Chapter 6
Aftermath of Industrial Pollution, Post COVID-19 Quarantine on Environment

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Abstract  Human beings always stride toward the protection of the environment and global climate change at various levels. Though, due to diverse reasons our efforts were not enough. But now as the outbreak of COVID-19 has hit mankind globally, many countries are forced to implement self-quarantine, resulting in anthropogenic activities across the globe coming to a halt, especially in production/manufacturing. It has been clearly established that ever growing industrialization for the last two decades has immensely polluted the atmosphere, biosphere, and hydrosphere; also other overlooked concerns like noise pollution, soil pollution, etc., never gets adequate attention. As recently, all the activities have been seized considerably, the pollution level in the environment is expected to go down within a curtailed period. This chapter undertakes a brief and specific scenario of industrial pollution during lockdown; hence, the aim is to be focused on the dissemination of information in general, related to the current parameters regarding the status of the decreased level of industrial pollution in air, water, and soil. In the context of water pollution we have discussed the improvement of water quality in terms of change in pH, total dissolved solids (TDS), suspended particulate matter (SPM), biological oxygen demand (BOD), chemical oxygen demand (COD), heavy metal contamination in sewage as well as ground water, and biological parameters like reduction in coliforms, fecal coliforms, organic wastes, planktonic population, etc., whereas in case of air pollution it was found that there has been a sharp drop in the major air...
pollutants like PM2.5, PM10, O₃, SO₂, CO, hydrocarbons, and NO₂ as compared to the pre-lockdown phase, same consequences were also obtained in case issues related to the soil pollution. Also recent observations suggest that the ozone hole at Earth’s polar regions has begun to heal. These changing statistics of pollution rate can help us in the exploration of various public and private views, which could further encourage us to adopt better pollution controlling strategies; highlighting and also examining different social, economical, and technical challenges related to industrial pollution.

**Keywords** Lockdown · COVID-19 · Pollution · Environmental impact · Industrial pollution · Air quality

### 6.1 Introduction

From the scratch of human history the world has faced numerous pandemic situations which have led to heavy casualties in the past. History of pandemic goes ages before industrial revolution; from every pandemic disease world majorly faced various other problems like poverty, economic crisis, health-related issues, etc. And now in this twenty-first century, with the advancement of the modern world, COVID-19 pandemic has hit very hard globally in the end of 2019 (December, 2019) [61]. Novel corona disease (COVID-19) is highly contagious that resulted due to recently evolved virus emerging from the city of Wuhan, Hubei mainland province of China [39]. The disease is caused by a novel lineage B beta coronavirus better known as SARS-CoV2 (Severe Acute Respiratory Syndrome Coronavirus 2) [53]. Emerging from Wuhan, the virus took no time to spread across the globe. According to the WHO’s report updated on July 23, 2020, there are 14,731,563 confirmed cases of COVID-19 while 611,284 has lost their life from 216 countries and most of the fatalities were reported in America (WHO report 2020 dated 07-22-2020). Due to the high spreading rate of this virus by the means of personal contact, respiratory droplets of infected people, privation of proper treatment and unavailability of a vaccine, several countries imposed complete lockdown to break the infectious chain, and maintain social distancing hence reducing the rate of casualties.

Ultimately, all the human activities, industries, schools, religious, and sports activities ceased and the economic crises rose drastically to a point that even developed countries failed to stand against this virus. Normal life of people halts around the globe since February 2020 [70]. However, other than negative aspects there are also some positive facets of this global pandemic as it has been proved by various studies that the principle factor responsible for pollution in this sphere is due to uncontrolled anthropogenic activities [56]. From the very start of industrial revolution, environmental pollution increased vigorously affecting our hydrosphere, lithosphere as well as our atmosphere and causing major health risks to humans, animals as well as to our mother Earth. Before the COVID-19 outbreak [32] the pollution levels were continuously reaching the threshold, due to ever existing issues like traffic, modern
industries, new inventions, excessive chemical and pesticide uses; caused air, water, soil, as well as noise pollution. On top of that various other problems like thinning of the ozone layer to an alarming range were causing a serious disturbance in our environment. Since due to lockdown most of the anthropogenic activities have been restricted for months, it has been predicted that the pollution levels in the environment are experiencing a sharp decline [70]. Other than that, the industries are also temporarily non-functional, so for now the production is off or minimal because of which the resulting byproducts, generally in the form of effluents and emission has cut down a lot, leading to a humongous decrease in water and air pollution. Minimal traffic, lesser activities in industries or factories and also in the construction sectors have improved the air quality by a giant stride (Fig. 6.1). According to the Environmental and Energy Study Institute (EESI) the aviation emissions, which globally holds for 2.4% of CO2 emissions in 2018, have now declined considerably [50].

These changes have resulted in the resurgence of nature and finally the Earth’s ecosystem is responding positively and giving signals of improvement in context of natural parameters of hydrosphere, biosphere and atmosphere [2]. The obvious effect of this quarantine situation has also been noticed by the increase in sudden appearance of many indigenous birds, also vultures, especially in the cities. Abundance in insect pollinators has appeared on crops and other plants. Consequently, all this

![Fig. 6.1 Collateral advantage of SARS-COV2 on environment](image)
together comprises to be a positive indicator towards the rejuvenation of ecological balance and biodiversity. Sadly, the most disastrous and alarming situation of our environment, which Earth was suffering for decades was nothing but the result of ever growing greed of mankind to enforce its sovereignty globally [50].

Crystal clear water bodies, fresh air, blue skies, or the overcast weather in metropolitan cities are the pure indicators of the reduced pollution levels markedly during lockdown. These reductions in pollution levels have also helped the aquatic ecosystem to heal and flourish. With this understanding of natural recovery, we try to focus on the further reduction in water, air, noise, and soil pollution of the entire world as these upgraded environmental improvements are temporary for now. So there is an immense need to discover a better and sustainable way of fighting with the increasing pollution levels for our better tomorrow [70].

