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Review Article

COVID-19 pandemic and its impacts on the environment: A global perspective

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Abstract

Many researchers worldwide have focused on the health impact of the coronavirus disease 2019 (COVID-19) pandemic without paying much emphasis to the environmental impacts associated with the pandemic. Evidence suggests that prior to the pandemic there was an alarming increase in environmental pollution due to rising industrialization, in particular in urban areas. Following the COVID-19 pandemic, satellite data over Asia and Europe showed a substantial decrease in air pollution, in particular nitrogen dioxide. However, the increase in industrial and household wastes may pose a significant challenge to environmental management. The improper management of these wastes poses an unforeseen "knock-on" effect on human health and the environment. It is imperative to establish an effective and safe procedure, for handling and disposing of the consequential wastes accumulating during the pandemic. The review aims to highlight both the beneficial and detrimental effects of COVID-19 pandemic on the natural environment and to discuss the possible strategies to improve the quality of the global environment during the period of the pandemic and beyond.

Keywords: COVID-19, environment effect, air pollution, waste management, environmental pollution

Introduction

The coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), primarily affects the respiratory system in humans [1,2]. The SARS-CoV-2 was first identified in the Hubei province of China and COVID-19 was declared a pandemic on March 11, 2020, by the World Health Organization (WHO). The COVID-19 pandemic has had a marked effect on global health and on the economy worldwide [3-5]. As of mid-March 2022, more than 470 million cases and more than 6 million deaths have been reported worldwide [4]. There has been evidence showing a substantial correlation between lockdown measures and improved air quality, cleaner beaches, and reduction in environmental

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noise [5]. The COVID-19 pandemic is having a significant impact on the daily lives of many individuals. The various steps taken by most government worldwide to curb the spread of the virus are significantly impacting the environment [5]. There has also been a marked decrease in noise pollution across many countries worldwide [5-7]. However, there has also been a notable decrease in the rate of recycling and a resultant rise in waste generation and accumulation, further leading to the contamination of water bodies, land, and air [8]. Researchers have suggested that there is a possibility of salvaging the universal environment from the deleterious impacts of human activities such as the burning of fossil fuel and industrial activities via interim lockdown measures [9].

The social adaptation to the lockdown measures by individuals and corporate organizations has also reduced environmental emissions globally [10]. Variations in weather conditions and cultures of various regions around the world could influence energy consumption particularly as people are forced to stay indoors hence leading to increased emissions over time. An example includes people staying in temperate regions needing heaters and fireplaces to stay warm which also contributes significantly to the average individual's carbon footprint [11]. There are various impacts of the COVID-19 pandemic on the environment. While some scholars have reported a decrease in environmental pollution, others believe the pandemic has negatively affected the environment. A good understanding of the indirect impact of the COVID-19 pandemic is necessary for post-COVID-19 pandemic policy formulation. In order to strike a balance, this review aims to highlight the positive and negative impacts of COVID-19 on the environment and discusses the possible mitigation strategies to reduce its detrimental environmental effects.

Environment and COVID-19: Interconnected relationship

Weather is key to the spread and establishment of infectious agents and pollution further helps in the propagation of diseases such as lower and upper respiratory tract infections [12]. Several climatic conditions have been proven to enhance the transmission of SARS-CoV-2 [12]. Temperate and cold climates have been reported to favor the spread of the SARS-CoV-2, while arid and tropical climates are less favorable [13, 14]. Environmental conditions can facilitate the transmission of SARS-CoV-2 from human to human, and unfavorable climates can destabilize the virus quickly, consequently lowering its virulence [15]. Environmental pollutants and viruses (including SARS-CoV-2) elicit deleterious immunological responses [16]. A study suggested that there is a direct link between environmental air pollution and COVID-19, in which particulate matter (PM2.5, PM10) has been reported to obstruct the airway thereby escalating cases of COVID-19 [17]. Some studies have revealed that PM2.5 concentration has a positive correlation with COVID-19 incidence [19,22,23]. Air quality index fine particulate matter (PM2.5), Nitrogen dioxide (NO_2), and temperature are key factors that potentiate and sustain transmission of SARS-CoV-2 [22, 23]. The effects of air pollution have been reported to be pro-inflammatory. The pollutants affect the lung, inducing certain pathological changes through mitochondrial-produced oxidative stress [18]. Particulate matter (PM) exposure over time could weaken and dysregulate immune response, enhance virus invasion, cause ACE2 overexpression, leading to an increase in viral load [19]. Airborne PM can facilitate the transmission of SARS-CoV-2 over long distances [19]. One recent study carried out by scientists at Harvard University reported that a minute increase in long-term exposure to PM2.5 can increase the chances of dying from COVID-19 related complications [36].

