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Environmental Footprint of Covid-19 in India: Short Term 'Green Effect' but Long Run Pitfall

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Abstract

The outset of novel coronavirus namely SARS-CoV-2 or COVID-19 first came into the limelight in Wuhan, China in December 2019 and was soon declared a 'global pandemic' by W.H.O. in March 2020 after realizing its highly infectious and transmission capability and its potential to develop severe pneumonia-like respiratory infection amongst the humans. This declaration along with the rising number of COVID-19 infected cases and deaths globally led to the complete locking down of countries and cities, thereby limiting all unnecessary human movement and activities by way of imposition of strict measures to control and minimize the spread of the virus. This study reveals that this sudden halt of all major activities and movement resulted in providing a much needed temporary short-term relief to the environment from excessive exploitation at the hands of humans which has caused alarming levels of environmental pollution and GHG emissions, particularly in India. However, on the downside, it has also added a substantial burden on the environment by creating a panic-like situation leading to more than usual waste generation and an enormous challenge of its effective management and disposal which is most likely to persist in the longer run. On the whole, this review points out that years of damage done to the environment cannot be undone by although crucial but short-term relief resulting from such a temporary halt of activities. In the wake of this situation, an attempt has been made to discuss the future challenges that lie ahead of us and recommend possible solutions based on a holistic integrated planning approach which is the need of the hour to tackle the pertinent issue.

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Introduction

During the past few months, the term 'Coronavirus' has probably attained the distinction of being one of the most if not the most deliberated matters of concern throughout the world primarily due to the severity and magnitude of deaths and health-related problems it has caused. Coronavirus was first described by Tyrell *et al.*[1] who were able to cultivate the viruses from patients with the common cold in 1965. The term 'Corona' means 'Crown' in Latin and the virus was so named because of its identified morphology of spherical virions with core-shell and spike projections on the surface,[2] which essentially resembled a crown.[3] As per Ma *et al.,*[4] coronaviruses are enveloped RNA viruses that are broadly distributed among mammals, humans, and birds with the potential to cause respiratory, neurologic, hepatic, and enteric diseases.

A novel coronavirus (nCoV) is a term used for a form of the virus that has been newly identified and was not detected in mankind earlier.[5] The newest strain of coronavirus was first reported in Wuhan of Hubei Province in China in December 2019. Although initially reported as an acute respiratory infection with an unidentified origin6, a careful examination of the respiratory samples of this infection revealed clinical features similar to viral pneumonia.[7] Subsequent investigations led the experts at PRC Centre for Disease Control to conclude that the pneumonia was effectuated by a novel coronavirus and the infection was hence named Novel Coronavirus Pneumonia (NCP). This new virus strain was officially named SARS-CoV-2 while the World Health Organization termed it 'Corona Virus Disease 2019' or 'COVID-19'[8] and declared its outbreak as a pandemic on March 11, 2020.

As it was a new strain with little existing knowledge about it, it became imperative to find out about its origin which could then serve as the starting point for all subsequent research and contact tracing. In the pursuit to know the source of the spread, it was revealed in a study based on genome sequences that SARS-CoV-2 is closely related to BatCoV RaTG13 (a bat coronavirus that was previously detected in *Rhinolophus affinis* in Yunnan Province, China).[9] This view was supported by Velavan *et al.*[2] who pointed out that SARS-CoV-2 whose whole genome level is more than 95% similar to a coronavirus detected in bats, was seemingly successful in making the initial animal-to-human transition in the Huanan seafood market in Wuhan, China where live animals were sold. However, it became evident by further investigations that some people contracted the virus despite no record of their visits to the seafood market and this observation implied the human-to-human transmission capability of this novel coronavirus which was evidenced by subsequent reporting of such cases in more than 100 countries. The spread or transmission of the virus between humans took place as a result of close contact or exposure to cough, sneeze, respiratory droplets, or aerosols of the infected person.[10,11] Despite these findings, the origin of the virus remains a controversial issue to date as some other studies have suggested differently that the virus originated from ant eaters or pangolins.[12] Thus further investigation is needed to confirm the source and origin of the virus.

When the first and arguably the most lethal wave of Covid-19 established its presence in almost all continents as shown by the region-wise number of weekly cases and deaths in Figure 1, its profound impact was felt in almost every sphere of human life including economy, business and education but most significantly in the two fields of healthcare and environment. Within a fortnight of the advent of the first wave in most countries, the healthcare sector was burdened with such an enormous number of Covid-19 cases and deaths that it had neither expected to witness nor was capable of handling simultaneously. According to the region-wise data released by W.H.O.,[13] more than 37 million confirmed cases of Covid-19 were reported worldwide out of which about 1 million cases resulted in deaths during the period ranging from 31 December 2019 to 11 October 2020 (which roughly coincides with the first wave period in different countries taken together). During this period, the intensity of the spread in India was so high that out of the total 7911036 cases reported in South-East Asia, India alone accounted for 7053806 cases. These were whopping numbers that even the most sophisticated healthcare sectors around the world never anticipated or prepared to encounter simultaneously and therefore this led to the breakdown of healthcare systems even in some prominent countries.

