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Review

Environmental impact of the COVID-19 pandemic

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Abstract

The influence of the COVID-19 pandemic on the environment garnered attention from the outset of the crisis, with observations and studies of immediate repercussions as well as long-term forecasts. Year 2020 has been billed a "Super Year for Nature" in a variety of conversations on environmental issues. Epidemics and even pandemics are influenced by a variety of biological variables, which can result in a variety of environmental feedbacks. The novel coronavirus disease (COVID-19) was designated a pandemic on March 11, 2020, and its quick onset, vast geographic spread, and complex implications make it a once-in-a-generation global calamity. The COVID-19 pandemic had a wide range of environmental repercussions by in the year 2020, both beneficial and harmful, such as air and water quality improvements in metropolitan areas and disastrous contamination owing to the disposal of biomedical and organic waste that piled up during this period. This review presents a summary of the COVID-19's observed and potential environmental effects.

Keywords: COVID-19, Environmental consequences, Pandemic, Antimicrobial resistance, Biomedical waste

Introduction

Analysis of the post-COVID world show immediate consequences from reduced anthropogenic activities dominating short-term effects, while long-term repercussions are likely to arise from the economic recession's cascade effects on poverty throughout the world, green investment, as well as human behaviour. The COVID-19 pandemic is a public health emergency affecting everyone. The most serious implications are the public health crisis and related economic and humanitarian calamities, which are having unprecedented effects on human welfare. This crisis has led to tremendous alteration of human interactions with the Earth System, for example, energy emissions, temperature, air quality, poverty, globalisation, food, and biodiversity with long-term, extensive, and variable repercussions across space and time. Many environmental accords along with the assembly of large physical gatherings, have been postponed as a result of the current COVID-19 pandemic's uncertainty. Effects can be seen in a range of long-term physical measurements (such as better air quality and lower seismic noise) as well as social indices (such as reduced mobility and declining economic growth and greenhouse-gas emissions). Reduced traffic congestion, clearer skies, cleaner rivers, and the free movement of animals into human areas are just a few of the positive effects that have been recorded across the world. On the other side, negative consequences have been seen, including cascading effects on unemployment, inflation, poverty, food security, mental health, and biodiversity. Overuse and safe disposal of biomedical and organic waste has also become an environmental hazard in the current scenario which is a grave cause of concern [1].

Positive Impact on Environment

The pandemic has had a positive impact on the environment resulting from government-imposed strict lockdowns and quarantine measures around the world. The travel restrictions, halted construction works, shutting down of all markets and worship places, ban on public gatherings and celebrations etc. have resulted in a huge change in the environment, which is a promising sign for the fatal global environmental catastrophes, such as greenhouse gas emissions and ozone layer depletion. Lakes and rivers around the world are cleaner, with fresh air quality, reduced smog and haze dispersions and wildlife thriving in the open areas.

Impact on Air Quality

World Health Organization (WHO) estimates that around 7 million people die annually because of air pollution caused by pollutants like NO_2, SO_2, O_3, CO and particulate matter (PM) which possess serious health risks [2]. Around 8.8 million deaths were reported every year because of exposure of particulate matter (size < 2.5 μm) and O_3 [3]. Of several positive impacts of lockdown imposed by COVID-19 pandemic, the immediate effect has been seen on air pollutants, reduction in concentration of NO_2 has been reported post lockdown in Wuhan, China [4] where a 29 percent reduction in NO_2 (with a 95 percent confidence interval of 44 percent to 13 percent), 11 percent reduction in Ozone (O_3), and 9 percent reduction in PM2.5 during the first two weeks of lockdown was observed. Furthermore, it has been shown that air pollution causes 4000 fatalities each day in China, resulting in 1.6 million deaths in 2016. [5].