In recent years, we have witnessed an increase in environmental pollution, linked to dramatic industrialization, especially in urban cities [24], presenting a significant risk to the human and animal population worldwide. Air pollution has been reported to be one of the major causes of premature death worldwide [25]. Evidence has shown that environmental air pollution caused 8.8 million premature deaths globally in 2015, signifying about a three-year abridging of life expectancy throughout the entire human populace [26]. Across the world, critical environmental pollution indices that have been documented to deteriorate for the majority of the last century have now been seen to improve markedly [27]. Environmentalists all over the world are now seeing how human-influenced climate change is coming to a halt

[28]. After many decades of man's dependence on natural earth resources, the stress on the environment due to man's activities has greatly reduced.

Air pollution resulting from indiscriminate burning of fossil fuels, carbon emission from vehicle gaseous emissions and toxic gaseous emissions, have declined steadily, due to various measures put in place across the globe to curb the spread of the SARS-CoV-2 [20,22]. Various policy changes as a result of the COVID-19 crisis could enhance efforts to reduce greenhouse gas (GHG) emissions and help prepare the populace for future crises [12]. As vehicular traffic cleared and industrial activities come to a halt, carbon emission has been seen to reduce over cities in various countries worldwide during the days of lockdown [28, 29]. The quarantine and lockdown measures put in place by most governments have led to less build-up environmental pollutants in many recreational centers. It is key for governments worldwide to take from some of the lockdown measures those policies that have helped improve the environment greatly on a long-term basis and mitigate the negative impact of climate change.

Ozone levels are markedly affected in various urban regions across Western Europe, a sequel to the implemented movement restriction measures, although fine particle concentrations over time have been less pronounced than on NO_2 (−5 to −15%). This may be ascribed to the fact that traffic is not the exclusive source of fine particles. Additionally, PM levels in western Europe have been seen to surge following lockdown measures implemented since European residents have been observing the quarantine [30].

COVID-19 is affecting almost all countries worldwide, but the African continent seems to have been the last continent to be hit by the pandemic [31]. Recent findings have revealed that South Africa accounts for about 40% of the entire confirmed cases in the African continent, followed closely by Egypt (18%), Nigeria (6.8%), Ghana (4.6%), and Algeria (3.6%). The majority of the African nations in which outbreaks of the virus have been reported have currently instituted partial lockdown measures restricting all forms of motorized movements in most parts of the country, while in other parts complete dusk to dawn curfew was imposed [32]. In Nigeria, the most populous country in Africa with nearly 200 million population, COVID-19 cases are more concentrated in the highly populated states of Lagos and Kano which possess a high level of pollution. A large percentage of the world's population stays in an environment where air pollution is above its guideline limits, and this may complicate the management of individuals with severe COVID-19 related conditions [33].

According to the WHO, household and outdoor air pollution contribute to millions of global premature deaths yearly, with more than 50% of these mortalities due to outdoor air pollution, primarily generated by power stations, traffic exhaust fumes, burning fossil fuels, factory fumes, and waste products [34]. In line with the current pandemic ravaging the world, the Government of Ghana has developed a National Adaptation Plan (NAP) to help fight climate change, Ghana's government aims to ensure that the post-COVID-19 recovery investments and stimulus packages are 'climate-proof' [35].