6.2 Categories and Impact of Industrial Pollution

Humans have always thrived to obtain more and more, the consequence of this never ending greed of humans continued with the setting up of various types of industries including both small as well as large-scale industries [64]. From the mid-eighteenth century to the early nineteenth century the industrial revolution has brought an extreme change in the social and economical lives of humans. The benefits of this revolution are experienced even today but with that come to the consequences as well. One thing that has followed the industrial revolution is industrial pollution. These industries prepare a variety of products from raw materials as per the increasing demand but with never ceasing greed and desire to be perfect, a large amount of load has turned on toward the environment which is now surrounded from technoecosystem. At the start only small-scale industries existed and the pollution was limited to minimum, smog being the primary pollutant. However, advancement in science and technology changed the situation and these industries got converted into large plants, spreading all across the globe, resulting in increased level of pollutants which are today a major concern globally. Industrial installation largely takes place in the areas which are closer to the urban areas and near water bodies. This makes waste management and supplies easier for the companies plus more labor at cheap cost allows the industries to work day and night. The government set up large industries to boost their economies, they have also made sure of some ground rules which do not allow malfunctioning industries to release all their waste into the surrounding environment hence, they need to take some proper measures. However, the execution of these laws is quite poor and the government is also overlooking this issue. To maintain the resilience in the society and to make sure it doesn’t get vulnerable to extreme events demographic, industrial, or economic it is important to make sure that the natural balance does not get disturbed [23]. These recurring environmental problems are not just intensifying the disasters but also can make sure to lead a potential secondary disaster. Japan’s Ministry of Environment has a study conducted on air pollution which suggests that acid rain during hurricanes and typhoons is
the result of pollution from urban cities and industries. Environmental degradation contributes to be a key factor in turning utmost weather events into natural disasters; therefore this issue needs our foremost attention [49]. The challenge includes desertification, deforestation, pollution, and climate change. Industrial pollution being the ground cause of the major environmental issues; our sole purpose is to emphasize problems sourced from industries to obviate environmental degradation which eventually helps us counter society’s vulnerability toward nature. Figure 6.2 is describing how industrial pollution is generated.

The 1984 Bhopal Disaster in India contributed to the world’s first civilian pollution crisis. Union Carbide factory was responsible for the leakage of industrial vapors which belonged to Union Carbide, Inc., U.S.A. This incident took away the lives of more than 3787 people in one day and injured up to 150,000–600,000. The worst air pollution event for the United Kingdom goes to the Great Smog (London 1952). In around 6 days 4,000 people died and a recent study suggests that the estimate rose to the figure of around 12,000 deaths. Former USSR in 1979 had a biological warfare laboratory near Sverdlovsk which had an accidental leakage of anthrax which is believed to be a reason for nearly 64 deaths. Single worst incident of air pollution in the US occurred in 1948 in Borough Donora in late October, where 20 people died and over 7,000 got injured [20].

Pollution can be of various types as the source and affected areas vary, while industrial pollution refers explicitly to any contamination to the environment caused by industries, making it the major source of pollution on the planet. Industries are
the source for a diverse range of pollutants which significantly is a burden to society. Usually this burden fails to get compensated because of the economic benefits and local jobs for income. The common type of pollution caused by industrial pollution is air pollution, water pollution, soil pollution, and to some extent noise pollution as well. Some other type of pollution created by industries includes radioactive pollution and thermal pollution, although their amount is quite less in comparison to the above-mentioned types of pollution. Air pollution can be given as introduction of any unwanted substance in the air with concentration more than the desirable amount is called as air pollution. There are commonly two sources of air pollution on the earth namely Anthropogenic (man-made sources) and Natural sources. The major cause of air pollution is related to the combustion of fossil fuels for example coal, diesel, etc. The primary pollutants of air pollution are CO₂, CO, SO₂, NOₓ, CFC, NH₃, Volatile organic compounds (VOC), and Particulate matter [35]. Depending upon the concentrations of pollutants in the exposed reason with high concentration of air pollution emitted from the industrial zone decides the morbidity and mortality level. Health hazard of these pollutants are discussed below:

**Sulfur dioxide**: disturbances in the respiratory symptoms and malfunctioning of lung especially among asthmatic, bronchitis patients, and patients of Chronic Obstructive Pulmonary Disease (COPD) [35].

**Nitrogen oxides**: inflammation of respiratory system; increased respiratory symptoms (attacks) among asthmatics and COPD patients; exposure to pregnant women can cause fetal damage.

**Carbon monoxide**: decreased carrying capacity of oxygen in blood, resulting in dizziness, headaches, and nausea; affects concentration; damage physical ability and awareness. Major risk to fetuses and the elderly population [14].

**Particulates**: respiratory, cardiac morbidity, and mortality. Smaller sized particles cause serious health damage as they penetrate deep into the respiratory tract.

**Non-methane volatile organic compounds**: Mostly carcinogenic; can cause damage to liver, kidney, digestive tract, and central nervous system; irritation in eye, nose, and throat; headaches; loss in coordination; breath shortening; nausea; allergic reactions; vexation [52].

Human activities add up to the contamination of water sources. Major water sources include lake, river, oceans, aquifer, and groundwater. Direct release of inadequate treated water can lead to severe damage to aquatic ecosystem. This directly affects the nearby population by inflicting major health problems. Scarcity of fresh water leads to the contamination of public water sources, ultimately leading people to use same polluted water. Consecutively, water pollution has become the world’s leading cause of death and diseases (e.g. waterborne diseases). Industrial wastewater contains pollutants such as heavy metals, organic burden, oil, and salts which impacts widely, starting with damage to wastewater transportation system and wastewater treatment systems, ending up with even more adverse quality of released effluents which are later recovered for irrigation purpose. Concluding, industrial wastewater is significantly more negatively potent toward the environment than its corresponding
share in urban wastewater. Usually after pre-treatment the industrial wastewater is discharged directly to the public sewage system [30].