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According to Chen et al. (2020), a reduction in PM2 contributed to prevent 3214 PM25-related fatalities (95 percent CI 2340–4087) during the lockdown period [6]. Effect of the pandemic on changes in NO_2 level over the major epicentres in South Korea, France, China, Italy, Spain, Germany, Iran and the United States by satellite measurements of air quality have shown significant reduction in emission in all countries by 20–40% [7]. Global CO_2 emission data from 69 countries was compared and astonishingly it was found to be reduced by 17% on an average, while a few countries have shown reduction upto 26% [8]. Hence, undoubtedly the lockdown was efficient to offset global warming. Studies have also shown that people living in more polluted areas were twice as likely to be infected with COVID compared to those in areas with less pollution [9]. An increase of only 1 $\mu g/m^3$ in long-term exposure to PM2.5 was found to be associated with a 15% increase in the risk of COVID-19 mortality [10]. The Central Pollution Control Board (CPCB) daily publishes data regarding air quality index (AQI) using data from Continuous Ambient Air Quality Monitoring (CAAQM) stations. Comparison of data from 2019 & 2020 clearly showed improvement in air quality and more number of days falling under Good & Satisfactory categories (Figure 1).

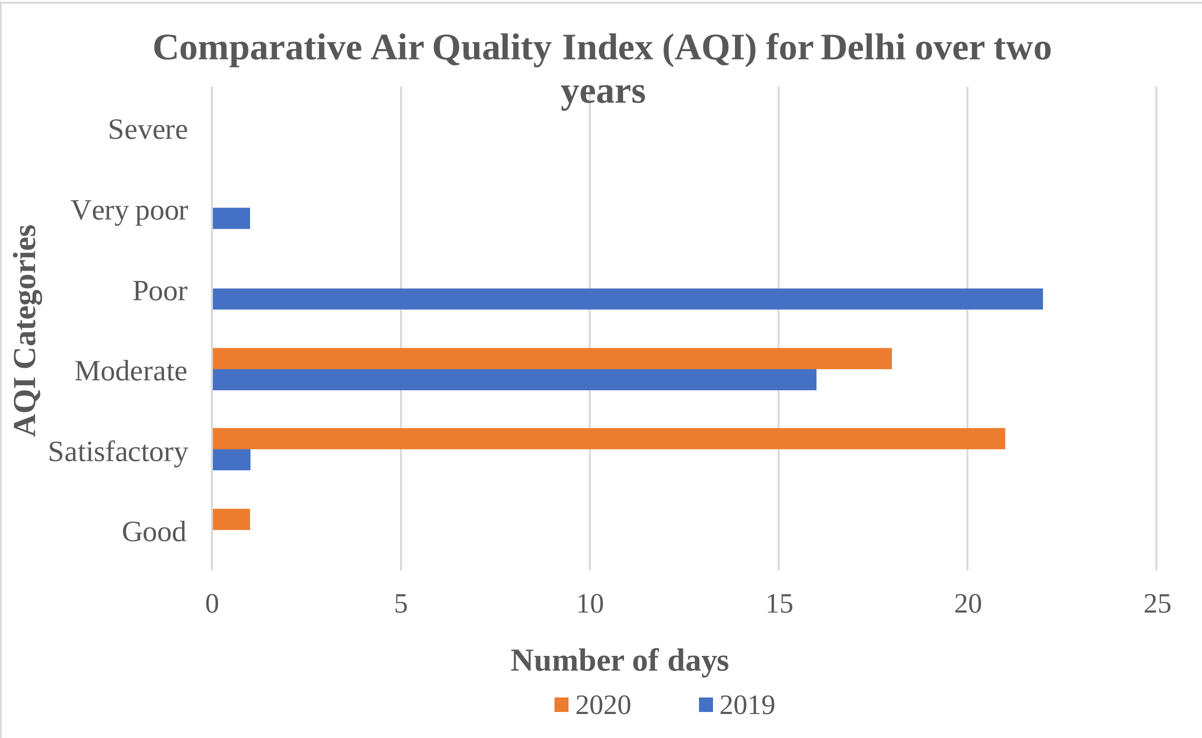

Figure 1: Comparative AQI during March 25th – May 3rd, 2019 and 2020 for Delhi [Redrawn from 'A Report on Impact of Lockdown on Ambient Air Quality' by Central Pollution Control Board, Ministry of Environment, Forest & Climate Change, Government of India released on September 23rd, 2020 (https://cpcb.nic.in/upload/Report-Impact-lockdown-AAQ.pdf)]

Impact on Noise Pollution

Noise pollution is defined as high levels of sound produced by various human activities (for example, machinery, cars, and building activity), which can have negative impacts on humans and other living creatures. People were forced to stay at home due to the quarantine and lockdown procedures, which hindered economic activity and communication globally, lowering noise levels in most places. For example, during the recent lockdown period, the noise level in Delhi, India's capital, was decreased by 40–50 percent [11]. Noise levels at Govindpuri metro station (Delhi) have been decreased by 50–60 decibels, down from 100 decibels, due to reduced vehicle traffic during the lockdown time [12]. As a result, city people have enjoyed the chirping of birds, which is often between 40 and 50 decibels [12], these sounds were completely unheard in pre COVID-19 times.

