Tel Aviv, Israel mainly due to decrease in the level of noise pollution and traffic on the roads and in oceans [56]. Garlick (2020) since the start of lockdown the herds of goats roaming around Llandudno, Wales, water in Venetian canals is running clear, arrival of red kite at Meltham Wildlife Reserve in Holmfirth, West Yorkshire [25]. Ioannides and Gyimothy (2020) stated that COVID-19 offers private, public and academic people a unique opportunity to design and consolidate the transition towards a more balanced and greener tourism [30]. Freire-González and Vivanco (2020) have shifted the mobility behaviour and enhanced implementation of technologies such as ICT.
which has a potential to reduce the burden on the environment and triggering rebound effects [22]. Corlett et al. (2020) concluded that biodiversity is benefitting from reduced human activities [14]. Lokhandwala and Gautam (2020) illustrated that there has been a dramatic decrease in road traffic, tourism and industrial activity worldwide due to spread of COVID-19 which has acted as a blessing for the environment and nature as during the lockdowns imposed to prevent the spread of pandemic water in rivers and air quality has improved and wildlife is fully blooming [39]. McElwee et al. (2020) stated that COVID-19 pandemic put forward the measures for nature and biodiversity conservation and wildlife trade bans. The economic activities should be shifted away that may cause undue harm to ecosystems and biodiversity [44]. Kanniah et al. (2020) illustrated that enforced lockdown was imposed in Malaysia and other Asian countries in order to control the spread of the disease which effected the natural environment positively [33]. Somani et al. (2020) illustrated the positive effect of COVID-19 on the environment by reducing anthropogenic activity [65]. Arora et al. (2020) stated that the corona pandemic was an advantage for nature as shutting off of urban, industrial, social and economical activity has shown improvement in air quality, water in rivers, decreased levels of noise pollution with calm and undisturbed wildlife. Thus, although corona vaccine is not currently available but we humans have acted as a virus for our environment and coronavirus a vaccine [3]. Ghosh et al. (2020) in their study on megacities of Chennai, Kolkata, Delhi and Mumbai stated that the COVID-19 outbreak has helped our environment to regain its health globally and improve for a short span of time minimizing the degradation of environment [26]. Shaikh et al. (2020) stated that almost 0.3 billion–0.7 billion trees have been prevented from cutting due to the lockdown imposed worldwide to reduce the spread of coronavirus and environment contamination [60]. Wani et al. (2020) illustrated that as per data of ESA (European Space Agency) and NASA (National Aeronautics and Space Administration) level of pollution has reduced by 30% in India, China, Spain, USA, etc., with Gangas Dolphins a critically endangered species spotted in the water of Ganges at various ghats of Kolkata after 30 years and Navi Mumbai witnessing thousands of flamingos due to reduction in water pollution during lockdown [71]. Somani et al. (2020) stated that COVID-19 is a try out for the future for dealing with climate change as the initial days of lockdown have positively affected the quality of air, water and decrease the emissions of greenhouse gases and noise pollution [65].

Thus, from the various online studies it can be concluded that COVID-19 lockdown has given time for the wildlife to move freely at the places that they belong and has also made man to realize the harm he has been doing to the nature by cutting forests for his desires.

### 7.3 Negative Aspects of COVID-19

Although the lockdown due to corona has made the human beings to realize the wrong he has been doing to the nature but COVID-19 has come with a lot of problems
which will take a lot of time to get back to normal. Some of the negative aspects of coronavirus are given below:

1. Pandemic has resulted into unemployment and greatly impacted economies of different countries which will ultimately put pressure on limited natural resources in future.
2. Due to decrease in availability of cargo transportation services and further due to restrictions on import, there is decrease of agriculture and fishery export which has resulted into unshipped organic waste and levels of methane (CH4) emissions have increased because of decaying of organic waste [27].
3. It has lead to increase in recyclable waste. Municipalities are not doing recycling activities as they are afraid of contracting viruses while segregating waste as waste contains used masks, PPE kits, etc. [27].
4. Food retailers are using plastic bags instead of reusable paper bags as they fear that usable bags can spread virus [34]. The use of plastic bags has been increased due to demand for take-away food with single-use packaging as people prefer to stay at home due to restrictions [27].
5. People are throwing used masks, sanitizer bottles, etc., in water which are disturbing natural ecosystems. By throwing used masks, bottles in rivers, seas, etc., people are not only polluting water but also putting life of water animals in danger.
6. By throwing used masks, medical waste, etc., in open area there is a chance that virus can be transmitted to animals if they come in contact with these medical waste.
7. Tourism has also been affected by natural areas. This lack of ecotourism will also lead to unemployment and people will start using resources from fragile ecosystems as these people will need food and money for their survival which will put pressure on the resources and leads to unsustainability [27].
8. Exports of agricultural and fisheries products have decrease due to which production of these products has been stopped which will increase unemployment.
9. Maintenance and monitoring of natural ecosystems got disturbed due to coronavirus. Due to coronavirus, environmental protection workers are staying home due to lockdowns due to which they are not able to monitor national parks and different conservation zones. Natural ecosystems and wildlife and species which are protected are at high risk because of illegal deforestation, hunting and fishing [27].
10. Due to lack of ecotourism activity, our natural ecosystems are at high risk as there is possibility of illegal harvesting and encroachment.
11. According to the WHO, people who are aged and have pre-existing medical problems, are at higher risk of getting affected by this virus. India has the highest number of tuberculosis cases. Such people are at high risks due to coronavirus [53].
The above facts regarding negative impact of coronavirus on environment and human beings are also verified by different research studies. Some of them are given below:

**Review of Studies Depicting Negative Aspects of COVID-19.**

Sivakumar (2020) in his paper illustrated the negative aspect of COVID-19 with respect to water. In order to control the spread of Corona use of disinfectants, soap and water has increased which in turn has increased sewage in drains which will impose an additional cost on wastewater treatment facilities. And in under developed and developing countries where there is a lack of facilities for treating the wastewater, the untreated wastewater from industries and homes will pave its way to nearby water bodies affecting the water quality critically [64]. Newsome (2020) stated that although lockdowns observed during COVID-19 pandemic has given a chance for environment to heal but it has created a negative pressure on wildlife tourism which is a threat to protection of wildlife as tourism funds their conservation [49]. Rutz et al. (2020) stated that although wildlife flourished to its fullest during the lockdown period but challenges have been imposed on animals dwelling in urban areas such as monkeys, rats, etc., that were dwelling on the food provided or discarded by humans. Further reduced human activities in remote areas can increase the risk of poaching of endangered species, such as raptors and rhinos [56]. Garlick (2020) stated that although wildlife reserves will be affected by the reduction in tourism which in turn will affect the work of conservation but unlawful hunting of endangered species may prove catastrophic due to absence of humans in Kenya [25]. Taskinsoy (2020) stated that if the second or third wave of COVID-19 reappears ahead of 2020, most economies will be thrown into a condition of coma [68]. Kuzemko et al. (2020) stated that with almost 300 million people losing their jobs with service-oriented economies the global economy is likely to shrink to 6% by 2020 [36]. Lee et al. (2020) stated that the first lockdown imposed on 24 March 2020 in India resulted in significant economic costs, with increase in use of masks by 73%, in handwash by 10% and indoor time spent by people by 51%. But it has drastically affected the mental health of the people and also restricted the supply chains and immensely affecting the poor migrant workers in different parts of India [38]. Pandey et al. (2020) in their study on dentists found that due to closure of their clinics many dentists fear their jobs to be lost and the stoppage of income leads to develop mental stress [51]. Sharma et al. (2020) in their study highlighted the challenges faced for management of solid waste during the onset of pandemic for plastic, biomedical and food waste as it can pose a major safety and health hazard for sanitation workers. The usage of single-use plastic is likely to rise due to hygienic concerns particularly for products used for health care and personal protection. Though the generation of food waste in the houses may reduce due to food shortage concerns but food wastage is likely to increase due to supply chains being broken due to restricted movement of vehicles and decrease in number of workers in handling of food products in warehouses [62]. Islamaj, Mattoo and Vashakmadze (2020) stated that a global shock has been caused due to COVID-19 causing recession and financial shock in the developing countries of East Asia and the Pacific leading to rise in poverty [31].
Thus, though lockdown during pandemic has helped our Mother Nature to heal but it has changed our lives completely and has impacted people socially, psychologically and economically. 24 million people are estimated to be trapped in poverty in the regions of Pacific and East Asia in 2020 alone according to World Bank [73]. Further the generation of biomedical waste [65] has increased due to large-scale use of masks, PPE kits and sanitizers [27], increase in cost of treating sewage water and managing solid waste which are posing an extra burden on the economy, various businesses like eatery, hotels, restaurants, cinema halls are in a great loss since the initiation of COVID-19. The positive effect due to lockdowns is only temporary but the negative effect has posed a huge financial burden which can pose a threat in various programmes implemented by the governments to attain the goals of environmental sustainability. So to maintain the legacy of positive effects we have achieved due to lockdowns it is essential that there should be proper implementations of environment protection policies at national and international level.