Waterborne diseases are highly contagious in nature. Heavy rainfall and floods promote the growth of infectious diseases even more, mainly in underdeveloped and developing countries. Near about 10% of the population consumes edibles that are irrigated by contaminated water. Health risk associated with industrial water pollutants includes neurological disorders, cardiovascular diseases, respiratory disorders, cancer, diarrhoea, etc. Nitrogenous chemicals potently used in industries and irrigation are carcinogenic and are also linked to blue baby syndrome. Cancer mortality rate is higher in rural areas than it is in urban areas as urban inhabitants use treated water while rural population suffer lack of facilities. Pregnant ladies are more susceptible to the negative effects of contaminated water; resulting in increased rate of premature births, stillbirths, and low birth rates [63].

Polluted water declines the crop production rate, contaminates soil, and infects food through biomagnification. It is also quite hazardous for aquatic life as the water bodies are loaded with heavy metals (mainly iron) which interfere with the respiratory system of aquatic animals. Iron deposits in the gills of fishes is fatal for them; which in turn are consumed by the man leading to major health issues. High concentration of metals leads to renal failure, liver cirrhosis, neural disorder, and hair loss. Pathogenic diseases are spread more efficiently via polluted water hence affecting human health [24].

Soil pollution simply refers to the contamination of soil and deteriorated soil quality. The pollutants reduce the quality of soil by affecting the pH and nutrient level, which makes soil inhabitable for micro and macroorganisms which are crucially add to soil composition. Natural processes and human activities both could result in soil contamination hence, soil pollution. Although, soil contamination is majorly the result of human activities. The presence of chemicals like ammonia, petroleum hydrocarbons, pesticides, herbicides, nitrate, mercury, lead, naphthalene in excessive amount contributes to soil contamination. The improper ways of chemical waste disposal from industries also cause contamination of soil, which in the long run lead to soil acidification. It causes detrimental effects on the soil ecosystem and the environment at large. Living, working, or playing in the contaminated soil leads to skin diseases, respiratory disorders, and toxification. After rain the surface run off adds to water bodies carrying pollutants in it eventually polluting underground water as well. This water becomes unfit for human consumption as well as for animals, as attributed with toxic chemicals. As soil is an important habitat for different microbes and other animals like reptiles, mammals, birds, and insects therefore its contamination can cause a massive imbalance in soil ecosystem. The soil pollution negatively impacts the life of microflora as well as creating huge threat to grazing animals [55].

Another remotely discussed issue of industries is noise pollution which is refers to the noise produced in factories which is jarring and intolerable. The unwanted amplitude of sound becomes noise when it starts bothering the sanity of an individual. Industrial noise pollution is harmful to an alarming rate specifically to the people who are in close surrounding to these industries. Noise more than 85 decibel, is scientifically proved that it leads to hearing impairment and does not meet the
criteria of a healthy working environment. Various other effects other than hearing impairment are increased stress, high blood pressure, fatigue, stomach ulcers, stress, sleep disturbance, aggression, and anxiety. High volume increases adrenaline levels resulting in increased blood pressure and stress. The problems are well analyzed but the solutions are probably not easy to accomplish since the contradiction in thoughts differs in legislation, guidance, and documents [8].

6.3 Comparison Between Pre and Active Lockdown Conditions

6.3.1 Air Pollution

As the world got affected by the deadly virus (COVID-19), this resulted in isolation of more than 3.9 billion people living in 90 different countries across the globe; which ultimately lead to the shutdown of all forms of transports, factories, markets, and other social and economic activities [54]. This caused a lot of problems in the human lives, affecting their social life, global mobility, and economy. But for the environment this lockdown for the humans came out as a boon; as the major parameters of pollution began to show improvements. This enhanced the overall air quality around the globe as the air pollution levels experienced a steep decline in an unparalleled way and provided new opportunities to study air pollution and various ways to control it when the lockdown gets lifted [65]. A healthy human life needs clean air with an adult individual breathing almost 20 m$^3$ of air each day. But according to the reports of WHO [69], right now air pollution has become a substantial environmental health risk on the earth causing premature death of seven million people annually, worldwide. Number of deaths caused by air pollution stands quite less than the other causes of deaths such as diseases like tuberculosis, HIV/AIDS, and also road accidents combined together. The severity of air pollution in our environment can be determined easily by the data that shows 9 out of 10 people breathe air with high levels of pollutants [69]. It is estimated that each individual dies 28 years earlier of their actual lifespan than they would do if they inhale fresh and clean air. Along with the health issues air pollution also affects our economy and is one of the potent causes in the degradation of the environment [33].

Developing countries (India and China) experience the worst effects of air pollution and also the underdeveloped countries (Bangladesh, Pakistan, Kazakhstan, Kuwait, Iraq, Nepal, etc.). Around 94% of the deaths caused due to air pollution occur in countries with low and middle incomes. Besides this the South East Asia and Western Pacific regions carries maximum burden with 2.4 and 2.2 million annual deaths, respectively. In Africa the number of deaths is around 980,000 followed by the Eastern Mediterranean region and the least
number comes from Europe and America with 348,000 and 233,000 deaths, respectively. The remaining deaths are seen in countries with high income like Europe, America, Eastern Mediterranean, and Western Pacific (Fig. 6.3) [68].