Impact on Energy Consumption

Studies have shown significant reduction in energy consumption in several countries like Italy (30% reduction), India (20%), UK (16%) Germany (12%) and France (15%) [13, 14] that followed complete or partial lockdown. This significant reduction in energy consumption has been because of the closure of industries. In totality, 10% lower energy consumption was observed during COVID-19 in comparison to pre COVID-19 times. Although hospitals have shown 5-50%

increased energy consumption during March-April 2020, but it has decreased in other sectors. During the lockdown, electricity use fell to Sunday levels, with substantial cutbacks in services and industries only slightly compensated by increased home use. When solitary confinement was lifted in Italy and Germany in April 2020, power demand began to improve. In May 2020, other nations (India, France, Spain, and the United Kingdom) reduced their lockdown restrictions, confirming the pattern [15]. Similar trends were seen in oil, gas and coal sector where, consumption of oil reduced by 5% in the first quarter of pandemic, in Europe, North America, and allied countries along with 8% and 2% reduction in coal and gas consumption respectively [16, 17]. Prior to the COVID-19 pandemic, energy efficiency, energy conservation, and innovative energy solutions were viewed as key components in maintaining energy demand stability. Energy demand stabilisation is a critical indication for preserving economic and urban sustainability during and after the epidemic. As the epidemic persists, it will be difficult to completely stabilise and restore energy demand. Figure 2 depicts diagrams of energy demand stabilisation in various thinking styles.

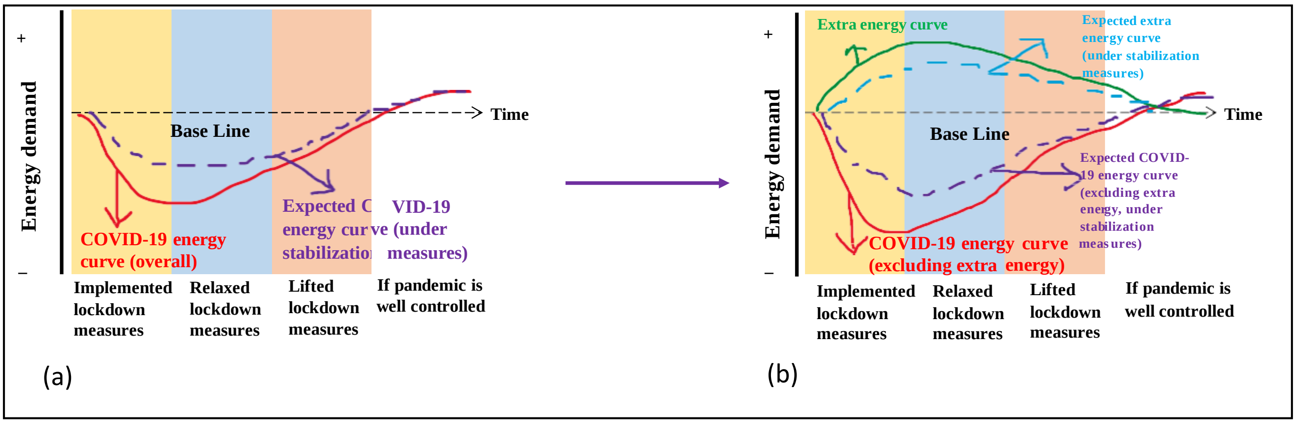

Figure 2: Conceptual diagram showing energy demand (a) under traditional thinking (b) under system thinking. The conceptual curves roughly depict overall energy consumption by taking into account commercial, industrial, and residential use ;Redrawn from Jiang P *et al.* 2021 [18]

