Negative and positive environmental perspective of COVID-19: air, water, wastewater, forest, and noise quality

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ABSTRACT
The ongoing coronavirus disease 2019 (COVID-19) pandemic driven by severe acute respiratory syndrome coronavirus – 2 (SARS-CoV-2) has become the most critical universal health disaster of this century. Millions of people are staying at home obeying lockdown to halt the spread of this novel virus. The spread of the virus has forced people to use the mask, gloves, hand sanitizer, etc. daily, and healthcare workers to use personal protection equipment following the WHO guidelines, resulting in huge amounts of medical waste. This pandemic has led to a slowdown of economic activities significantly, and consequently, stock markets have nosedived beyond speculation. Although the deadly coronavirus has taken away millions of precious lives and the livelihood of many sections of people worldwide, it has brought several positive changes in the world. Furthermore, it has led to a massive restoration of the environment and improved air and water quality. Pandemic showed the resilient nature of the environment, including air and water, when human activities are paused. In addition, we also discussed how this pandemic affects human lifestyle behavior.

Introduction
Severe acute respiratory syndrome coronavirus – 2 (SARS-CoV-2) is the novel emerging strain of coronavirus, which is believed to originated from animals (Pangolins, Bats, others) and inducing severe respiratory diseases [1–3]. It mainly causes the coronavirus disease (COVID-19), which is declared as a pandemic disease that has affected most parts of the world [4]. The said pathogenic viral infection has been first reported from the Huanan Seafood wholesale market, Wuhan, China, on 31 December 2019, where live animals were...
human transmission makes it challenging to prevent community transmission and to formulate evidence-based standard protocols for infection control. Meanwhile, India has reported nearly 9.7 million positive cases with nearly 0.14 million deaths as of 6 December 2020 (COVID-19 outbreak in India: https://www.covid19india.org/). This pandemic is contemplated as the most critical universal health disaster of this century after the 2nd World War as well as the 1918 Spanish Flu pandemic of the 20th Century [23–25]. The SARS-CoV-2 has been reported to have a higher transmission tendency as compared to influenza, MERS-CoV, and SARS-CoV. The transmission rate of the virus is indicated numerically by R0 (R naught), which is a mathematical representation of the ability of a microbe to transmit the infection. The R0 defines the transmissibility of viral infection from an infected individual to a susceptible individual. If a virus has an R0 equal to 1, it means that an infected person may transmit the disease to one person. SARS-CoV-2 has an R0 > 5 and up to the unknown, as compared to its predecessors MERS-CoV (R0 < 1) and SARS-CoV (R0 < 1). The R0 of previous pandemics that include the 1918 Spanish flu (R0 > 1 and up to 2.4) and the 2009 Influenza virus (R0 > 2 and up to 16) were reflecting their increased transmissibility rates. The R0, in turn, will influence the doubling time of the infected population.

Coronaviruses can cause disease in both animals and humans. Although certain reports highlighted that SARS-CoV-2 also might infect animals (dogs, cats, tigers, lions, ferrets, minks) [2,26,27,3,28] thus revealing cross-species jumping, however, such reports are limited. It is also reported recently that the virus can recognize ACE2 of pigs, cats, ferrets, monkeys, humans, and orangutans with comparable efficacies [29]. Timely actions are imperative to reduce human-to-human transmission to hold back the rapid transmission, thereby suppressing the ongoing pandemic. This includes the adoption of appropriate prevention, control, and mitigation strategies such as early
diagnosis, social distancing, wearing face masks, regular washing, and sanitization of hands, disinfection, and hygiene to avert SARS-CoV-2 infection as well as the strengthening of health care facilities for treating COVID-19 patients with recommended therapies and supportive care [30, 31–35]. Proper infection control strategies must be enforced to save health workers, children, and old-aged individuals [36–38]. Lockdown measures have been adopted by almost all the countries to curb the human-to-human transmission, which has been reinforced by curtailing the cross-country movement of people by imposing travel restrictions by the governments. The diminishing traffic movement and the industrial activities have substantially reduced air pollution; for instance, the pollution levels in China have come down an estimated 25% during the lockdown period [39]. This lockdown improves air and water quality worldwide [21,40]. These are also confirmed from NASA and ESA satellite images.