Air pollution is fundamentally of two types—Ambient air pollution (outdoor air pollution) and Indoor air pollution. The chief cause of ambient air pollution are power generation, transport industry, building heating systems, agriculture, waste incineration, and various forms of industries releasing pollutants like CO₂, CO, SO₂, NO₂, lead, ozone, etc. However, for the indoor air pollution the major sources include burning of fuel such as coal, wood, and cow-dung in inefficient stoves releasing a variety of health hazardous pollutants like the particulate matter (PM2.5, PM10), carbon monoxide, methane, poly-aromatic hydrocarbons, and volatile organic compounds [9, 16, 73]. Exposure to these pollutants may cause a large number of diseases affecting mostly children causing stroke, heart diseases, chronic obstructive diseases, cancer, musculoskeletal injuries, and even poisonings [16, 52].

In most of the countries the implementation of lockdown resulted in clean air, blue skies, and a better visibility especially in the urban cities. Improvement in the
visibility can be confirmed from the various local media reports of Punjab (Jalandhar) a state in India, where people were able to clearly sight far away snow-capped Himalayan peaks for the very first time in decades within the third day of lockdown. Himalayan mountain range is 130 km (100 miles) away from the city Punjab (Fig. 6.4); the view itself isn’t usual as the atmosphere is almost always covered with smog due to air pollution [15]. The Global Carbon Project [22] estimates that greenhouse gasses could drop to a proportion never seen before since World War II.

According to the report by IQAir [25] there is a drastic drop in the gasses and particulate matter in the atmosphere, over ten major cities which are currently under lockdown; Delhi, Mumbai, Wuhan, London, Los Angeles, Milan, New York, São Paulo, Seoul, Rome, all of these cities has showed reduction between $-9$ and $-60\%$ as compared to data of 2019 and between $+2$ and $-55\%$ compared with the average of prior four years [4].

NASA [45], Gautam [21] have stated that within the first week of the lockdown the reduction in levels of aerosol strike is 20 years low in the Northern parts of India (Fig. 6.5). They also noted that the air quality index (AQI) reduced between 44 and 15\% in different areas of the study. The results of the study done by Wang and Su [66] in China suggest that the outbreak of coronavirus resulted in the concentration reduction of $\text{NO}_2$ $12.9 \, \mu\text{g/m}^3$ (Fig. 6.6) and this improved the air quality in a very short span of time. $\text{NO}_2$ concentration also fell down significantly in Rome, Paris, and Madrid, the first cities in Europe to execute a complete lockdown. While PM2.5 showed a decline by $1.4 \, \mu\text{g/m}^3$ in Wuhan and an average decline of $18.9 \, \mu\text{g/m}^3$ in 367 other cities. The overall drop in the PM2.5 was approximately 20–30\% all over China as compared to the monthly average of February for the previous three years.

Another study mentions that China’s carbon emission (the world’s largest source of carbon emission) went down to 18\% (250 m tones) in the middle of early February.
Fig. 6.5 Change in the level of aerosol in India over the period of time (Source [45])

Fig. 6.6 Evolution of NO$_2$ concentrations in China (Source [72])

and March which was more than equivalent to the UK’s annual output. Similarly in Europe the carbon emission is expected to go down by 390 m tones while in America it has fallen up to 40%, where vehicular traffic is the major source of carbon emission [50]. In the Indian subcontinent there was a slight decrease in the carbon emission between 11th and 16th week of 2020. For the Northern parts of India, substantial
amount of reduction was observed in the mid of March to the end of April duly because of efficient enforcement of lockdown [31].

Almaty, a city in Kazakhstan and Salé city in Morocco enforced lockdown as soon as they had the first case of COVID-19 on March 19, 2020. As they learned the lesson from other countries that delayed implementation of lockdown can cause severe damage to many lives. Usually the quality of air improves in Kazakhstan after the end of February due to reduction in coal use but for this year there was a remarkable improvement in air quality in contrast to the previous years. Here concentration of PM2.5 decreased by 23% in 2020 in comparison to the concurrent period in previous years, where the reduction was up to 18% only. Similarly there was a substantial reduction in the concentration of CO and NO₂ by 49% and 35%, respectively [26]. Likewise the concentration of PM10, NO₂, and SO₂ decreased by 75%, 96%, and 49% respectively, within the few days after enforcement of COVID-19 countermeasures [46].

6.3.1.1 Comparison of Air Pollution Between Major Countries Affected by Corona Virus

As of now the death toll due to COVID-19 reached up to 14,731,563, most countries are under complete or partial lockdown, are facing substantial arduousness in various sectors like health care, social relationships, economical aspects, and many more apart from the large number of deaths ascribed to the ongoing pandemic. The countries with the most deaths include the United States of America, Brazil, India, Russia, Spain, the United Kingdom, China, etc [17]. These countries have faced a lot of difficulties and have implemented lockdown for a long time in contrast to other countries as some of them were not prepared for the situation beforehand and saw early cases of COVID-19 while others saw a huge number of cases in a very short span of time. Here we are going to give a more elaborated account of comparison on how the implication of lockdown rejuvenated the air quality of the major countries with most number of cases or most number of deaths [60].

The USA is the most affected country by coronavirus with 4,706,180 affected people and 156,764 deaths. Bermen and Ebisu [5] reported that the decline in the concentration of PM2.5 and NO₂ was observed in urban areas due to the closer of non-essential business in the USA during COVID-19 period (Fig. 6.7).

China was the first country to have coronavirus cases and due to insufficient preparation they experienced a huge number of cases in a short span of time in the Hubei Province due to which they implemented lockdown to a greater extent. During this period, China’s major industries operation level was much lower than the normal. From last 3–5 years the production and consumption level of the energy has decreased, while this year it came up to its lowest point. The average consumption of coal reached its minimum in the last four years and the demand for oil reached the minimum since autumn 2015. In addition, demand for various other products such as petroleum products, steel, and other metals saw a sharp decline. Overall the use of crude oil and coal reduced up to its maximum levels during the lockdown phase
Fig. 6.7  Current (2020) and historical (2017–2019) county concentrations of NO$_2$ (a) and PM2.5 (b) during the COVID-19 period (March 13 through April 8th) Shapes denote county urban–rural status; triangles = rural, square = urban, dots = major urban (Source [5]).