Impact on Surface Water Quality

Lockdowns have also improved the quality of water bodies overall. Images captured by satellites have shown that the canals in Venice have become clearer during lockdown and have 50% reduction in total suspended matter because of cutback in boat traffic [19, 20]. As a consequence of tourism getting banned there has been a significantly reduced level of water pollutants in Venice canals and several other beaches like Acapulco (Mexico), Barcelona (Spain), and Salinas (Ecuador) [21]. Also, the water quality of highly polluted Rimac River in Peru has improved . Real-time water quality monitoring data by CPCB has shown that pre-COVID polluted Ganga (India) water has pH ranging from 6-8 with biological oxygen demand level less than 3 mg/L and dissolved oxygen (DO) greater than 4 mg/L which dramatically improved by 79% post one moth of lockdown [22]. Similarly, chemicals and detergents from industries that are responsible for production of toxic foam in Yamuna river in New Delhi also significantly reduced during lockdown [23]. These improvements resulted in transparent waters and allowed the aquatic life to blossom. According to the study, the temporary halt of activities caused by the crisis, as well as reduced traffic on the seas and demand for marine resources, might provide oceans with "much-needed breathing room" to recover from pollution, overfishing, and climate change consequences. Before quarantine, the beaches of Salinas and Manta were scored 2.2 and 2.8 (less than acceptable) on a scale of 1 to 5, and 4.5 and 4.3 afterward; findings from the second poll (after 18 weeks of limitations) were nearly identical. Galapagos responses followed a similar pattern, although with less pronounced variations. More fish and big marine creatures, such as humpback whales (*Megaptera novaeangliae*), bottlenose dolphins (*Tursiops truncatus*), and manta rays (*Manta* sp.) were seen along the coast, in addition to less plastic and rubbish on the beaches. Turtles, sea lions, and sharks were seen on Galapagos beaches in far greater numbers than before COVID-19 [24].

Socio-economic impacts

Interestingly, according to a survey, nearly 60% of Indian entrepreneurs expect COVID-19 to have a long-term positive influence on their operations. Entrepreneurs identified digitisation, consumer behaviour shift, new business prospects, and efficiency and resilience gains as positives to their businesses [25]. The survey also discovered that Indian entrepreneurs' life satisfaction and perceived stress levels were improved than that before the epidemic, owing to lifestyle modifications such as daily exercise, enough sleep, and yoga or meditation practises. The COVID-19 pandemic has led to the paradigm shift of the traditional in-person meetings and conferences to online format that have far extended from mere urgent discussions to online conduct of teaching-learning modules. Whether such online exchange of ideas and discussions can replace the traditional meetings is still debatable, it is widely agreed that, at best, they serve as a stopgap measure.

Negative Impact on Environment

While the pandemic and the response measures have led to significant improvements in the air quality and reduced the global carbon footprint in the short run, there appears to be a potentially long-lasting environmental impact projected from the generation and inappropriate disposal of large amounts of biomedical and organic waste. The outbreaks and rapid spread of antibiotic-resistant pathogens is another long lasting concern arising from the overuse of disinfectants during the pandemic.

Increased sanitation - induced long-term imbalance in ecosystem

The usage of disinfectants, soaps and detergents for repeated washing of hands and sanitization that has been the basic precaution against infection by COVID-19 has taken a toll on the environment. All packages arriving from outside homes have been advised to be sanitized. For this purpose, sanitizers that contain varied concentrations of alcohol have been mass produced by every local industry. Disinfectants containing hypochlorite, acids and chlorine have been used in large quantities that are anticipated to create a long-term imbalance in the ecosystem arising due to its toxicity to the environment and useful microorganisms in our vicinity and on human health [26]. Discharge of excess chemicals from soaps, which have been used very frequently during the pandemic has further harmed the quality of soil and water bodies. Alcohol containing sanitizers if spilt over water bodies, harm the aquatic fauna and foam discharge deteriorates soil quality. Ethanol, a very common constituent of alcohol-based hand sanitizers is a known toxicant and a central nervous system depressant [27]. Triclosan (TCS) or 5-chloro-2-(2,4-dichlorophenoxy) phenol, an antimicrobial agent provides an ethanol-free alternative to the disinfectants. It is a regular component of many personal care products like soaps, deodorants, fresheners and can persist in the environment for a long period of time and is emerging as a contaminant of interest. It has been reported to cause disorders of the endocrine system as well as weaken the immune system. It also causes oxidative stress in goldfish, making it a ecotoxicological risk to the aquatic niches [28]. Another synthetic biocide, triclocarban (3,4,4'-trichlorocarbanilide) along with TCS can accumulate in the food chains via biomagnification, as a result of overuse of antimicrobial personal care products [29]. Therefore, such indiscriminate use of sanitizers would lead to emergence of resistance in organisms creating a long-term imbalance in the ecosystem. The dumping of plastic bottles of soaps and sanitizers in huge numbers in the soil needs grave attention to mitigate the crisis of ever increasing soil-pollution. If the indiscriminate generation and discharge is not kept under check, disposal of voluminous plastic waste by incineration is bound to release greenhouses gases as well as metals, dioxins, furans and polychlorinated biphenyls [30].