This global reduction in modern human activities such as traffic movement and the industrial activities has been termed as ‘anthropause’. The objective of this study is to review the impact of ‘anthropause’ driven by COVID-19 on global environmental (air, water, and wildlife) health. After we have lived with the pandemic for over one year, it is imperative to look back and to evaluate the effect of the pandemic on the planetary health.

**Environmental aspects of COVID-19**

The COVID-19 is treated as the biggest universal health disaster of this century. Wuhan, with 11 million people, was the epicenter of the pandemic and is believed to have generated a huge amount of clinical trash (200 tons) on 24 February 2020 [39]. Medical waste management would soon emerge as a big challenge for the governments as the novel virus had rapidly spread throughout the world. Since the COVID-19 outbreak, the generation of such wastes has increased exponentially in India. Moreover, due to COVID-19 patients, household wastes become biomedical wastes. In the meantime, the waste management companies of medical health organizations have already started taking steps in Coronavirus decontamination services [39]. At the same time, it is our duty to obey the rules and regulations in disposing of wastes such as face masks and other related waste materials [41].

The scavengers and corporation trash collectors are in danger due to their direct exposure to such wastes. They become the most vulnerable groups to contract the disease. In addition, they may also be infected by other pathogens such as meningitis and Hepatitis B. The surgical masks must not be worn for more than a day. Therefore, discarded masks, sanitizer bottles, tissue papers, etc., make up enormous wastes for the environment. According to a recent survey, a huge quantity of rejected masks was washed up to 100 m stretches of a beach in Hong Kong by the tide. When 7.81 billion people unexpectedly use masks, gloves, sanitizers, etc., daily, there would be a phenomenal increase in the amount of trash created that subsequently gets thrown into the environment. When these discarded medical wastes enter the habitat (ocean and land), a large number of innocent animals lose their lives by eating them mistakenly as their food [42]. The waste is thrown openly near highway sides, rivers, and oceans [43]. As we know, cows, cattle, dogs, etc., are commonly searching for foods from wastes thrown by humans. It is reported that a huge number of cows, cattle, goats, dogs, etc., are dying every year by eating polythenes containing waste food materials; the problem would further aggravate if they will come in contact with such medical wastes during this pandemic period.

Due to the outbreak, most of the world’s cities are under lockdown for an extended period. There is a ban on free movement, and the people were instructed to stay home to prevent the uncontrolled proliferation of the virus. International travels are banned and/or
restricted from time to time as per scenarios and pandemic waves [44]. Moreover, several cultural, religious, scientific, social, and political events such as Car Festival, Olympics, Hajj, etc., are also canceled. The industries are not functioning to their full capacity, and all types of travel (National and International) are put on hold. All these factors together have a tremendous positive effect on the environment. Also, fossil fuels in industries have been minimized considerably, which reduces industrial waste emissions. Restriction on vehicular movement decreased the emission of toxic matter and green-house gases to our environment [45]. This entire phenomenon has helped the ecosystems to recover in a significant way. A recent article discussed the positive and negative impacts of the COVID-19 on the environmental matrices. It showed that the pandemic significantly improved air quality in numerous parts of the world, minimized green-house emission, improved water quality, and reduced the noise [46]. Though there is considerably large number of articles and opinion reports are published on COVID-19 following the origin of the pandemic, the proportion of studies in the environmental field is substantially lower (<3%) compared to health (65%) and medicine. Moreover, of all the articles published related to environmental sciences, only around 20% put forward the impact of COVID-19 on plastic and waste pollution [47,48].

**Aquatic mammals**

As per ICTV (International Committee on Taxonomy of Viruses), the subfamily Coronavirinae is classified into four genera, namely *alpha*, *beta*, *gamma*, and *delta* Coronavirus. The α and β type infect humans, including multiple species of mammals. The SARS-CoV-2 (β virus) attaches to ACE2 (Angiotensin-converting enzyme 2) through RBD (Receptor Binding Domain) regulating cross species as well as human-to-human transmissions [29,49]. As per reports, α Coronavirus also infects harbor seals [50]. The γ variants are observed in birds, aquatic creatures (whale, dolphin, etc.), while δ viruses are observed in mammals and birds [51,52].