In China. Also in correspondence to the time stretch, followed by the spring festival holidays in 2019 (within the same 2 weeks), the CO$_2$ emission got lowered by 25% or more. The above data explains that China has dwindled to about 1 million tons of carbon emissions, analogous to the 6% of global emissions over the same period. These fall in levels coincided with the lockdown during the pandemic.

Another study done by Li et al. [36] on Yangtze River Delta (YRD) which is a group of major economic cities of China suggests that concentration of PM$_2.5$, PM$_10$, CO, SO$_2$, and NO$_2$ got reduced by 33.2, 29.0, 14.7, 25.9, 27.2, and 7.6% in comparison with 2019 before the epidemic (Fig. 6.8). This reasoning gained attention, especially in the winters as the air quality worsens as compared to other seasons. The improvement in the AQI of this reason has a direct relationship with restrictions in human activities.

Another major country affected by COVID-19 is India. India is a developing country with lots of industries, construction work, mining, and a huge population. Due to these reasons Indian cities have always been making their way in the top twenty polluted cities of the world for the recent past few years and exceeding the ambient air quality standards suggested by WHO and Central Pollution Control Board (CPCB) [59]. As the government of India implemented a complete lockdown of 21 days starting from March 23, 2020, North India saw a great decline in the concentration of PM$_2.5$, PM$_10$, NO, and NO$_2$. For example, the PM$_2.5$ concentration decreased by 34% in 2020 while it had decreased by only 12% in recent years. Similar results were observed in the other parts of India. There was a slight increase in the concentration...
Fig. 6.8 Changes in concentration of PM2.5, PM10, CO, NO₂, SO₂, and O₃ in 41 cities in the YRD during January 1st to Mar 31st, 2020 (Source [36])

of SO₂ in comparison to 2019. This was due to consumption of coal in the power plants. Similar to SO₂ the O₃ concentration decreased in comparison to 2019, while it increased by 10% when compared with the average of the last three years (Fig. 6.9).

Few countries in Europe started the count of COVID-19 from the mid of January. A country of Europe that was severely struck with this pandemic is Spain with 28,445 numbers of casualties till date. The lockdown in Spain came late into enforcement (March, 14, 2020) due to which it saw a very large number of cases. Following the similar pattern like other major countries under lockdown, the concentration of major air pollutants came to a sharp decline as recorded in various studies. In a study done by Baldasano [4] in the 2 biggest cities of Spain (Barcelona and Madrid) saw that the concentration of NO₂ fell by an average of 53% during the first week of lockdown and reductions of 62% was observed in the second week.

6.3.2 Water Pollution

Genesis of life occurred on water and therefore is considered the most important element of life for every living creature on earth, while other planets in the solar system do not possess water that is why they are not proficient in origin of life.
According to most of the studies the 2/3 of earth surface is submerged in water, out of which only 3% is drinkable water; and out of this 3% water, the surface acquires only 1% water and the rest is underground or in frozen state [42]. According to WHO, approximately 2 billion people across the globe drink contaminated water due to the release of huge variety of pollutants by the industries and public sources directly into the water bodies, as a result various diseases such as cholera, polio, diarrhea, typhoid, dysentery, etc., spread at a large scale. Not only the human lives, industrial water pollution also plays a chief role in ecosystem degradation, this type of damage mainly affects the people of developing and underdeveloped countries (India, Bangladesh,
Nepal) which solely rely on ecosystem services [51]. Industrial discharge (water-waste) is one of the major causes for irreversible ecosystem degradation [3] hence; several countries around the world are struggling to form effective laws to control the industrial discharge into their ecosystem.

Lockdown was quite helpful in revival of water resources by reducing both direct and indirect sources of water pollution. Direct source of water pollution includes effluents, wastewater released from factories, refineries, sewage treatment plants, etc., that releases fluids directly into the water bodies [13]. The indirect source consists of contaminants that enter in water supply through groundwater systems or from the atmosphere directly through rain. Sources for groundwater contaminants are the improperly disposed industrial wastes, residues of human/agricultural practices (pesticide, fertilizers, etc.); atmospheric pollutants are also the consequence of human practices such as emission of gasses from factories, automobiles, burning of plastic products, etc. [62]. Due to worldwide lockdown, most of the industries were closed and if open they were manufactured with lower demand, which directly affects the amount of contaminated water discharged by these industries as their byproducts and this directly saves our surface water resources. About 70% of industrial effluent directly adds up to the drinking water resources in developing countries because of the lack of funds and contribution toward water pollution but due to COVID-19 outbreak, water sources have once again started to clean out effectively.

According to Selvam et al. [57] the quality of groundwater in Tuticorin industrial city (South India) with reference to the concentration of NO$_3$, As, Fe, Pb, Se, fecal coliforms, and total coliforms has improved throughout the lockdown period of COVID-19 and this decrease in the levels of pollution was due to measures taken to restrict the anthropogenic activities and closure of several small- and large-scale industries. Yunus et al. [70] reported that the longest freshwater lake of India (Vembanad lake), the concentration of suspended particulate matter has decreased by 15.9% on average during this period as compared to pre-lockdown conditions (Fig. 6.10), this decrease was noticed in 18 out of 20 zones of the lake and also stated that pollution from industrial wastes and tourism had severely damaged water quality and lake ecosystem. Water pollution was directly associated with the health of an individual and the common pollutants present in the water bodies, as industrial waste had a differential impact on the overall health outcomes of the society and these effects were mainly harsh on low-income respondents [67]. A sudden fall in the concentration of dissolved zinc and other heavy metal was observed in the coastal region of the maritime state of West Bengal during lockdown phase in April [1].