Increased Antimicrobial Resistance (AMR)

Antibiotic stewardship or careful advising and monitoring antibiotic use in healthcare settings is integral to tackling the 'silent pandemic' of antimicrobial resistance (AMR) [31]. The preventive COVID-19 measures such as hand washing, physical distancing and quarantines may be effective in reducing AMR-associated health risks. However, the substantial increase in antibiotic use may lead to more significant long-term concerns [32]. As per CDC, outbreaks of antibiotic resistant pathogens such as *Acinetobacter* and *Candida* have been reported in healthcare settings at a much higher rate since the COVID-19 pandemic that appears to influence the spread of resistant germs and could undo much of the progress on AMR globally. Concerns on our approach towards treating COVID-19 patients have been highlighted by the scientists. There has been a major surge in the use of antibiotics to treat COVID-19 but that is not limited to critically ill patients with increased risk of secondary infections [33]. The misuse of antibiotics such as hydroxychloroquine was spurred after it was touted as COVID-19 cure and was inappropriately consumed by the patients requiring supportive care alone [34]. Rawson et al., 2020 reviewed the prescribing of the antimicrobials to COVID-19 patients and found that 72% of patients were administered broad-spectrum antimicrobial therapy in the hospitals while only 8% suffered bacterial and fungal co-infection [35]. In this regard, the low- and middle-income countries might have been greatly affected. With the resources for antimicrobial stewardship deployed towards curbing the COVID-19 pandemic, AMR may pose an even severe threat in the long run.

Biomedical Waste (BMW) Generation

The overwhelming surge in the hospital waste during COVID-19 has amplified the problems with the sustainable management of such waste. According to WHO, waste generated from healthcare activities include non-hazardous/general waste, hazardous pathological waste, infectious waste, sharps waste, chemical waste, pharmaceutical waste, cytotoxic waste, and radioactive waste [36]. Our little knowledge on the novel coronavirus has resulted in an unusual increase in the amount of such waste generated during the pandemic. For instance, the reported medical wastes generated per day in Wuhan (China) during the outbreak rose up to 5 folds than that reported during normal times [21, 37]. This forced the deployment of 46 mobile waste treatment facilities and construction of new waste plants in the country [38]. An increased use of medical waste from gloves, face masks, eye protection and other protective equipment is reported in all countries across the globe [37, 39]. By September 2020, India reported additional ~100 tonnes/day of medical waste related to COVID-19 while the country already lacked resources and personnel to dispose the usual 750 tonnes of waste generated per day [40]. In Barcelona, the medical waste generation increased to 1200 tonnes that is roughly more than 4 folds as compared to the during the pandemic [41]. Hence, the existing strategies to control biomedical waste generation and disposal are needed to be modified in order to check the associated viral spread. Inadequate management of such hazardous waste may potentially expose healthcare workers, waste management personnel, patients as well as contaminate the environment [40, 42]. Inappropriate management and disposal of COVID-19 waste was already posing as a cause of concern on water bodies along the shorelines in Hong Kong and China within six months of the outbreak [43]. In India, the CPCB has been proactive since the beginning of the pandemic and has issued guidelines under the Bio-Medical Waste (BMW) Management Rules, 2016 to keep the situation under control and to ensure that biomedical waste generated is treated at appropriate designated facilities. A COVID-19 Biomedical Waste Management (BMW) App has been launched to monitor the situation in real-time. However, the reports show that more than 20 states and Union Territories generate more waste than they can handle. Biomedical waste management infrastructure has also undergone severe stress during the second wave in May, 2021. It has been speculated that between June, 2020 and May 2021, that about 45,308 tonnes of biomedical waste has been generated as a result of the ongoing pandemic. This amounts for a 17% hike in biomedical waste generation in our country compared to the pre-COVID era [44, 45]. Even as the human race is currently focussing on vaccinating maximum numbers of the populations, a worry that comes along is that every jab generates a waste syringe as well as a waste glass vial. The disposal of such waste by responsible personnel is of utmost priority to prevent such outbreaks in the future. Thus, technical ingenuity on its management including segregation at the site of generation, transport, storage and disposal is required to handle the emergency.