It has also been hypothesized that SARS-CoV-2 may infect marine mammals [53]. This virus may survive on the discarded medical wastes for a few days [54]. The used masks, sanitizer bottles, gloves, tissue papers, etc., float in water following their disposal [55]. The aquatic mammals hold a high risk of contracting the disease on consuming those wastes unknowingly. This may lead to another massive loss of lives of aquatic mammals in the near future. Moreover, ACE2 receptor for binding of SARS-CoV-2 is also found in aquatic mammals, which indicates the susceptibility of aquatic mammals to SARS-CoV-2 infection [49,53]. Furthermore, an effort has been made to publicize the wastewater matrices associated risks, as a potential source of virus spread in the environment [56–58]. According to the literature, a huge number of marine mammals showed viral pneumonia and untimely death [59]; the death of 1000 common seals in Iceland in 1918 [60], 445 harbor seals in the USA during 1979–1980 [61], and 28 harbor porpoises during 1990–1995 in Wales and England [62]. Moreover, Morbilli Virus is also responsible for the death of several mammals; the death of eighteen thousand harbor seals in the Baltic and the North Sea in 1988 [63], striped dolphins in the Mediterranean Sea [64], and thousands of Baikal seals in the Soviet Union in 1987 [65,66]. In addition, 60 long-finned pilot whales [67] and 100 striped dolphins [68] were also affected in 2007. Furthermore, pneumonia caused by various bacteria or viruses is held responsible for the death of dolphins worldwide [69].

Coronavirus strains (HCoV229E, HCoV-NL63) were also identified in fecal swabs of Indo-Pacific bottlenose dolphins [70], beluga whale [71], and harbor seal [72]. These strains were frequently infecting humans. The cell entry mechanism of such viruses identified in marine mammals is still unclear. So, it is difficult to
understand the risk of the virus transmission associated with birds to others. Also, there is no surveillance on CoV in aquatic biota (fish) [72]. Moreover, a variety of birds were identified as hosts for CoV [52] as per extensive surveillance reports conducted in Brazil [73], Australia [74], Cambodia, and Hong Kong [75], Chile [76], Korea [77], Sweden [78], Norway [79], Finland [80], and USA [81,82]. Considering the above studies, we can say the water reservoirs may provide significant hotspots of the virus.

Aquatic environment and wastewater

Although the transmission of CoV through aerial route has been adequately reported, it is yet to be established whether water can act as a vehicle to transmit the virus, which is indeed a demanding task. Considering the theory of nonexistence of life without water and air, the possibility of virus survival via its transmission through the aquatic route cannot be completely ruled out. As the virus can sustain for a long time (hours to days) depending on the conditions [83], there is fear and anxiety among the people that the virus can be transmitted when infected person clean up the hazardous waste from their homes. Australia has detected CoV in untreated wastewater [84,85].

As per [86], SARS-CoV-2 may enter the sewage system via stools and survive for a number of days. The sewage normally goes to the ocean and rivers without treatment, thus transmitting the virus to the aquatic biota. Hence, the discharge of untreated or ineffectively treated sewage wastes may be a source of viral entry in rivers, lakes, and ocean leading to waterborne illnesses [87–89]. All CoVs infect digestive systems and respiratory tract, and their RNA is found in stool [90–93], which may increase potentially the risk of infection. Hence, it is now another big challenge for developing countries to avoid any further wave of CoV. According to William F. Marshall, M.D., no reliable evidence is found to propose that COVID-19 spreads through the mosquito. There is no evidence that the virus spreads through swimming pools. It is also unidentified whether the virus is spread through urine, vomit, breast milk, or semen. In some cases, the viral RNA was detected in fecal samples. However, this route of transmission is not generally significant; it may have greater implications in poor sanitation areas [94–96]. It is also uncertain whether the SARS-CoV-2 can endure on passing through the stomach [97]. However, gastrointestinal symptoms (nausea, abdominal pain, diarrhea, and vomiting) are also observed along with other common symptoms [98–101].

CoV’s survival in natural water resources depends mainly on light, temperature, pH, organic load, etc. Elevated temperature reduces the survival and proliferation of enveloped viral particles [102,103]. Hence, the survival of CoV in rivers and lakes depends on geographical location [104]. Chorine, Ozone, UV rays may be effective in treating CoV in water. But these techniques are effective when limited dissolved/suspended solids are present in water [105]. In such situations, the virus will not be able to find a perfect hiding place; otherwise, it may release back again. Moreover, if the virus will get an ideal host that is resistant to the above techniques, then the effluent water is expected to have CoV. The viral titer may decrease if exposed to UV light. However, UV-A was found to be futile in CoV deactivation [106]. The effectiveness of UV-B and UV-C is still unexplored.