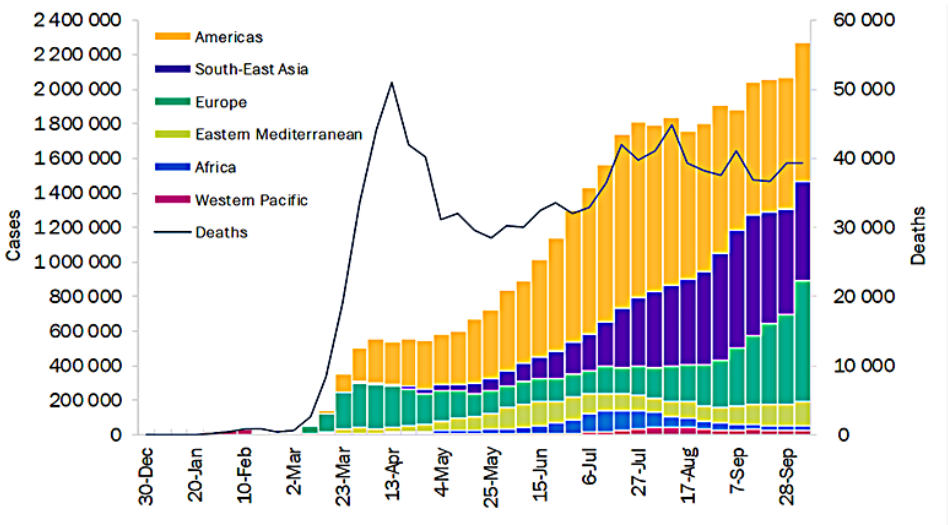

Fig. 1: Region wise weekly report of Covid-19 cases and deaths from 30/12/2019 to 11/10/2020
Source: W.H.O.[13]

In order to break the chain of the spread of this virus and given its potential to cause irreparable devastation, the authorities and governments around the world were forced to enforce lockdowns and shut down all activities to counter its spread and limit the number of new cases and deaths. Of all the negatives the virus caused, one major positive that came out of these pandemic-induced lockdowns was seen on the environmental front in the form of much-needed cutbacks on the pollution and contamination of the environment. The pollution levels which over the past few decades were dangerously breaching extremely high levels significantly dropped during the first wave. Nature started to reassert itself with the drop in the air and water pollution levels and various kinds of lockdowns and shutdowns imposed started proving to be quite successful not only in breaking the chain of infection but also in the vital healing of the ecosystems and the environment.[14,15,16] As a result, although the coronavirus pandemic led to a significant loss to humans and families around the world, apparently it also resulted in catalyzing a desirable 'Green Environmental Effect' during the first wave which is reviewed in this paper from an Indian perspective. The drawback or flip side of the coin is also taken up in this study, which is the detrimental environmental impact of Covid-19 that was also quite evident as the use of cleansing and sanitizing materials multiplied manifold which extensively burdened the limited ecological resources. Given the scenario, this study finally concludes with a brief discussion of future environmental challenges and recommends possible solutions.

The Green Effect of Covid-19

As humanity was forced to retreat indoors due to the imminent danger posed by the coronavirus, the natural environment and its components seem to have been liberated from the cages of humanity-induced pollution. The various water bodies which notoriously became dirty looked cleaner, with the haze dispersed and smog gone the air felt fresher and easier to breathe and the wildlife seemed reasserted with less trespassing of the humans. Ghosh *et al.*[17] suggest that the environment is probably the only sector that has benefitted from this Covid-19 situation. It seems like the natural environment which we have exploited extensively over the past few years is benefiting from our absence. In the following sections, we have attempted to discuss some of the most obvious positive impacts or the 'Green Effect' of the coronavirus pandemic-induced lockdowns on the quality of the environment based on a careful study of recently published data from research articles and some prominent Space Organizations like NASA and ESA.

Air Pollution and Climate

According to the data published by W.H.O., it is estimated that 7 million people lose their lives each year worldwide due to outdoor air pollution and the urban population exposed to unhealthy air is more than 80%.[18] As far as India is concerned, the situation is severe if we consider the fact that air pollution causes around 16000 premature deaths and more than 350000 new cases of childhood asthma every year.[19] As the spread of the virus became largescale, the people restricted themselves to their homes and all industrial and travel activities came to a standstill in lockdown. A considerable improvement was seen in the air quality and a drop in the release of harmful emissions caused by these activities.[20] The following factors are some of the most important components that determine the quality of air and hence they have been reviewed to determine the influence of Covid-19 on the quality of air and pollution.