Positive effects of COVID-19 on environment

Improvement in air quality

There has been a dramatic increase in recent years in reports of environmental pollution and this has been linked to a growth in industrialization, especially in urban cities. Hence, a great number of the population dwelling in urban regions is exposed to poor air quality [38]. National Aeronautics and Space Administration (NASA) and European Space Agency (ESA) have reported a decrease in environmental pollution in some countries such as Italy, Spain, and the USA by 30% as of August 2020 [40]. The number of deaths has been reported to be quite significantly prevented by improvement in environmental air quality due to the lockdown measures [39]. In Europe, most COVID-19 related deaths have been linked to regions with a high level of environmental pollution. In European cities such as Milan, Turin, and Madrid, high automobile traffic and mountain ranges prevent air pollution from dispersing [41]. The various lockdown measure that was strictly enforced around March–April 2020 in major European cities contributed to a significant decrease in nitrogen dioxide levels across major

cities and industrial zones across Europe, mainly attributed to a decrease in traffic in these regions and also a decrease in industrial activities. The nitrogen dioxide levels seem to fall back to near-normal levels in July–August 2020, with exception of large European cities having some form of low levels of human activities (**Figure 1**).

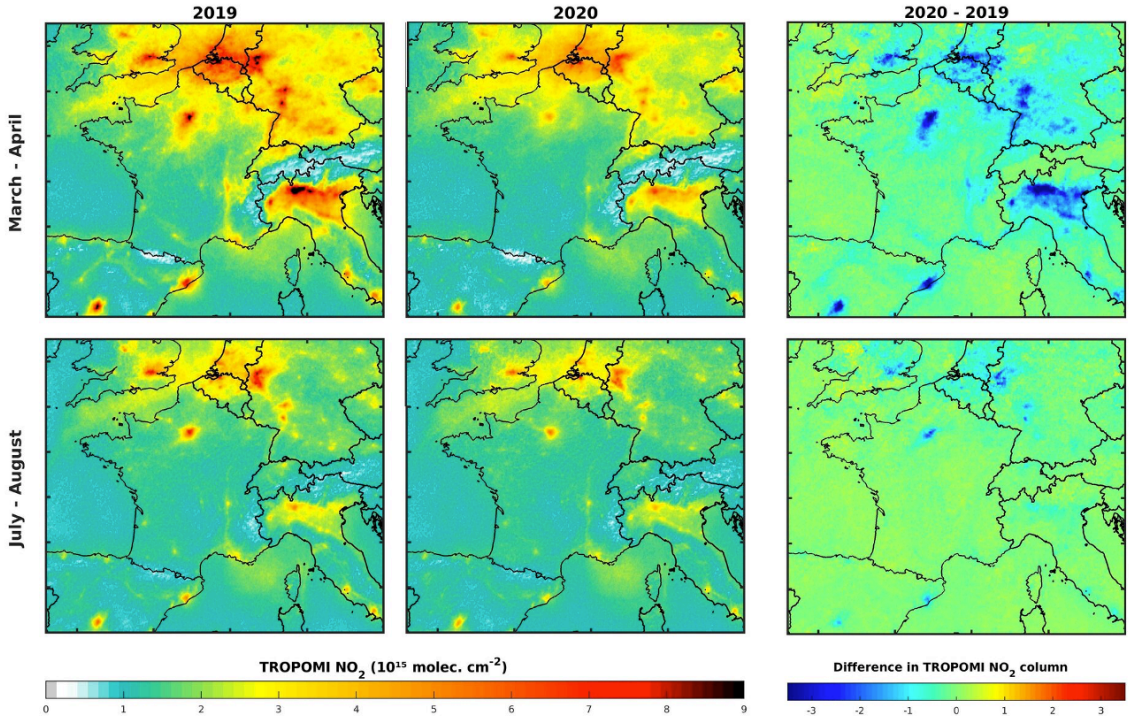

Figure 1. Nitrogen dioxide concentrations over Europe (Data source: ESA, 2020)