At room temperature, SARS-CoV-2 is reported to be highly stable in wide pH ranges [54,107]. Nevertheless, it is susceptible to standard disinfection methods. The disinfection method involves destroying the cell wall of microbes to kill or inactivate them. But the disinfectants are not always impressive against all types of microorganisms [4]. There are many sanitizers available in the market, which are composed of chemical substances (Alcohols, Aldehydes, Peroxy and peroxy acids, Phenolic agents, quats, chlorine solution hypochlorite or hypochlorous acid).
**Effect on air quality**

According to the New York Times, 14 cities in India have the most hazardous air in 2019. Due to the COVID-19 lockdown, industries and transportation systems have shut down. This led to some unexpected consequences and caused a rapid reduction in carbon emission. As compared to the last year, the decline in PM2.5 and PM10 was about 39% and 60%, respectively, in Delhi [108]. The AQI is decreased by 44, 33, 32, 29, and 15% in the north, south, western, east, and central India, respectively [109]. In New York, the level of air pollution has decreased by 50%, compared to the previous year, due to the following measures to restrict the virus spread. As per the Ministry of Ecology and Environment (China), there was less quality air before the COVID-19 lockdown era. [110], have discussed the influence of lockdown on health and air pollution in Wuhan. The same was also supported by NASA satellite images [Figures 1 & 2] [111]. Furthermore, a massive reduction in the NO₂ concentration was observed due to the lowering of fossil fuel burning [111–114]. In Europe, NO₂ emission was reduced noticeably in Spain, the UK, and Italy [115]. Moreover, the impact of lockdown in renewable energy sector and environment was examined and discussed [116]. Consequently, a study by Copernicus Atmosphere Monitoring Service (CAMS) reported in Gulf Today on 2 May 2020 has suggested that the largest hole (Figure 3) in the ozone layer over the arctic has been closed [117,118]. But, these positive environmental changes are not permanent, and the pollution level may rise again in the future [119].

During the lockdown period in Croatia, as a consequence of the reduced human activity, air pollutants’ levels were found to be decreased [120]. The findings from the study indicated a 35% reduction in the concentration of NO₂ and PM1 particles, while 26% reduction was observed in the concentration of polycyclic aromatic hydrocarbons (PAH) at the traffic measuring site. However, a slight decrease was noted only in the NO₂ level in the residential measuring site, while PM1 particles, and PAH levels remained the same [120]. The decreasing levels of NO₂ and carbon emission during the lockdown period can be mainly attributed to fossil fuel's limited consumption by industrial sectors, air transportations, and thermal power plants [121]. The consequence of COVID-19 on air pollution in Indian cities was studied using NO₂ reduction and Aerosol Optical Depth (AOD). Among the Indian cities studied, the highest NO₂ reduction was observed in New Delhi (61.74%), followed by Delhi (60.37%), Bangalore (48.25%), Ahmedabad (46.20%), Nagpur (46.13%), and Gandhinagar (45.64) [122]. Temporal analysis of the data identified a progressive decrease in the NO₂ levels in all the major cities during the lockdown duration. In addition to that, the temporal pattern of NO₂ matched the AOD signal [122]. Following the implementation of lockdown in the entire country, the air quality index (AQI) calculated by combining sub-indices of seven pollutants, namely NO₂, NH₃, SO₂, PM2.5, PM10, CO, and O₃, improved by up to 30–46.67% after lockdown [123].

CoV’s significant impact is the dramatic reduction of coal consumption that has led to a drastic fall in the quantities of airborne pollutants such as CO, CO₂, SO₂, and NOx. This is a direct consequence of the decreasing demand for polluting fuels in power stations and coal-based industries [124]. Thus, this pandemic, in addition to improving the quality of air, also helps in saving energy to a large extent. The COVID-19 lockdowns, quarantines, and border closures had led to a reduction in air pollution, a positive environmental effect [119,125–127]. The NO₂ concentration has reduced by 45–54% in most populated cities in Europe [121]. The change in air quality in some global cities during this lockdown is shown in Figure 4. [128], have discussed the impact of the measures on Brazil’s air quality by comparing CO, NO₂, O₃, and PM concentrations during the partial lockdown with those of 2019. Their study
reveals a significant reduction [30.3–48.5%] in CO levels in the atmosphere, related to the diminishing vehicular emissions during the pandemic. The amount of NO₂ also dropped while PM10 levels were reduced only during the first week of lockdown. [129] have reported the air quality in São Paulo, Brazil, during the partial lockdown period. According to the study, the concentrations of NO (up to −77.3%), CO (up to −64.8%), and NO₂ (up to −54.3%) were drastically reduced in the urban areas during the lockdown period. An increase of 30% in the ozone level was also detected, presumably due to a decline in nitrogen monoxide concentration.