Air Quality

Aerosols refer to tiny solid and liquid particles which are suspended in the air with the capability to cause reduced visibility and damage to the heart and lungs of living beings. The sources that lead to the aerosol suspension include to some extent natural sources such as volcanic eruptions, forest fires, and dust storms. But the main sources include human activities such as the burning of croplands and fossil fuels that contribute the maximum to aerosol levels and have great potential to cause damage to human health.[21] It is measured in terms of Aerosol optical depth (AOD) which simply indicates the extent to which direct sunlight is obstructed from reaching the ground by the tiny aerosol particles. An aerosol depth or thickness of value less than or equal to 0.1 indicates a clean atmosphere whereas a value greater than 0.4 indicates a hazy condition.[22]

It was on March 25, 2020 when the Indian Government placed 135 million citizens under a nationwide lockdown which was further extended multiple times to counter the spread of coronavirus and the consequent drop in the aerosol levels was almost immediately evident. After just a week of reduced industrial activity and traffic caused by the government's mandate, a 20-year low of aerosol optical depth (AOD) for that time of the year was observed by the NASA satellite sensors for the Northern Indian region as depicted in Figure 2. Similarly, time-averaged visual maps (Figure 3) plotted online for the months ranging from January to April on NASA's GIOVANNI website by Verma *et al.*[23] also show a considerable decline in other air pollutants like NO_2, SO_2, and CO besides aerosol after the lockdown was imposed in India. The work of Dasgupta *et al.*[24] which is based on the study of 5 air pollutants (PM10, PM2.5, NO2, CO, and Ozone) during the initial lockdown days in India also confirms that lockdown is indeed positively related to better air quality in some of the most polluted cities of India like Delhi, Gurugram, Mumbai, Jalandhar Ahmedabad, Varanasi, Ghaziabad, and Jaipur.

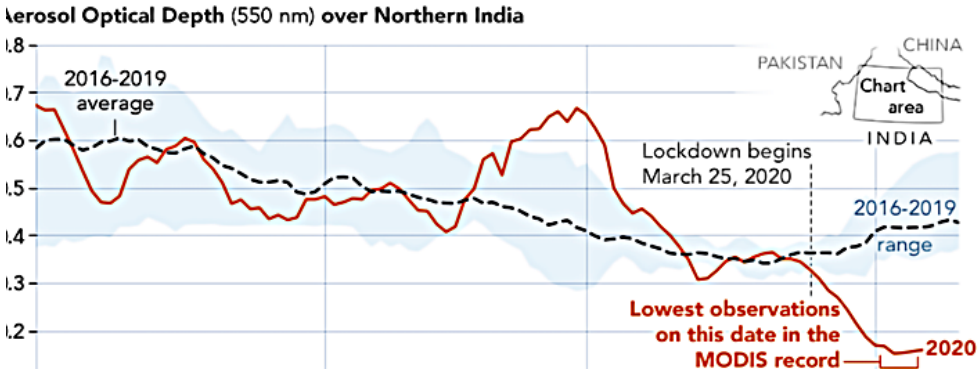

Fig. 2: AOD levels in Northern India for the period Jan 2020 to April 2020
Source: Patel[21]

Carbon Emissions

According to Hewage *et al.*,[25] out of the 6 main Greenhouse gases (GHG) specified by the Kyoto Protocol that harmfully impacts the environment, carbon dioxide (CO_2) is considered as the most significant contributor to climate change in the world. Heede[26] states that 80% of global carbon emissions are a result of urban human activities such as the combustion of fuel for power generation, transportation, construction, and industrial operations.