ESA satellites images suggested that carbon emissions have decreased considerably, industrial activities reduced, human activities in residential areas quieten, and air transport grounded across several countries in Europe [29]. Satellite imaging in parts of Italy has revealed a sharp decrease in air pollution-specifically nitrogen dioxide. With the aid of the Tropomi device on the Copernicus Sentinel-5P satellite, visual images acquired from 1 January to 11 March 2020 displayed NO_2 levels considerably declining [29]. These findings throw more light on certain aspects of modern-day life that are essential and what favorable modifications need to be made to protect the environment [42]. In Europe, the border crossing between France and Switzerland can be seen clearly. This is an indicator of the massive and cascading impact of COVID-19 [43]. This current situation can provide an excellent opportunity to assess how the levels of PM and NO_2 in our ambient air can be greatly improved [44, 45].

In the United Kingdom, the lockdown measures have improved the air quality with measurements of toxic small particulate matter down reduced by a factor of 50 percent in some major cities [46]. NO_2 levels in London also declined by approximately 40% [44]. There have been marked changes in NO_2 emissions in Düsseldorf, Germany linked to less urban traffic due to COVID-19 control measures with constant measurements of down-welling light using a RoX automated field-spectrometer [30]

The National Centre for Atmospheric Science in the U.K reported a drastic decline in toxic NO_2 levels in Birmingham, London, Manchester, and other cities [47]. In European countries such as Liechtenstein, Norway, and Iceland, the amount of energy utilized during various industrial activities and in road transportation account for approximately 54% of the non-methane volatile organic compounds (NMVOC), 51% of the NOx, 30% of PM2.5 and 25% of SOx emissions. Hence the various lockdown measures in these countries had a positive impact on the environment [20]. In Africa, some highly polluted cities and industrial areas in Africa are seeing a significant reduction in atmospheric air pollution due to COVID-19 lockdowns. There has been little or no information to determine the effect of air pollution readings in Africa, but

there is no doubt that the various lockdowns imposed by African countries have a positive impact on the environment [48].

Globally, China contributes considerably to the world's global greenhouse-gas emissions, followed closely by the United States of America and India [29]. Because of COVID-19 containing measures, the country has reported marked improvement in air quality [49]. Satellite data revealed the levels of NO_2 over urban cities and industrial areas in Europe and Asia were markedly lesser when compared to 2019 leading to lesser air pollution [29, 45]. In addition, the Copernicus Atmosphere Monitoring Service has reported a major decrease in nitric oxides and fine particulate matter, air pollutants generated from automobile traffic, and the burning of peat, wood, and coal. With the aid of satellite surveillance and computerized atmospheric models, researchers have discovered a 20 to 30 % decrease in the surface particulate matter over huge swathes of China [50]. Within the last two months, the increased improvement in environmental air pollution is projected to have saved the lives of close to 4,000 children under 5 years, and 73,000 adults above 70 years in China [51].

In India air pollution is among the world's worst; the Himalayas for the first time can easily be seen by the populace of the country. In Delhi, with poor quality air, levels of harmful atmospheric gas have been reduced greatly [52]. With the lockdown measures put in place, the level of environmental pollution reduced by more than 40% within this period in the Kolkata megacity. So, decreases of PM10, NO_2, SO_2 and O_3 have a greater effect on cloud lightning flashes in the pre-monsoon period [53]. Similarly, in Kazakhstan, there was a decline in the PM2.5 levels by 21% in 2020 compared to the same period in years preceding the lockdown with considerable spatial differences in Almaty, Kazakhstan [54].

In the United States, cities such as New York and San Francisco that have documented a considerable amount of COVID-19 infection among the populace possess some level of environmental air population while other cities such as Hawaii and Maine have fewer cases of COVID-19 related infections [55]. Moreover, in Canada, the levels of NO and nitrogen oxides significantly lessened across Ontario, with both pollutants displaying their least levels ever recorded [56].