According to the World Economic Forum, a correlation exists between COVID-19 cases and the level of air pollution [130]. As per the study, an increase in particulate matter (PM) concentrations of 1 μg/m³ may raise fifteen COVID-19 cases and four hospital admissions with three deaths. A significant number of questions still need to be answered, such as ‘why there are more positive cases and deaths in some places than in others. Air pollution, a factor that could be partially suggested [130]. Extended acquaintance with fine particulate matter, such as NO₂ and SO₂, may cause respiratory disorders and impair lung function. Moreover, these contaminants may cause a relentless inflammatory response and ultimately raise the infection risk by targeting the airway.
Hence, meager air quality may allow people at higher risk of virus exposure and are vulnerable to serious illness and at times leading to death. In addition, a US-based study suggested that increase in PM2.5 concentrations of 1 μg/m$^3$ may raise the 8% COVID-19 death rate [130].

Particulate matters (such as dust, tiny parts of metals, microplastics, soil, chemicals, etc.) are formed in the air mainly due to burning fossil fuels, use of automobiles, steel making, etc. Particulate matter (PM) is described in micrometers. The commonly used terms are PM10 (< 10 μm) and PM2.5 (< 2.5 μm). According to the study reported in Hindustan Times [131], Mumbai (third most polluted city) observed a 42% decrease in PM2.5 levels between 23$^{rd}$ March and 13th April, compared to the past four years (during the same period), and 34% reduction in comparison to 2019 (during the same period). It is also reported that the city has a PM2.5 concentration of 28.8 μg/m$^3$ in this lockdown period. Wuhan is the most adulterated city (35.1 μg/m$^3$) followed by Delhi (32.8 μg/m$^3$), the second most polluted city. New York (4.4 μg/m$^3$) had the lowest PM2.5 levels, followed by Los Angeles (5.5 μg/m$^3$) and Madrid (6.4 μg/m$^3$). In addition, the study also suggested that nine out of ten global cities experienced 25–60% reduction in PM2.5 levels from the same period in 2019.

**Effect on water quality**

COVID-19 lockdown not only reduced the air pollution levels but also improved the quality of water around the globe (Figure 5) [46,132–134]. The quality of water in River Ganga near holy cities

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**Figure 2.** NASA image on NO$_2$ emissions in Wuhan [111,114].
like Varanasi, Hardwar, etc. has improved significantly during the lockdown period due to decreased use of the holy river as a consequence of the decline in the pilgrims from all across the country during the pandemic. It is indeed a rare sight to see deserted riverbank at the rivers ‘Ganga’ and ‘Yamuna’ confluence in India [121]. The surface water quality has changed with SPM reduction up to 15.9%. With the closedown of factories located on the river bank, the amount of toxic industrial effluents into the river has reduced drastically. Consequently, certain stretches of rivers have become cleaner. One-tenth of the source of pollution to the river is the industries. The river water quality near the crushing unit has markedly improved because of no dust release into the river, which also reduced the TDS level significantly in the river water [135]. Moreover, [136] have examined the water quality parameters of southern Jiangsu [SJ]

Figure 3. Ozone layer comparison over the Arctic as per CAMS [118].

Figure 4. Air quality comparison in some global cities during this lock down.
segment of Beijing-Hangzhou Grand Canal with fluorescence fingerprint technique. According to their study, the intensities of fluorescent components reduced due to the shutdown of textile industries in this region.