The entire world is showing some positive environmental impact due to COVID-19 outbreak; the lagoon of Venice has always got affected by anthropogenic stress but when the lockdown was enforced in Italy the water jam around Venice stopped leading to a reduction in suspended matters and hence transparency of water increased. The high water transparency is because of the combined effects of both COVID-19 restrictions (Fig. 6.11) and natural seasonal factors [6]. Chinese government advised its water treatment plant to strengthen its disinfection routine to prevent new coronavirus infection spreading through wastewater [72].
(i) **Aftermath of Lockdown on Water Quality of Major Rivers in India.**

India is known as the land of rivers as it is blessed with the extensive network of Himalayan and peninsular rivers. Most rivers from the northern region are perennial in nature and originate from Himalayan Glaciers, while peninsular rivers are largely fed by rainwater and mainly arise from Westerns Ghats. Many ancient civilizations took birth on the laps of river banks as they provide a rich source of life and these rivers are still considered sacred in Hindu mythology as well as some other mythologies.
| S. No. | River       | Originates from              | Falls into         | Major Indian cities on the banks                  |
|-------|-------------|------------------------------|--------------------|--------------------------------------------------|
| 1     | Ganges      | Gangotri Glacier            | Bay of Bengal      | Varanasi, Allahabad, Haridwar, Patna              |
| 2     | Yamuna      | Yamunotri Glacier           | Ganges River       | Delhi, Agra, Mathura                              |
| 3     | Brahmaputra | Angsi Glacier [Tibet]       | Bay of Bengal      | Guwahati, Dibrugarh                              |
| 4     | Narmada     | Amarkantak, MadhyaPradesh   | Arabian Sea        | Jabalpur, Harda, Bharuch                         |
| 5     | Godavari    | Trimbakeshwar, Maharashtra  | Bay of Bengal      | Trimbakeshwar, Nashik, Rajahmundry               |

River system in India plays an important role as it provides potable water, cheap transportation, livelihoods, electricity, irrigation water, etc. Table 6.1 describe some major rivers in India. Due to fast growing industrialization in India, especially in the last two decades; has helped to improve the living standard of people but for that we had paid a nasty amount to nature in the form of increasing pollution. Hence, both the river water we take and the air we respire is heavily poisoned [38]. The anthropogenic activities in and around the river are continuously destroying the marine life and are responsible for the imbalance of aquatic ecosystem, also for the increase in the process of eutrophication hence, unplanned industrial setup is rapidly adding on to marine discharge and to the total amount of pollutants being disposed in the river or sea [27]. These discharges consist of heavy metal and other toxic elements which may get accumulated or biomagnified as they first get transferred into our food chain and then to the food web [1]. In this section of the chapter we will see how the water quality of major rivers in India got differently affected during social lockdown caused by the deadly virus, COVID-19.

(ii) Eco-Revival of River Ganga during Lockdown.

Currently there are several industries and cities which are present along the bank of river Ganga and ceaselessly discharging tons of industrial, municipal, and domestic wastes straight into the river which directly increases the biological oxygen demand (BOD) and reduce the concentration of dissolved oxygen (DO) in water which is essential for aquatic life [12]. River pollution has become an emerging issue for various developing countries due to the fast growing industries, uncontrolled population, and management issues. This leads to ill-handling of byproducts from all waste producing sources that are now entering into the river directly and is the foremost cause of environmental toxicity, which has ruined the water quality with aquatic flora and fauna [12].

The river water has a significant influence on the growth of microbial flora, since the microbes take up their nutrition from surrounding water. The level of fecal coliforms in Ganga’s water from the human waste is hundred times higher in some areas than the permissible limit assigned by the government [44]. Coliforms
are the group of gram-negative, rod-shaped, aerobic, or facultative anaerobes which ferment lactose and produce acid and gaseous as their byproducts [34]. This group of bacteria makes most of the microflora of fecal matter of warm-blooded animals including humans as they add up to the major microflora of our gut. The coliforms do not cause any kind of serious illness however their excessive presence in drinking water is a strong indicator of contaminated or polluted water [34].

Lockdown has significantly changed the water quality standards of river Ganga. Mukherjee et al. [44] reported that there was a sharp decrease observed in the number of total coliforms values in the Ganges during COVID-19 lockdown period (April 2020) and this sudden drop is due to the non-functioning of industries, less traffic, and closed tourism in conjunction with the reduced waste disposal activities. According to Dutta et al. [19] river, Ganga has shown significant signs of revival and also other improvements on different parameters. This change of impact can be noticed in terms of increased dissolved oxygen (DO), reduction in numbers of total coliform especially fecal coliform, nitrate (NO₃) concentration, etc., this data was observed in many districts falling under the Ganga basin, during lockdown. Decline in the concentration of nitrate was observed due to limited industrial activities and limited agriculture runoff (Fig. 6.12). A sharp reduction was observed in the nutrient load of phosphate and nitrate, confirming the constructive role of lockdown for the aquatic system of river Ganga which leads to a balanced ecosystem of the river. Lockdown also allowed aquatic life to revive and also reduced the strain from aquatic flora and fauna [58]. The pH levels of the aquatic ecosystem of river Ganga has reduced due to climate change, which results in increased dissolution of atmospheric carbon dioxide (CO₂) and caused acidification (carbonic acid formation) of water, however during lockdown there has been a uniform increase of pH confirming reversal process of acidification [18, 19].

![Fig. 6.12 Source of biggest untreated municipal wastewater in Ganga river a before lockdown b during lockdown (Source [19])](image-url)
(iii) Observed Changes Occurred in the Water Quality of River Yamuna.