Improvement in land and water pollution

A direct impact of the COVID-19 pandemic has been, water quality improvements owing to reduced release of industrial effluents. In most countries worldwide, social distancing measures have led to cleaner beaches and crystal-clear water as seen in beaches in Mexico, Ecuador, and Spain [57]. The COVID-19 pandemic has led to a significant reduction in the quantity of solid and liquid waste generated from construction and industrial processes that account for a significant amount of water and soil pollution. In addition, due to the decrease in export/import activities, the movement of a large ship and other sea vessels have reduced drastically, leading to a significant decrease in marine pollution [58].

The lockdown periods across several countries saw several industrial activities such as crude oil spillage, wastewater disposal, and heavy metal pollution that affect the aquatic ecosystems greatly reduced [59]. There has been a reduction in shipping traffic across various water bodies worldwide, and it has been estimated that international shipping accounts for a total of 2.5% of greenhouse emissions, hence this greenhouse reduction is helping in reducing the rate of acidification and deoxygenation of these water bodies [59]. It is estimated that in this current pandemic an estimated 129 billion and another 65 billion gloves are used every month, the challenge it poses is that these used items find their way into rivers and oceans and may increase the risks of survival for fishes and other sea animals [60]. A positive impact of the COVID-19 pandemic has been noticed in Venice's canals in Italy, the waters in the canal are seen to appear cleaner with a corresponding decrease in water pollutants and increase aquatic activities [60].

Improvement in environmental noise pollution

Noise pollution has been reported by the World Health Organization to be a key source of environmental pollution. The recent pandemic has had a marked impact on noise generated in the environment in relation to road, rail, air, and ship traffic (61). The COVID-19 pandemic has

led to a significant decrease in the level of noise pollution in most countries. A significant proportion of this diminished pollution has been linked with major reductions in both air, rail and water transportation. Residents of aerotropolitan areas have reported a significant drop in noise stress associated with air transportation [62]. Also, the reduction in shipping traffic across various water bodies worldwide has resulted in less environmental noise disturbance for wildlife inhabiting these water bodies [62].

Further, a reduction in the utilization of both private and commercial public transportation, as well as economic activities and social events has led to an overall decrease in noise pollution [57]. Data obtained from research conducted in Ireland and India to determine the effect of lockdown on noise pollution there was a significant decrease in sound levels at major sound monitoring stations during the lockdown period as compared to the period prior to when the lockdown began [63]. These highlighted observations are a typical representation of the situation report in other countries of the globe and this goes a long way in improving the health and wellbeing of both humans and animals given that exposure to environmental noise pollution is associated with the increased production of free radicals, and consequently, oxidative stress which underlies the pathological mechanism of a large number of diseases [64].

Detrimental effects of COVID-19 on land and water

The increased use of Personal Protective Equipment (PPE) in most developing countries has led to an increase of their disposal in open dumps and the long run these wastes find their way into nearby rivers hence leading to water pollution. Since the COVID-19 pandemic started, medical/municipal waste generation has increased worldwide, which is of significant public health concern. Worldwide there has been a substantial decrease in trading of agricultural/fishery products which has led to the accumulation of a large amount of organic waste; in addition, surveillance and examination of the biological ecosystems have also been halted and all these have contributed greatly to unrestricted harvesting, encroachment, and increase in land/water pollution [65]. It is reported that most isolation wards, quarantine centers and individuals quarantined at home are all leading to the accumulation of a considerable number of biomedical wastes, hence it is seen that the exponential rise of hazardous waste and management has become a major problem besieging local waste management authorities [66]. To curb the environmental contamination with the SARS-CoV-2 virus, a significant number of disinfectants and other chemical compounds are being sprayed on roads, industrial/residential areas to decontaminate the environment, these activities may also destroy some beneficial flora and fauna present in the environment [58]. Around March 2020 at the peak of the COVID-19 epidemic, the Cisadane river in Indonesia saw a massive pile-up of syringes, used masks, and other personal protective equipment [66]. This was attributed to the collapse of the landfill wall causing a substantial amount of waste to clog a large proportion of the Cisadane River, the authorities at that time were concerned about the environmental impact these wastes could cause on the citizens and the aquatic life [66].