7.4 Future Suggestions to Maintain Environmental Sustainability Post-COVID-19

No doubt, coronavirus is a life threatening disaster but it has given us understanding to differentiate between our needs and luxuries at individual level. This understanding can lead to environmental sustainability at various levels such as global, community, individual and state. Some of the suggestions to maintain the environment sustainability are:

I. Air quality achieved during coronavirus can be achieved permanently if we go for electrification of transport. The people should stop use of cars in all residential, academic and other government institutes and should avoid cars for going to office, shops, etc. Electric vehicles may be made available for the needy. The use of electric cars by phasing out petrol and diesel cars and using more and more public transports such as metros, electric trains, etc., for daily commutation instead of individual cars will help in reduction of air pollutants such as NO$_2$ [47]. The air quality can be improved permanently by using renewable energies and low carbon sources instead of fossil fuels. This can reduce monthly NO$_2$ emissions by 10% [47].

II. By making forced lockdown for at least three weeks twice in the entire country for the nature to recover every six months. Lockdowns can be used as an emergency measure to prevent situations of severe air pollution [15]. It is also seen that source control can improve the air quality [40].

III. All the industries who are throwing effluents in freshwater lakes or rivers should be strictly directed to process their effluents to the level of fresh water they are drawing. They will naturally recycle the water in use.
Increase in cost of process as well as products due to this will be really immaterial as we see in today’s COVID infected world.

IV. Develop a self-sustaining economics in every region so that people do not suffer. Luxury is really not required as many understand today. Initially develop infrastructures like ponds, lakes, water bodies for farming and fishing. Build Proper barrier to stop floodwater from entering villages using low-cost resources and local solutions.

V. Governments and businesses must come up with new ideas of work after the pandemic so that improvement in quality of air that we have got due to coronavirus can be held permanently [47].

VI. Industrial effluent tracing can be done using episodic opening closing to determine their impact on water resources [15]. Minimization of industrial effluents in the water bodies will result in clean water [49].

VII. We should take the period of coronavirus in positive way by taking this halt due to coronavirus as a catalyst for better life quality in coming years. It is also found that lives lost before pandemic due to air pollution were more than that occurred due to this pandemic. According to WHO, dirty air present outdoors and inside, results in seven million deaths yearly globally. We should also take lives lost other than this pandemic seriously [34].

VIII. Due to coronavirus all the economic activities are shut which are causing loss of revenue for government. To cover all losses, governments can relax health-protective regulations in future [34].

IX. The growth of wildflowers on the roadside can become a habitat for nesting and foraging for pollinators if left in such conditions for a year like in coronavirus [66].

X. The increase in the number of green belts as people are staying at home due to coronavirus is also helpful for increase in species and wildlife [66].

XI. During coronavirus due to less movement of human beings, different species and wildlife are moving in different landscapes freely. By continuing these practices for long after lockdown and following strategies like micro-habitats shelters to provide shade or cover can help in maintaining species and wildlife [66].

XII. More investment should be done in cleaner energies and there should be ramping up of the industries that are totally dependent upon fossil fuels. We should look for more sustainable options and stop using coal and non-renewable energy [4].

XIII. The environmental restoration due to coronavirus outbreak will not have a long-term impact. The main aim will be to take economy back to track post-COVID-19. People will get back to work and continue leading lives as usual. So, need of the hour is utilization of renewable sources of energy, forest conservation and effective waste management systems to maintain these gains in future [4].

XIV. Substantial results can be obtained at the individual level by a combination of structural changes and policies to slice greenhouse gas emissions [4].
XV. The society must start caring for the environment and must change its attitude [10]. People should retain some of the lifestyle changes that they have adopted because of coronavirus which are beneficial to the environment [15].

XVI. There is always a problem of pollution and crowd at tourist places. Due to lockdowns, there has been reduction in crowd and pollution. So future planning must be done to find a balance between the tourist spots and tourism to avoid pollution and overcrowding [10].

XVII. People should adopt new mobility habits. One should move towards clean mobility and should remodel their urban space.

XVIII. There is need to change urban space allocation which is required to make physical distancing easy and to make space for a cleaner mix of mobility. The most important method to reduce air pollution is to control the car traffic. Some of the methods are already implemented in European countries to reduce car traffic. These are use of pop-up bike lanes in Berlin, building of long cycling network in Paris, development of cycling infrastructure and widening of pavements in Krakow, conversion of city centre into open-air cafe in Vilinus, conversion of city centre into residential complex which gives preference to walking and cycling in Brussels and removal of parking lots for cycling lanes in Dublin [4].