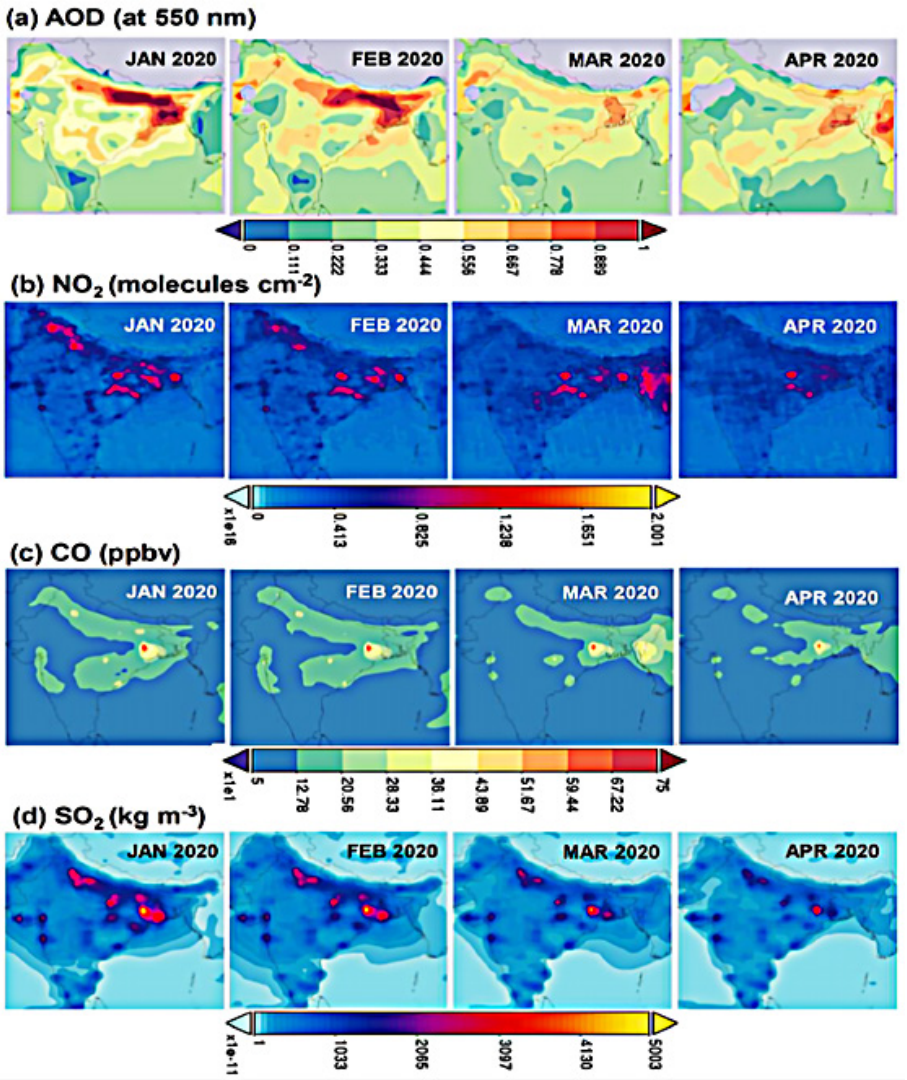

Fig. 3: Time averaged visual maps of a) AOD, b) NO2, c) CO and d) SO2 corresponding to geographical domain of India with coordinates 8N°–35.5N° and 68E°–97E°.
Source: Verma *et al.*[23]

Although the growth of renewable energy sources and sector in India coupled with the Indian economic slowdown since early 2019 played its part in bringing down the country's year-on-year fall in CO2 emissions for the first time in 4 decades in 2020, the main factor that led to the yearly power generation growth and oil demand becoming weak was the compounding effect of the steps taken to the

curb the spread of the virus. The national lockdown imposed by the Indian Government led to a fall in yearly oil consumption by around 18% in March 2020. Similarly, the drastic cut in India's electricity demand as compared to the electricity demand of the years preceding the coronavirus pandemic is evident in Figure 4. As a result of these factors, the first yearly decline in four decades in CO_2 emissions was registered in March 2020 when the emissions fell by 30m tonnes as shown in Figure 5 and by 30% in April 2020.[27]

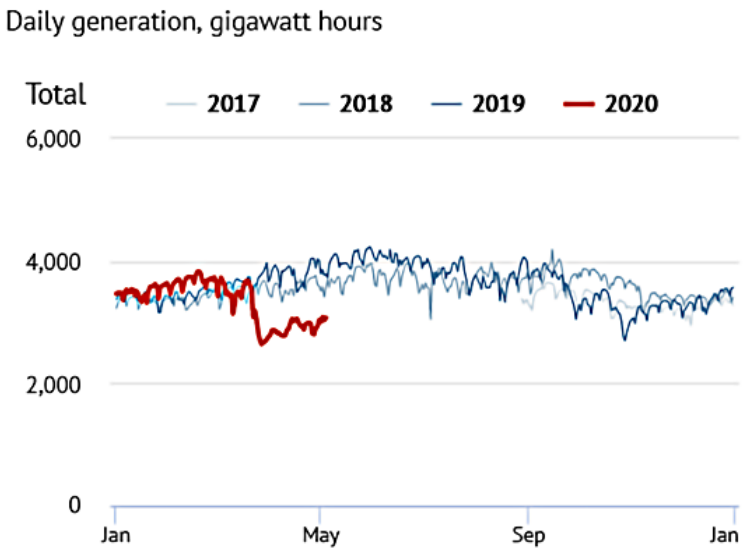

Fig. 4: Steep fall in India's electricity demand during national lockdown in March, 2020
Source: Myllyvirta *et al.*[27]