Inappropriate handling and sorting of household/healthcare waste may pose serious public health implications and a negative impact on the environment. The need of thorough management of healthcare waste has been key since the COVID-19 pandemic began in late 2019. The accumulation of household waste due to reduction in recycling is one of the negative effects of COVID-19 on the environment [57]. As various countries are combating the COVID-19 pandemic, the health sector is most likely to see a considerable level of medical wastes emanating from used PPE and other wastes. Some of these wastes such as masks, disposable gowns, or gloves are made of polystyrene or polyester which are usually non-biodegradable with a long afterlife. There is also the challenge of disposal of leftover decontamination chemicals. The tendency to decontaminate and disinfect frequently in medical facilities and households during this pandemic is making the waste management industry overwhelmed by huge accumulating wastes [57]

Hospital wastes contaminated with infectious materials are becoming a major concern for many health care facilities. Patients and hospital workers are rapidly utilizing medical materials leading to piling up of medical waste that must be discarded safely. In Wuhan, China, Medical

Facilities produced six times as much medical waste at the peak of the COVID-19 outbreak as they produced before it all began. They produce a daily output of 240 metric tons of medical waste. Unprofessional use of face masks can lead to a severe environmental problem, as solid waste and microplastic pollution in the marine/freshwater ecosystems can occur. Improper disposal of face masks raises serious environmental threats [27]. With the persistence of the COVID-19 pandemic across the world and adversely affecting the public health and economic wellbeing of various countries, it is important that governments worldwide begin to pay more attention to waste management to help improve human and environmental health [67]. Good waste management impacts the environment positively and proper handling and disposal of these wastes act as essential keys in effective emergency response. Fragments of infectious SARS-CoV-2 have been found in untreated sewage in some countries [68].

In Nigeria, a study revealed that due to the COVID-19 preventive measures instituted, generated wastes are left unprocessed and uncollected in the community. This is in addition to the increase in the generation of hospital or medical infectious wastes by pharmacists, medical shops, and hospitals/clinics. There is also an increase in the felling of trees for fuel purposes which have a negative impact on the environment [69].

In the management of municipal solid waste from households and hospitals, various waste treatment facilities are mainly equipped in treating such waste materials to steady and predictable quantity of waste, but the COVID-19 pandemic has really put a lot of strain on the various environmental agencies in many countries across the world [70].

There has been an increase in the generation of organic waste from several households across several countries as well as there is an increase in online purchases of food items that are in packages leading to an increase in inorganic wastes [57]. It can also be seen in a country like France that the movement of residents of urban cities to rural communities prior to the enforcement of the lockdown measures is a likely source of strain to such rural areas' waste management programs [71].

The pandemic has made countries like the USA halt recycling activities in some major cities to prevent the spread of COVID-19 in the recycling centers. The same decrease in recycling activities and waste management has been seen in most European countries most notably in Italy, where residents have been restricted from sorting their waste [57].