[137], discussed that the improved air quality, reduction of noise, and cleaning of beaches are a sustainable way for environmental cleanup. In this pandemic, a reduction in the number of tourists has caused a prominent change in many beaches. Due to heavy crowd and non-responsible use, many beaches throughout the world were facing pollution concerns [138]. Due to the COVID-19 lockdown, thousands of flamingos have conglomerated in Navi Mumbai. These birds commonly migrate to the area every year, but residents have noticed a massive increase in their numbers this year. In many cities and areas, the inhabitants are visualizing the clear sky in their lives for the first time. Interestingly, the current pandemic and associated lockdown increased the rainfall in India from March to May compared to the previous years. It will immensely benefit India’s people as the groundwater level would increase, and a severe water crisis could be avoided during the summer [139].

Improvement in water quality due to lockdown has been reported from different parts of the world. For example, by analyzing Sentinel-2 satellite imagery, [140] reported higher transparency of the lagoons in Venice after urban water traffic came to a halt due to lockdown. Similar report also came from the Vembanad Lake, the longest freshwater lake in India [141] where 16% reduction in suspended sedimentary matter (SPM) was recorded during the lockdown period. Water quality of India’s two holy rivers, the Ganges and the Yamuna showed improved dissolved oxygen and reduced organic and chemical load [as indicated by BOD and COD measurements] due to closure of factories and commercial establishments and almost zero pilgrim footfalls. In African continent, off Tangier, northern Morocco, [142] found normal surface water temperature and improved water quality which is otherwise affected by industrial wastewater discharge.

Improved water quality was noticed even in case of ground water as was reported by [143]. Analyzing the ground water samples from coastal industrial city of Tuticorin in Southern India they reported significant reductions in metals such as Se (42%), As (51%), Fe (60%) and Pb (50%) along with reduction in NO₃ (56%), total coliform (52%) and fecal coliforms (48%). Such improved ground water quality points out to the tight coupling of surface and ground water vis a vis how reduced industrial effluents and organic loads in the surface water helped improving ground water quality. Effect of the lockdown has been proved to be beneficial for the marine life as well [40]. With a ban on commercial fishing industries, the marine fish stocks are showing signs of fast recovery which has been unpresented since the world wars. Significant reduction in noise levels from the shipping traffic has resulted in lower stress hormone level among the marine mammals leading to their reproductive success. Migratory turtles successfully mass nested in different parts of the world during the lockdown period.
Effects on forest and wildlife

The lockdown due to CoV affects forests adversely. Due to repeated lockdown and shut-down, regular forest works are affected. Anthropogenic pressure on forests is on the rise. Miscreants play a vital role in smuggling wildlife. Thus, the illegal wildlife trade has escalated. Forest-dwelling tribals’ dependency on the forest has increased; this affects the growth and regeneration of the forest. We are continuously neglecting our primary job that is forestation, whereas billions and trillions of dollars are being spent developing medicines for its treatment to prevent this outbreak. It is now very much essential for us to understand the importance of forests. China has temporarily put an official ban on wildlife markets, where bats, civets, pangolins etc., are kept alive for sale. More than 60% of transmutable diseases originate from animals, and more commonly from wild animals. Hence, the trade of wildlife might boost the risks of such emerging novel viruses. Many personnel urged to ban wildlife trading permanently, which would protect us from further pandemics.

COVID-19 pandemic strikes the ecological balance in a very short period and made the wild animals to experience the sudden absence of human beings due to lockdown. It appeared as if the wildlife habitat is restored overnight. During the initial pandemic phase, several reports witnessed the movement of wildlife in unorthodox settings such as wild boar foraging in the city of Barcelona, nesting sea turtles in beaches of Brazil, the small Indian civet (nocturnal) in broad daylight on the road in Kerala. COVID-19 impacted the restoration of degraded habitats and facilitated forest and wildlife recovery [144].

The implementation of global-wide lockdown that was aimed to restrict COVID-19 induced behavioral changes among wild animals, pets, birds, and butterfly [121]. In certain regions, the survival of natural creatures has flourished during this period due to the relatively lower or noninterference of human activities. The unexpected reduction in human activity pushed the wild animals to exhibit uncommon behavior [121]. Wild animals started exploring human-dominated zones, which is a rare phenomenon and can be attributed to long-term lockdown implementation.