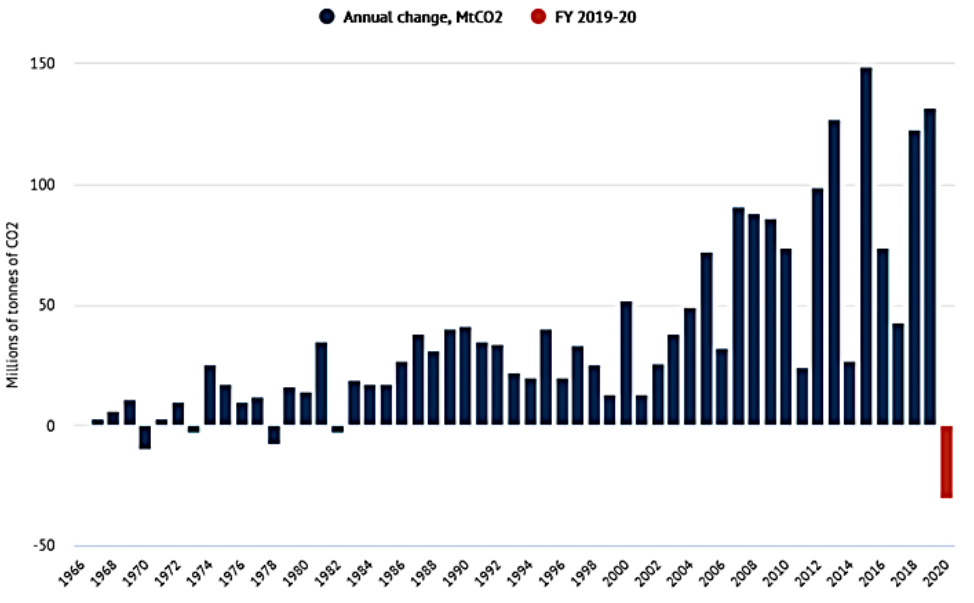

Fig. 5: Change in C02 emissions in India for the period 1966-2020
Source: Myllyvirta *et al.*[27]

Water Pollution and Marine Life

Millions of litres of agricultural and industrial waste is discarded into 55 minor, 14 major and hundreds of small rivers and water bodies in India out of which only a small proportion of about 10% of wastewater gets treated while the rest is discharged as it is into the water bodies. The main source of pollution of our rivers is the industrial waste and sewage that comes from big cities. Another significant water pollutant is the agricultural run-off which is the water that contains pesticides and fertilizers and drains into rivers from agricultural fields.[28] Apart from the industrial and agricultural waste, India's age-long religious and social practices such as cremation near the river banks, disposal of carcasses and ashes in rivers, mass bathing, and immersing offerings add to the pollution load of the rivers.[29]

Jadhav[30] asserts that during the lockdown period, there was a noteworthy improvement in the water quality of major rivers of India. The main causes for this include the significantly less amount of industrial effluents discharged into the rivers during the lockdown and human-related factors like the reduction of cultural and religious activities on the banks of rivers in India.[31] The term water quality refers to the chemical, biological and physical features or characteristics of water which is measured by various water quality indices (WQI) based on several parameters like dissolved oxygen (DO), Biochemical oxygen demand (BOD), and total coliform to determine the quality of water for human use and consumption.[32]

Due to the Covid-19 induced lockdown, one of the most significant and holiest rivers of India Ganga which is also considered one of the most polluted rivers in the world displayed a 40-50% improvement in water quality and became fit for drinking after decades. This was as per the parameter requirements specified by Uttar Pradesh Pollution Control Board[33] such as BOD (less than 2 mg/L), DO (more than 6 mg/L), Total Coliform Organism (less than 5000 per 100 ml), and pH (between 6.5-8.5 Range). What the government was unable to achieve for decades was made possible by Covid-19 Lockdown as Central Pollution Control Board (CPCB) and UPPCB data revealed decreased BOD levels for Ganga and Yamuna even in the most polluted stretches of both the rivers.[34]

Besides Ganga and Yamuna, the waters of minor rivers like Rapti and Saryu in city areas also became transparent as a result of lesser deposition of domestic and industrial waste.[35] Based on the Water Quality Index (WQI) measured by CPCB, samples taken from Mithi river in Maharashtra gave a WQI rating of 51 and 58 during the lockdown which corresponds to a Yellow or "non-polluted" category as compared to a rating of 25.7 and 37.4 before lockdown which comes under the Red or "badly polluted" category.[30] The discharge of pollutants into Buddha nullah which is known to contain effluents from more than 2400 industrial units and carry them into the Sutlej River in Punjab reduced significantly during the lockdown. The positive effect was also witnessed in southern rivers of India as the water quality of River Cauvery and its tributaries like Lakshamanathirtha, Hemavati, Kabini, and Shimsha also returned to levels they used to be decades ago.[31]

As the water quality became better and nautical activity came to a halt, it consequently proved quite suitable to the aquatic life and marine species as well. Freshwater ecosystems appeared rejuvenated which is evident by a study carried out around the Haldia port cum industrial complex that highlighted the eco-restoration of the Ichthyoplankton community (larvae and eggs of the fish) due to lower amount of grease and oil pollution during lockdown.[36] A similar investigation conducted at Diamond Harbour along Hooghly estuary revealed a greater amount of phytoplankton (microscopic marine algae which is fundamental to much of the aquatic food web) in April 2020. During the lockdown, reports began to surface about the rare spotting of Gangetic Dolphins from Meerut to Kolkata and even critically endangered species like Malabar Large Spotted Civet were found in the lanes of Kozhikode, Kerala.[37] The South Asian River Ganges dolphins which had become critically endangered began to be spotted in the Ganga River after almost 30 years. A massive increase in the number of flamingos who migrate to the area every year was also witnessed by the residents of Navi Mumbai as the birds appeared in tens of thousands this time around.[17]