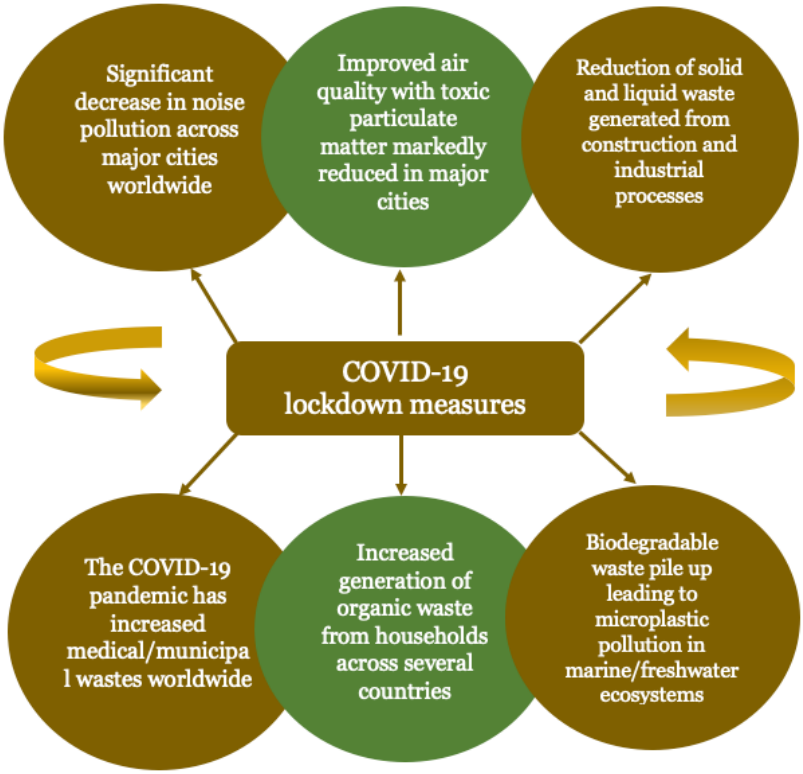

Figure 2. Summary of the impacts of COVID-19 pandemic on environment

Due to the poor establishment of proper waste management program mostly in developing countries, it can be seen that improper disposal of hazardous wastes can further aid in the spread of the SARS-CoV-2 [72].

In China, wastewater treatment plants have had to improve on their disinfection activities. This has been mainly achieved by increased use of chlorine in such water treatment plants, which was done to prevent the spread of the SARS-CoV-2 infection via wastewater. In the long run the excess use of chlorine could be detrimental to people's health [57]. In Hong Kong, where COVID-19 started earlier in the year, there has been widespread environmental pollution, an NGO Ocean Asia reports that a considerable amount of disposable masks was seen to litter about 100-meter stretch of beach. Few of these masks have been seen over the year in water bodies, but recently they are spotted along the high tide line and are constantly been washed up along the seashore [60].

The COVID-19 pandemic has seen a substantial usage of disinfectant products in many households worldwide. This can lead to a large amount of waste water containing traces of sodium hypochlorite and this chemical agent can find its way into landfill leachate. There have been findings of observing traces of SARS-CoV-2 in waste water and the continuous use of disinfectant in cleaning outdoor spaces across various cities in the world can result to the entry of disinfectants and their by-products into water drainages and their subsequent discharge into rivers and coastal waters which can lead to water pollution and affect aquatic life [73]. The summary of the impacts of COVID-19 pandemic on environment is provided in **Figure 2**.

Mitigation strategies to reduce detrimental effects of COVID-19 on the environment

Proper and safe disposal of household and biomedical wastes generated during this ongoing COVID-19 pandemic period is essential to help curb the propagation of environmental hazards [62]. International best practices for effective and safe management of biomedical and household waste should be adhered to along with ensuring that there is sufficient manpower and material resources that will help in the appropriate management of waste generated during this period. It is important that local authorities in each country set up contingency plans that will be supervised by well-trained professionals to ensure that regular waste disposal services in each municipality are never interrupted. There should be plans to ensure arrangements for extra waste trucks to be provided in case there is a breakdown of those in use, also there is a need to ensure that there is adequate environment health personnel working round the clock to make certain there is never a time when there is a shortage of staff. As additional waves of COVID-19 are being reported around the world, the role of waste workers and environmental health workers needs to be considered essential and vital [74].

It is important that policies be set up by countries that will ensure an assessment of national waste management capacity on a regular basis to make sure adherence by the individual states in each country. Sustainability Assessment of technologies (SAT) methodology, best available technology (BAT) and best environmental practices should be adopted by countries worldwide to help mitigate the deleterious effects of waste generated during this period [75].