Effect on noise quality

The lockdown has significantly decreased noise pollution [46]; it dropped below 60 db in the densely populated cities [117]. ‘The Times of India’ described a drop in noise level both in the residential areas (~ 30–40 db) and as well as populated metro stations (~ 50 db) [145]. The low-frequency sounds related to fishing motorboats and ships are significantly reduced in Ocean Networks Canada [146]. In European countries, the level of NO₂ (a major air pollutant) was declined up to 45 to 54%. The carbon emission is assumed to be reduced by 7% at the end of this year. The concentration of particulate matters like PM10 and PM2.5 is reduced by decreasing 31% and 43%, respectively, in various world regions [121].

Many bird species like spoonbill, gray heron, painted stork, open bill stork, ibis, and spot-billed pelican generally leave by March. However, they have prolonged their stay this year due to a significant noise pollution reduction in the lockdown phase. The number of butterflies and birds surged substantially throughout the country. Migratory birds also breed a much higher than before due to limited human activities and air/noise pollution [147]. The routine activities of pets were also affected, and the lockdown changed their normal behavior. Sometimes, they behave abnormally and become ferocious.

Effect on plastic pollution

Though the environment has gained significantly in terms of air and water quality, environmental pollution due to disposable plastic waste is a major challenge during the COVID-19 pandemic. While a lot of effort has been made in the recent past to reduce plastic
usage, the pandemic has increased the use of plastic materials as they are necessary to protect against infection in health care settings. The use of plastics has become very common in our daily life that has positively improved the quality of life. However, excessive use of plastic leads to plastic pollution and thus posing a devastating impact on human health and the environment. Implementation of the ban on plastic use has generally failed. There is a need to shift toward green substitutes such as biodegradable plastic. Economic disparities in the different parts of the world lead to a lack of internationally acceptable effort or policy to cut down plastic usage. Recently, Patricio Silva et al. published an article reporting the impacts of COVID-19 on plastic pollution and its implications on human health and the atmosphere [48]. The demand for single-use plastic is increased in the medical and health section due to COVID-19. The critical protective consumables such as the PPE, masks are used by healthcare professionals, and their demand has increased drastically. Considering the volume of PPE used globally, it will be a major contributor to plastic pollution. It is estimated that if every citizen in the UK (66.7 million population) used one mask every day, the entire country would generate around 60 thousand tonnes of contaminated plastic garbage [47,48,148]. These plastic wastes will eventually contaminate the ocean and become a major contributor to marine litter [47,48,149]. Due to covid-19, the behavior of people concerning hygiene due to the fear of transmission or acquiring COVID-19 infection has also increased the requirement for plastic bags, disposable utensils, groceries, and plastic-packaged food [Vanapal17]. It is also estimated that 65 billion gloves and 129 billion face masks are used every month worldwide during this pandemic, which result in widespread ecological pollution by the masks and gloves. These contaminated wastes must be disposed more accurately with standard protocols [150,151].

Furthermore, the commonly used surgical face masks (non-biodegradable polymeric materials) are now a source of microplastic pollution and affecting the aquatic biota [150,152]. This microplastic may be ingested easily by microorganisms in the aquatic life to higher organisms (fishes) and finally it enters human body through food chain and will initiate chronic health problems in later stage. [46] have also pointed the negative consequences of this pandemic such as massive use of masks, gloves and haphazard use and disposal of disinfectants. These commonly used items in COVID hospitals also pose a risk of transmission to other human and animals as SARS-CoV-2 can survive up to three days on plastics [153], Prata et al. made ten recommendations to mitigate plastic pollution, including regulation of plastic production and consumption, reducing the use, ecofriendly design, use of recycled plastics, improved waste collection systems, and use of biodegradable plastics, etc [154,155]. Hence, now more and more research needs to be initiated worldwide to understand such phenomenon in the entire environment.

**Food security of animals**

Generally, cats, crows, monkeys, local street dogs, and free-ranging birds rely on the foods of domestic persons and tourists. During the restricted period, they were observed to be in a food crisis, and often fighting with each other. The food shortage forced the wild animals to move toward the residential areas, such as the visitors fed the deer in Nara Park, Japan, but the food was dried up in the lockdown period. It might be because of their migration toward the city streets in search of food.