With commercial establishments and factories closed, commercial and fishing vessels anchored at ports, tourism subdued and people-free beaches

have not only led to the recovery of fish stocks in the water bodies but have also reduced the trauma caused to marine creatures through noise pollution generated from nautical activities like shipping and powerful seismic air gun blasts which are used to find the location of deposits of oil and gas in deep waters. There are also lesser chances of injuries to sea creatures caused by entanglement and indigestion of hazardous plastic and other marine debris.[34]

Downside of Covid-19 in relation to the Environment

Although the Covid-19 scenario has benefitted the environment and the ecosystem in the short run, the same cannot be claimed with confidence for the long term. Apart from the positive impact that the coronavirus pandemic has caused on the environment, there is a negative aspect to it as well. The use of cleansing and sanitizing materials and substances along with medical supplies which were earlier used sparingly have multiplied manifold. The coronavirus has incited such fear and uncertainty among the people that they began retorting to activities like hoarding, stockpiling, and overuse of resources. This has further created problems of excess waste, improper handling, and inappropriate disposal. The lockdowns and their repeated extensions to counter the spread of the virus has resulted in breaking the backbones of even some of the strongest economies of the world. The demand and supply networks and chains have collapsed even for some of the most essential commodities. The challenge possessed by the question that how the countries will recover after the pandemic gets over is magnanimous.

Contrary to the Basic Idea Behind the Concept of 'Green'

The concept of 'Green' basically revolves around all initiatives undertaken with the intent of reducing pollution and carbon emissions on the planet. These initiatives can be broadly classified into three types of activities or strategies i.e. Reduce, Reuse and Recycle which are primarily needed to lessen the burden of excessive human activity.[38] However, the scenario so far during this Covid-19 pandemic in some cases is quite opposite or contrary to these 3 basic principles of Green which have the potential to cause long-term repercussions as far as environmental sustainability is concerned. Instead of Reduce, Reuse, and Recycle, what we are seeing is the Overuse, Single use, and Disposal of resources respectively as depicted in Figure 6.

A significant rise has been seen in the use of soaps, hand rubs, and hand sanitizers containing isopropanol, alcohol, and disinfectants which were previously utilized sparingly. Large quantities of disinfectants like chlorine, hypochlorous acids, and also sodium hypochlorite which is known to be very toxic to the microorganisms and the environment are being used in almost every place with human activity to kill the virus.[8] Antibacterial soaps that contain hazardous chemicals like triclocarban and triclosan[39] are also being used extensively. These chemicals do not get degraded easily and also represents around 60% of the mass of drugs normally found in the mud or sludge of sewage or treatment plant of wastewater which poses a great threat to aquatic life and fauna.[40]

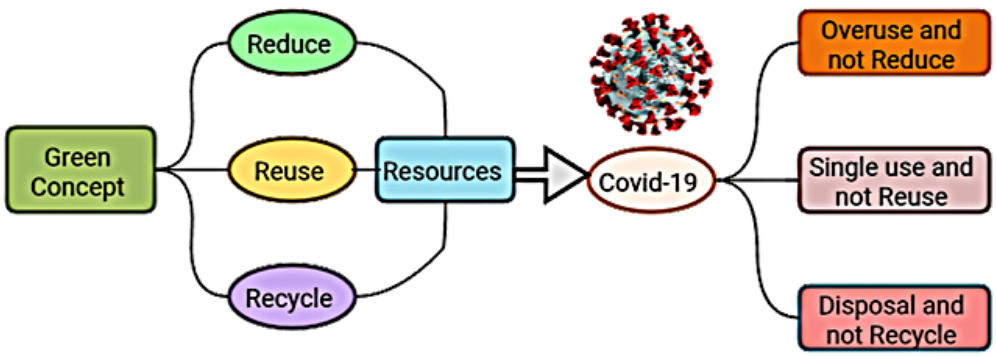

Fig. 6: Impact of Covid-19 on the usage of resources
Source: Author

Excessive Use and not Reduce

Qiu *et al.*[41] pointed out that it is highly probable that pandemic-induced lockdowns will cause people to likely engage in panic buying and excessive hoarding of even the most essential commodities despite their regular supply being assured by various states. This was evident in India as Bhushan[42] reported a significant change in the buying pattern of consumers who usually bought 1-2 kg of rice were now purchasing 4-5 kgs of rice during the initial outbreak of the virus. This pandemic triggered panic purchase of not only food items but also of things like cleaning goods and products, toilet papers, gloves, disinfectants, alcohol-based sanitizers, and face masks.[43] The fear of the novel Covid-19 was such in India that the recommended protective gear like disinfectants, sanitizers, and masks were rapidly reported out of stock in shops and outlets.[44] The comparative rise of stock outages of rice and disinfectants in India and select countries is shown in Tables 1 & 2 for pre lockdown period (random week in January 2020) and lockdown week respectively (the week in March 2020 in which national lockdown was first imposed in India).