The Yamuna is another major river of India and unfortunately is among distinctively dirtiest rivers in India. It is the second largest and longest tributary of Ganga hence the polluted water of Yamuna ultimately affects the water parameters of Ganga River. The Central Pollution Control Board (CPCB) had identified more than 351 polluted river sites across India in 2018 and many of these sites were situated alongside large urban cities and industrial areas [48]. Yamuna is considered as the most polluted river in the world [43]. Yamuna’s water quality mainly degrades when it enters into Delhi National Capital Territory (NCT) about 23 km upstream of Wazirabad Barrage (Palla) and travels around 6.9 km downstream of Okhla Barrage, this area of about 48 km in Delhi NCT consist of only 2% of total Yamuna’s path but receives almost 79% of its total pollutant load [48]. According to Kumar et al. [29] the water quality of Yamuna from the Himalayan segment up to Palla (before entering in Delhi) is moderate, whereas the Delhi segment is the worst affected area of entire river length.

The spread of COVID-19 has provided a ray of hope to improve the water quality of the Yamuna River, as the industries are operating partially within Delhi and also on other regions located on the banks of Yamuna. Patel et al. [48] analyzed the aftermath of lockdown on Yamuna’s water at different sites in Delhi and reported that, there is an improvement in water quality of 37%, which is a huge increment. The biological oxygen demand and chemical oxygen demand were reduced by 42.83% and 39.25%, respectively, with respect to the pre-lockdown phase and fecal coliforms decreased more than 40%. During lockdown the Yamuna possesses a declined effluent load, low levels of turbidity, suspended particulate matter, and algal signatures. Arif et al. [2] said that a general improvement in the water quality of river Yamuna has been observed during lockdown, the concentrations of pH, BOD, DO, electrical conductivity (EC), and COD has showed a cut down of 1–10%, 45–90%, 51%, 33–66%, and 33–82%, respectively, in comparison to pre-lockdown state. The water quality of Yamuna has improved much better during lockdown even when several efforts and actions were taken before for cleaning the river, where also an enormous amount of money was invested but no satisfactory results were obtained until now [2]. It seems that COVID-19 lockdown has provided us with a perfect opportunity to revive all those water bodies which are on the verge of dying; not only in India but also in the entire world. Of course there are several disturbing issues related to this pandemic situation which cannot be appreciated at all but as a society we need to accept that the lockdown has taught us an important lesson that we have to care for our nature for a better and glorious tomorrow.

6.3.3 Revamped Noise and Soil Pollution

With increasing human activities, the magnitude of anthropogenic noise as well as the noise pollution also increases. Environmental noise is known as the unwanted sound that is generated by anthropogenic activities, i.e. industries, traffic, music at high volumes, commercial activities, etc. [72]. Man-made noise reduces the capability
to receive natural sounds which play a crucial role in the reproduction and survival of wildlife [8]. In the past, noise pollution was considered to be a city problem but due to rapid growth and development of humans in rural areas, its reach has been extended [8]. Environmental noise is the main causal agent of health-related problems, discomfort in environment and population, and finally alters the natural conditions of this ecosystem [71]. According to Zambrano-Monserrate et al. [72] the imposition of lockdown measures by most of the governments of different countries in the world ordered people to stay at home resulting in the significantly decreased use of public and private transportation, many commercial activities, and air traffic have halted. All these changes help in dropping the level of noise considerably in various cities of the world. Mandal and Pal [41] reported that a decrease in the levels of noise was observed in the stone crushing and quarrying site situated in Dwarka, the river basin of Eastern India the noise level dropped to <65 dBA which was above 85 dBA in stone crusher dominated area during pre-lockdown period. Throughout the complete lockdown and quarantine period several drastic changes occur in the earth’s atmosphere including reduction in the noise pollution, decreased emission of greenhouse gasses, reduced solid waste production, etc. [30].

On the other hand pollutants levels which are being dumped or disposed in the soil such as solid byproducts of industries, automobiles used parts, mining wastes, etc., also decreased during lockdown but if we talk about the household wastes, hospital’s solid wastes material, the amount of these kind of wastes increases in the soil. The quarantine policies in various countries shift the consumers toward the online shopping and home delivery, hence the organic, inorganic solid wastes generated by households have increased. According to Zambrano-Monserrate et al. [72] hospitals in Wuhan are production houses of approx. 240 metric tons of medical wastes per day during COVID-19 outbreak with respect to previous average, i.e. 50 tons. Increased garbage from personal protective essentials (mask and gloves) was also reported in the USA [10]. The generation of inorganic and organic wastes is directly or indirectly associated with the broad range of environmental issues like deforestation, soil erosion, water and air pollution, etc. [55].