XIX. There is need to strengthen public transport. Due to coronavirus people are avoiding congested places. So there is need of measures like cleaning of vehicles and instalment of disinfectant dispensers in the public transports so that people do not feel that buses and trains are sources of spreading virus. There is need to revive public transport by adding more electric buses in the current system. Modernization, cleanliness and safety of the transportation system must be priority. There is need for an online system for booking tickets which can reduce physical contact points. There should be flexible timings of opening of schools and different offices which will reduce rush in metro or buses. Work from home option should be given if possible reduce daily commuters [4].

XX. There is need to develop low emission technologies. There is need of less polluting cars to reduce air pollution. There is need of development of zero emission as done in European countries. Electric vehicles must be adopted as alterative to internal combustion engines. There should be a complete ban on the cars running on internal combustion engines and use of cleaner energies to run vehicles must be promoted. Governments must come up with some rewards and subsidies for citizens to promote the use of cleaner energy sources [4].

XXI. The high-mileage vehicles, such as taxis, etc., must switch to electric vehicles. These taxis should complement public transport and cannot be taken as replacement of public transport. Sharing of taxis and car pooling must be promoted to reduce air pollution [11]. There is need of special packages for industrial manufacturers and transportation companies so
that provisions for reductions in emissions for future car models can be made [27].

XXII. Need of the hour is to give attention to environment and natural resources threats because of coronavirus pandemic. There will be consequential economic and social impacts due to coronavirus. Most of the people living in coastal and rural areas are reliant for their living on the optimal use of the local environment and natural resources. Mostly small farmers and industries dealing with the production of BioTrade, fishery products, forestry and ecotourism services have been affected due to corona pandemic because of decrease in export and consumption of these products. They are not able to earn money and income which are forcing them to leave this process of existing sustainable production. This has resulted in poverty and exploitation of natural ecosystems and resources as they want to generate income quickly to meet their daily needs [27].

XXIII. Governments and organizations must come to help rural and coastal producers so that they can adapt to current market conditions and proper actions be taken for improved performance and recovery and in post-crisis markets [37].

XXIV. There is need of resilience strategies which can maintain the income level of producers in any crisis by maintaining sustainable management of forestry, agricultural, marine and biodiversity-rich ecosystems [27].

XXV. There should be a proper collaboration between public support entities and producers to meet the challenges of future markets [37].

XXVI. Follow-up activities should be initiated to assist countries to restore their production after the pandemic [27].

XXVII. The methodologies should be framed to restore a sustainable flow of natural inputs [27].

XXVIII. Environmental challenges because of coronavirus crisis will go away when it will come to end and all the economic activities will come back to normal. All the benefits related to air and water pollution reductions will go away and there will be no permanent environmental benefits. However, the environment benefits and decrease of economic activity because of coronavirus has made humans learned that there is need to understand the technicalities of environmental sustainability, consumption patterns of society and methods which can reduce degradation of environment in future [27].

XXIX. The pollution source management can be helpful in restoring environment and ecosystem fastly [47].
7.5 Conclusion

The coronavirus pandemic has given us a temporary vision that lockdown and shutdowns can give us an environment in which we want to live. Though a stop in routine life is not an optimum way to reduce environmental pollution, but lockdown is a channel for improving quality of living in the coming future. This lockdown does not decrease the fright of the COVID-19. The clear skies have shown us how quickly we can bring down air pollution. COVID-19 has also exposed respiratory health crisis that humans were facing due to bad quality of air before coronavirus. The lockdowns have revealed the quality of air can be improved if emissions are controlled globally [4]. Several health problems such as heart disease, premature deaths, asthma, respiratory problems, etc., can be minimized by reducing the concentration of air pollutants. The continuous economic halt due to lockdown will undoubtedly be wrong as it can further lead to social problems of poverty, unemployment, robbery, etc. So, need of the hour is to maintain improvements achieved due to lockdowns permanently and develop technology that is eco friendly which can help in the sustainable development as well as environmental sustainability. Some of the methods that can aid in environmental sustainability are electrification of transport, partial lockdowns in case of emergency situations, work from home wherever possible, use of clean energies, conservation of forests, efficient waste management system, etc. This lockdown has provided a baseline data for different environmental parameters which can be used by the researchers to build a baseline data for environment which will aid in determining the contribution of environmental pollution in different sectors and can be used by government to build a sustainable development model for the nation. The coronavirus can be used as a learning lesson [53] for conducting more research to analyse the affect of such lockdowns for a better future and attaining the goal of sustainable development.

The decisions taken by governments and steps taken by all of us in coming times after coronavirus is over will determine whether we make or break our environment. The lockdowns have shown us that we can live without polluting our environment. We cannot build societies where we are used to dirty environment. We cannot give such environment to our coming generation. Now because of coronavirus, we have learned how we can control the degradation of environment and we must put all of these methods in use for our coming generation and to maintain environment sustainability.

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