Table 1: Comparative Stock Outage of Rice between January and March 2020 in India & select countries

	January 2020 (Pre-Lockdown)					March 2020 (Lockdown)				
Country	**27/01**	**28/01**	**29/01**	**30/01**	**31/01**	**23/03**	**24/03**	**25/03**	**26/03**	**27/03**
India	30.45	30.86	31.82	32.43	30.27	53.9	62.03	90.34	89.72	79.31
Indonesia	0	0	0	0	0	1.57	1.57	3.53	5.08	5.08
Ireland	0	0	0	0	0	0	0	0	0	0
Japan	4.2	4.16	4.26	4.12	4.05	3.95	4.91	4.54	6.36	5.3
Mexico	0	0	0	0	0	0	0	0	0	0
New Zealand	0	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	3.7	2.24	2.31	2.36
Saudi Arabia	6.61	7.32	7.38	4.24	4.17	10.87	9.47	5.56	1.15	0

Prepared by: Author; Data Source: Sareen *et al.*[45]

Table 2: Comparative Stock Outage of Disinfectants between January and March 2020 in India & select countries

	January 2020 (Pre-Lockdown)					March 2020 (Lockdown)				
Country	**12/01**	**13/01**	**14/01**	**15/01**	**16/01**	**20/03**	**21/03**	**22/03**	**23/03**	**24/03**
China	1.55	1.52	1.64	1.6	1.57	3.47	4.07	4.08	3.56	4.1
India	54.14	54.62	59.82	57.64	59.76	86.77	88.52	89.32	87.12	88.48
Italy	5.24	5.09	5.52	5.71	6.07	9.1	9.78	1.55	12	13.72
Japan	5.7	5.67	5.7	5.74	5.93	24.46	24.88	23.59	23.77	23.68
Spain	3.88	4	4.01	3.68	5.09	11.45	14.68	14.31	17.19	17.48
U.A.E.	6.78	2.93	2.86	3.33	4.18	2.99	42.12	39.38	3.35	2.92
U.K.	7.44	6.55	6.57	6.59	8.12	27.63	29.27	22.92	22.61	29.08
U.S.A.	11.05	10.98	11.31	11.02	11.47	18.31	19.08	18.58	17.88	17.27

Prepared by: Author; Data Source: Sareen *et al.*[45]

Single Use and Not Reuse

In the wake of the highly transmissible capability of the coronavirus and health concerns related to it, people are opting for the single-use and not reuse of products and items made of plastic which is against the restrictions imposed by many countries regarding its use. Most of the gear being worn around by people to protect themselves from the coronavirus such as PPE kits, medical equipment, face masks, and gloves is made from plastic and is being carelessly disposed off by people after a single use. Many shopkeepers and grocery stores have disallowed customers from bringing their own reusable carry bags and serving them products in single-use plastic bags in fear of contamination from the virus.[46]

Disposal and Not Recycle

Besides the excessive and single use of commodities by people during Covid-19, the pandemic has also resulted in the recycling industry being affected adversely due to the lockdowns and social distancing measures adopted by governments and institutions. The competitiveness of recycled plastic with virgin plastic has been negatively impacted due to the fall in the price and demand for oil47. Recycling activities have also been disrupted in developing nations that are dependent on foreign technologies for recycling their waste and hence the majority of the generated waste in Covid-19 is being disposed off instead of being properly recycled.[43]

Excessive Waste and Waste Management

Protective and containment measures adopted to restrict the spread of coronavirus have influenced the consumption patterns of consumers by raising the demand for household and medical products like food items, groceries, sanitizers, face masks and shields, multivitamins, soaps, disinfectants, and other cleaning products. This rise in demand has, in turn, led to a surge in domestic household and medical waste being generated creating further problems regarding its environmentally friendly handling and disposal.

The study of Bhakta *et al.*[48] highlights that panic buying along with unnecessary stocking of items with low shelf life and hoarding of perishable food items without cold storage facilities will increase the generation of domestic waste significantly. The study also points out that the surge in online orders of food and groceries due to lockdowns is likely to give rise to more packaging (plastic and paper) waste. According to W.H.O.,[49] healthcare waste or biomedical waste refers to the waste and by-products generated by healthcare centres and facilities, mortuaries, research centres, and labs. The biomedical waste generated by a Coronavirus patient per day is about 14 kg more than a normal patient.[37] Medical experts have estimated a 15 times increase in biomedical waste in India from 0.3-1 kg waste per bed per day in a normal situation to 4.5-15kg waste per bed per day in the Covid-19 scenario. For instance, In a particular week in 2020 (13-18 May 2020) in the state of Kerala alone, a massive 2-2.5 tons/day which is equivalent to a 13000 kg/day increase in biomedical waste was reported.[50] Similarly, a surge by double in health care waste from around 550-600 kg/day to 1000 kg/day was observed during the first phase of lockdown in Ahmedabad city in March-April, 2020.[51]