6.4 Effect of Revived Pollution Level on Existing Life Forms and Mother Earth

Environmental health is an essential factor to maintain the health of a being [11]. The over-exploitation by humans on nature and its natural resources had led the mother earth unable to breathe. At the dawn of the twenty-first-century humans started acknowledging the environmental changes and the threats caused by human’s anthropogenic activities to mother Earth. After which various policies, set of rules and steps were taken by us at various levels including global level, national level, local level, and by various types of NGOs. But due to some of the other reason or may be due to our continuous exploitation of the natural resources to all these
efforts were not significant to control the damage done by us. After the strike of COVID-19 pandemic emerged from China, many countries enforced lockdown as a measure to control the unrolling of infection. Many climatic data collected across the world signify the decreased level of exploitation of natural resources [47] which is the outcome of lockdown; on one hand as less adverse effect on natural habitats and on the other hand allows self-regeneration of the mother earth. Due to industrial shutdowns and cancellation of flights and other transportation, as an effect inflicted by coronavirus, the pollution level in air and water sources especially in urban areas showed self-recovering mode due to less exploitation of fossil fuels and release of industrial effluents [40]. Studies done in many countries such as USA, India, Italy, Spain, China, Philippines, Brazil, Denmark, and few other countries have seen positive correlation between COVID-19 infection, environmental toxicity, and various type of pollutions. Himalayan ranges are now visible due to sharp drop of air pollution and settling down of air particulate matter. Brasseur and his colleague [7] revealed that the mean surface O₃ concentration got elevated by the factor of 1.5–2 after enforcement of lockdown. Various case studies revealed the reduced level of two important environmental pollutants NO₂ and CO₂ across the world, as Nitrogen dioxide emission is the chief air pollutants released from industries and automobile operation. Reports from the European Space Agency (ESA) during February 2020 the level of NO₂ emission in cities and industrial areas especially Asia and Europe is relatively decreasing than previous years, by as much as 40% and after lockdown NO₂ pollution level fell by a massive percentage of 60%. The major contribution of NO₂ emission on the environment is by China among the whole of Asia which is about over 50% of total. But due to pandemic 40% of NO₂ emission is dropped in China. In Wuhan and China, NO₂ emission is decreasing up to 22.8 µg/m³ and 12.9 µg/m³, respectively. Due to decrease in combustion of petroleum and fossil fuel, which is the chief cause of carbon dioxide emissions in cities and industrial areas contributing to the dramatic change in environmental pollution level; the Mother Nature experienced for first time a reduction in global emission from past twelve years [28]. It happened due to the less transportation and industrial use of fossil fuel. Last year at the same time, it was reported there is an occurrence of 100 m tons of CO₂ emission which contributes 6% of global emissions. China, which gives major contributions to Ecotoxicity by maximum carbon emissions, observed a dramatic drop of 18% carbon dioxide emissions during the period of February and March, 2020. There was around 250 tons of reduction in carbon sources of China which is equal to annual half output value of the entire UK. In America, the major reason for CO₂ emission is because of vehicular traffic. However, the pandemic is helping to reduce the carbon sources in Europe, which is a reduction of around 390 m. It is magnificently reduced to 40%. China has been experiencing clean air due to the reduction in use of crude oil and coal burning which in turn reduced the carbon dioxide and nitrogen oxide emission. Additionally, Copernicus Atmosphere Monitoring Service (CAMS) is handled by European Union reported a decrease of PM2.5 from last February compared to the previous 3 years. According to this report a significant drop of 20–30% in PM2.5 was observed in the various parts of China, with respect to the monthly average of February 2020 (Lockdown period) and the
average of February 2016, 2017, 2018, 2019. PM2.5 level dropped up to 1.4 µg/m³ in Wuhan and average decrease by 18.9 µg/m³ in other 367 cities. The famous, canal city of Venice, Italy also experienced a decrease of industrial discharge into the canals which resulted in glittery water, found in March 2020. It has been reported that the major rivers in India like Ganga and Cauvery have drastically improved the purity of water. In Venice, the sea life is indulging again as the water canals have cleared up. Environmental noise is another major source of discomfort to the people and the nature causing health-related issues and affects the natural conditions of the ecosystem [71]. But due to lockdown imposed by the government, which caused less commercial activities and transportation hence resulted in considerable decrease in the level of noise pollution in most cities in the world. Also some study explored that lockdown has a heavy impact on the existing life form, specially giving wildlife a never seen freedom. It is revealed that in human dominating areas or “rewinding” urban areas, free movements of wildlife like peacocks, flamingo, White House, wild boar, sand dolphin have more frequent appearance. The air quality index is the major measure which indicates the changes in the health of Mother Nature. Probably, Mother Nature is trying to recover itself, when humans are not doing anything for it, which might be the greatest contribution of human toward the nature.

One of the leading problem contributing to environmental toxicity is the recycling of waste, which is now the major concern of interest in most countries [37]. Recycling is an effective and useful way to drop pollution, conserve natural resources, and save energy [63]. Due to the COVI-19 pandemic, many developed and developing countries like the USA did not continue the waste recycling processes in most of their cities, to stop the spreading of infection via recycling centers. Similarly, European countries affected by this virus have also stopped their recycling of waste.

6.5 Conclusion

COVID-19 which originated in Wuhan about 8 months back infected several people around the world, came out to be a blessing for nature and the environment, by providing nature a short time to heal and recover itself. Because of this we understood that the degradation caused by man to nature is not completely irreversible and this has been witnessed by almost everyone for the last 3–4 months. This chapter is mainly focused toward the changes that arise in nature during enforcement of lockdown. The environment has started to heal itself as industries, transport, other small factories have stopped their production, carbon emission rate has been reduced, air quality and water quality has made unpredictable improvements. The air quality index of major polluted cities, not only in India but also all across the world is now in two digits, which reflects a modestly good quality of air. Satellite images of the atmosphere also show a similar fashion of decrease in air pollution. The major rivers of India like Ganga, Yamuna, etc., are now cleaner and are supporting numerous numbers of aquatic lives. Aquatic ecosystem once again starts rejuvenating, beaches become clean and there has been a significant reduction in the level of noise pollution during
the whole period of lockdown. On the other hand reduction in the sum total of solid wastes produced by different types of industries was observed but the increment in the amount of domestic and medical wastes was also observed which is considered as one indirect negative effect of lockdown. It is now clear that COVID-19 has brought fear for human beings and become a curse to mankind but for nature it has emerged as a blessing in disguise.

6.6 Future Prospects

There is an urgent need for enforcing the importance of environmental concerns in order to protect the earth from at least those activities of man which could be controlled. These concerns should focus on both short-term and long-term goals. Less fascist policies and more eco-fascism are expected from the official domain for the society. The industries should not only focus on their products and profitability but also on the harm that they are doing to the nature. Some other suggestions which can be taken by industries, government, and by the society as a whole in order to control the degradation of the nature includes self-censoring by industries, monitoring of firms by various NGO and government agencies, applying pressure on the firms to improve and upgrade over the period of time, policies should be made by the government in order to control and assess the industries. However, the policies should be structured in such a way that when placed to implementation it is easier for the firms and public to comprehend. The carbon footprint of mankind can be reduced effectively as people have started doing work from home which came out as a better alternative. There is a further need to study that the implementation of lockdown could be an alternative for reduction of pollution and its impact on the economy.

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