As a sizeable amount of waste has been reported to be produced by health care facilities during this pandemic, it is important to determine the population of waste/environmental health workers involved in medical waste operations of optimum management and help assess their level of knowledge in handling medical wastes and organize regular training to ensure that they maintain environmental best practices in their daily activities. There is also the need for the assessment of waste management capacities not only within the hospital environment but also in humanitarian hotspots like displacement and informal settlements to make sure that there is no buildup of deleterious wastes in the environment, and emphases need to be paid by developing countries that harbor such camps [76].

One of the key strategies in protecting the environment from these deleterious wastes is the classification of waste based on origin, it is recommended that unique waste bins with a distinctive marking be provided at hospitals, isolation centers, households, and others to be

used in collection of COVID-19 related wastes. These waste bags should be disinfected and be double-layered sealed before transportation for further processing and disposal [62, 69]. As the second wave of the COVID-19 is sweeping majorly in most European countries, it is recommended that more designated waste disposal treatment facilities in municipal areas should be created to help meet up with the increasing levels of household/biomedical waste that are being generated. The use of incineration is also a safe alternative to take care of a large volume of waste. A temperature of >1000^{o}C is usually recommended for this purpose, in most instances the left-over mass after incineration is re-incinerated to further reduce the quantity of the final end product of processing [62].

Good COVID-waste management was put in place by South Korea by further tightening their Wastes Control Act and the new guidelines state that COVID-19 related wastes must not be stored for more than 24hrs and must be incinerated. This policy must be replicated by most municipal areas across various countries worldwide and must involve strict monitoring by the local environmental municipal agencies. The use of an on-site mobile waste disposal facility can also help in mitigating the harmful effects of waste build-up across several health care facilities and households [73]. Another important means of reducing the menace of the buildup of wastes in most cities worldwide is by safely burying them in the designated area thereby protecting the environment [74].

The buildup of fecal sludge and wastewater from various households and healthcare facilities is also of environmental concern. To protect farmlands and recreational waters, these liquid wastes must first be treated and be disposed of safely to prevent environmental pollution [68,77]. Overall, the COVID-19 pandemic has made people worldwide aware of the need to adhere to good waste disposal activities. Hence better enforcement of household and medical waste guidelines by local municipal authorities will help protect the environment more efficiently.

As the COVID-19 pandemic ravages on, it is necessary that there is adequate planning and designing of wastewater collection and treatment systems in various cities and particularly in hard-to-reach areas to help mitigate the negative effects of environmental pollution, emphases should be placed on regular cleaning and clearing of water drainages, redesigning of landscape to help in the process of wastewater treatment.

To further help entrench the culture of proper waste proposals there need to outreach via environmental health agencies to various health care centers and households to create more knowledge of appropriate segregation, storage, coded bag use, labeling, and safe disposal of waste. There is also a need of sanctioning more licensing of waste disposal companies, multi-sectorial or inter-municipality and transboundary cooperation, and finally the practice of re-use and recycling of waste products equipment [75].

Conclusion

The universal transmission and spread of COVID-19 under the influence of environmental conditions justify concurrent research on coronaviruses and socio-ecological systems [18]. Although the positive and negative environmental impacts of the COVID-19 pandemic may not last longterm, it is key that efforts need to be put in place to protect the environment from the deleterious effect of climate change [78]. The ongoing outbreaks posed very serious challenges in the renewable energy sector, such as delays in the supply of deliveries, hitches in stock markets, and the risk of not benefitting from governments' yearly incentives. However, the pandemic has proved that we can create green jobs, reduce carbon emissions to the environment, and change our deleterious attitudes towards nature. We can see clearly that the COVID-19 responses across countries through various policies, restrictions, and legislation can serve as a major force in protecting the environment and hence help reduce the negative effects of climate change [54]. Our report highlights the relevance and significance of continuing to enforce ongoing regulations on air pollution as a public health measure and adopting appropriate mitigation strategies to protect the environment and safeguard our health during and after the COVID-19 pandemic in a sustainable manner.

Ethics approval

Not required.

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Conflict of interest

The authors declare that they have no competing interests.

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Underlying data

All data underlying the results are available as part of the article and no additional source data are required.

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