With the recycling activities blemished due to lockdowns and restricted transportation provisions, this sudden rise in waste generated has resulted in putting an enormous burden on the already limited recycling capability in India and is turning the situation into a waste management nightmare. Singh *et al.*[52] state that India produces 550 tons of healthcare waste approximately in a normal scenario which is treated by a meagre number of Common Bio-Medical Waste Treatment Facilities (CBMWTF) and captive incinerators which are 198 and 225 respectively. This limited capacity has been pushed to the limits by the outbreak as a report by Central Pollution Control Board[53] highlighted that most of the states in India namely Delhi, Rajasthan, Bihar, Assam, Uttarakhand, Tamil Nadu, Orissa, Goa, and Kerala ran out of capacity in May 2020 to treat the growing quantity of biomedical waste and 70-90% of the states' CBMWTF capacity was already utilized. The duration for which this outbreak of coronavirus will continue cannot be estimated with certainty. This difficult situation of waste disposal and management in India can quickly go out of hand if the novel coronavirus (which has already evolved into many variants) induced pandemic continues for a few more months and the trend in the amount of waste generated remains the same as it has been for the past one year.

Future Challenges

There is no doubt that coronavirus and related lockdowns have provided much needed relief to our surrounding environment in the short term but it has also mounted some serious long-term adverse challenges on the ecosystem which need to be dealt with in the coming future. It is important to point out that short-term favourable circumstances for the environment resulting from lesser human activity cannot undo the years of harm done to it through excessive human trespassing and activity. Also, the enormous pressure under which the environment and the limited resources will be placed under once things get back to normal in order to cover the losses that occurred during this pandemic is not hard to imagine. It will require extraordinary efforts and careful holistic integrated planning to sustain the 'Green Effect' of Covid-19 that has been observed over the environment. We have summarized some of the imminent challenges that lie ahead for us and their possible solutions as shown in Table 3.

Table 3: Potential Environmental Challenges of Covid-19 and their Possible Solutions

Potential Challenges	Possible Solutions
Limited capability and capacity of India to recycle and dispose off all kinds of waste in an environment-friendly manner.	Including recycling in the 'Essential' activities category such as the healthcare services in order to facilitate their smooth operations even during lockdowns.
It can lead to a waste management disaster in India if the coronavirus comes in more waves and the trend in waste generation during the pandemic continues.	Including excessive waste management in the country's overall disaster management paradigm and drawing up an effective plan to deal with it in case the need arises.
Excessive and more than necessary usage of sanitizers, disinfectants, soaps and chemicals leading to heavy demand and waste generation.	Proper research is required to determine what quantity and frequency of use of such commodities are sufficient to protect from the coronavirus. Also the side effects of the overuse also need to be researched.
The anxiety and fear incited by the coronavirus might encourage people to continue panic buying, hoarding and stockpiling of items leading to overproduction and related waste.	Government-sponsored awareness programs through electronic mediums need to be carried out throughout the country that assures people the availability of essential commodities.
Improper cremation facilities and excessive rush at cremation sites due to massive deaths leading to people dumping dead bodies in rivers and other water bodies and hence polluting them.	Mostly unorganized cremation facilities and grave-yards should be brought under the management of the local administration of each district to ease the process and minimize the rush.
The potential decision by the government after the pandemic gets over to withdraw or limit the resources and packages for the environment and divert them to the economy to cover the losses suffered during the past few months.	Integrated planning at the central and state level is required that balances the needs of both the environment and the economy after Covid-19. Focussing on one and ignoring the other will lead to a cyclic effect and will have consequences for the long term.
Likely increase in the use of fossil fuels like coal, oil and gas and GHG emissions once things get back to normal.	Increasing public expenditure and investment in the renewable energy sector should be part of the recovery packages of the Government after Covid-19 as well as a priority for the future to discourage the use conventional sources of energy.

Conclusion

This study has strived to present a balanced but critical view as far as the environmental outcomes of Covid-19 are concerned. Contribution to the existing literature has been attempted by pointing out both the short-term and long-term reactions of the ecosystem to the coronavirus pandemic. The existing literature lacks strategies and solutions to prepare in advance for the post-pandemic era and therefore we have briefly tried to cover the research gap by recommending feasible solutions to the prime challenges that can disrupt India's path to recovery once the Covid-19 outbreak comes to end.

Finally, this research work has certain limitations. The study of the positive impacts of Covid-19 in our research is mostly restricted to the first national lockdown period announced on 24th March 2020 for 21 days as the subsequent lockdowns were not pan-India and varied in measures across the states depending upon the severity of the situation in each state. Future research can focus on and compare the environmental effect in subsequent lockdown periods and even between different states. Also, this research is primarily based on secondary sources as this research was conducted when pandemic-related restrictions were in place and imposed on all activities including travel to minimize the spread of Covid-19. Once these restrictions are fully relaxed, future research based on primary data can provide further insights.

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Competing Interests

The authors declare that they have no competing interests.

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