**Human health and lifestyle behavior**

As per WHO, nearly 4.6 million people die annually due to polluted air [156]. Enormous research has been conducted to learn relevant role of environmental factors in spreading
infectious diseases. Some factors such as particulate matter (PM2.5, PM10) have been shown to affect COVID-19 transmission. However, it is very essential to understand completely and clearly the role of climatic factors to control future epidemic threats [157]. Moreover, [158] have reported the role of air pollutants and climatological factors in COVID-19 transmission process. They have also discussed the excess use of disinfectants and its impact on human health. The COVID-19 pandemic has caused severe demographic changes, unemployment, and also the economic activities have been shut down due to lockdown and ban on global tourism [159]. Moreover, [155] have reported the environmental sustainability issues, health system policies and exchange rate measures introduced during the COVID-19 lockdown across countries. In this period, UK ranked as the country with the highest uncertainty level while USA has introduced highest policy cut-rate. In twenty European countries, [160] have investigated the public awareness of nature and environment during this ongoing crisis. The inadequate and mismanagement of current waste management system triggers a new environmental crisis [161,162]. Keeping in mind, the poor waste management strategies, some approaches toward a better waste management service have been suggested by [163] for the waste workers. We must think about the environmentally friendly materials like bioplastics and harboring new sustainable technologies to fight against future pandemics.

The COVID-19 restrictions have changed all nations’ lifestyle at every level regardless of religion, race, economic and political conditions [164]. Unfortunately, all the affected persons or patients recovered from COVID-19 are experiencing strange behavior from neighbors or the surroundings [165]. Abrupt deviations in lifestyle like the frequent use of sanitizer, masks, washing hands, and gloves wearing are extremely unlikely. The social association among teachers and students, doctors and patients, boss and assistants, and factory owners and workers even has largely been affected. Misinformation about COVID-19 and unpredictable effects of public health has impacted the people’s mental health, like anxiety, depression, shock, emotionally devastating situations, etc [121]. The anger, fear, sadness, annoyance, worry, helplessness, loneliness, frustration, and tenseness are the general psychological features of most persons during this unusual condition. Unemployment and economic fallout result in mental illness, and consequently leading to self-injurious and suicidal behavior [166,167]. The religious groups also avoid mass gatherings by directing online worship amenities.

**Conclusion and future prospects**

Although the deadly coronavirus has taken away millions of precious lives and the livelihood of many people worldwide, the pandemic positively impacted the environment. The lockdown and reduced human activities due to the pandemic have offered more space for safe and comfortable survival of wild animals and marine species without any disturbance from human beings, which were evident from the reports of elephants, kangaroos, seals, and many other wild animals freely roaming around the human settlement. Further, it has led to a massive self-restoration of the environment as the quality of air and water has improved like never before. The illegal wildlife trade has reduced substantially, and the forest activities like illegal felling of trees have been de-escalated. Thus, our planet is gradually witnessing a sudden restoration of the ecological balance where every stakeholder has an equal right to thrive. This has amply proved that whenever there is an overload due to indiscriminate activities of one of the constituents on the ecosystem, then nature will bounce back to maintain harmony.

The world has experienced an enormous change in the last few months due to COVID-19. However, COVID-19 has led to significant environmental gains in terms of restoration
undoubtedly. It has brought about a significant reduction in the emission of greenhouse gases that contributed to the reduction of air pollution and fossil fuel consumption. The greenhouse gas reduction is associated with the lockdown of factories, grounding of airplanes, and other modes of transportation. This pandemic has taught us several lessons that need to be remembered for a long time. It showed how the highly interconnected and interdependent economies and societies were fragile following the emergence of a pandemic, which highlighted the need for global cooperation and solidarity. The COVID-19 impact on pollution is considered temporary as the emissions will rebound once the economy reopens. However, global effort is needed by implementing certain policies such as working remotely and conducting business remotely, and avoiding unnecessary travel could further keep the emissions under control in the post-COVID -19 scenario. An effort must be made that the essential protective equipment and consumables may be produced using biodegradable plastic materials or recycling the used materials safely and efficiently. The rise of plastic pollution in the environment due to COVID-19 is a major issue that needs to be managed carefully. Otherwise, it may impact all the environmental gains achieved during the COVID-19 pandemic. Unfortunately, the dramatic ecological changes such as improved air quality, clear skies above many major cities, improved water quality in rivers, restored ozone layer, drop in greenhouse gas emissions will relapse to a pre-COVID19 situation when the world recover from the COVID-19 pandemic. A sustainable long-term plan to retain the environmental gain is needed, and it may avert any pandemic in the future.

Consent to Publish
All the authors have checked the final version of the manuscript and agreed to publish.

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