Generation of Municipal Solid Waste (MSW)

The COVID-19 outbreak has led to a deeper problem of management of municipal solid waste (MSW) and more so for the workers that handle it, making them prone to coming in contact with it during activities like sorting, transportation and recycling [46]. MSW consists of the everyday use material that is thrown away from homes, schools and hospitals. Waste accumulation can be prevented by reusing, recycling and composting. Waste management is already a great challenge with rapid growth of industries and urban development, and the onset of lockdowns in early 2020 due to COVID-19 have just made the process more difficult. Panic buying of non-perishable foods was at the highest level along with home-bound citizens ordering groceries and all necessary items online. This led to a surge in accumulation of packaging waste, plastics, bottles and cartons.

Generation of e-waste

As a consequence of social distancing and the concept of work from home for students of schools and universities and office staff, a shift in basic nature of work has taken place. Technology has formed the framework of growth of this post-COVID world where everyone is dependent on laptops, desktops, mobiles and other gadgets. Use of such media is a potential threat for generation of more e-waste in the coming years that will hamper the future.

Conclusion

The COVID-19 pandemic has had both positive as well as negative impacts on the environment as summarised in Figure 3.

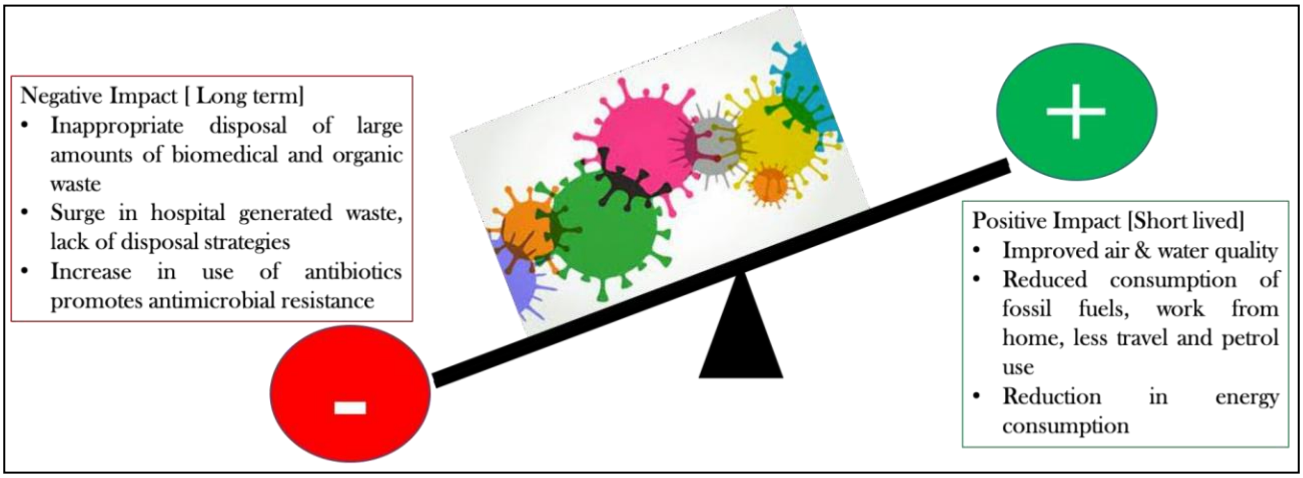

Figure 3. Impacts of COVID-19 pandemic on the environment

Weighing these impacts is crucial for assessing their long-term social as well as economic effects. Positive impacts of COVID-19 are an end product of postponed anthropogenic activities, with travel restrictions, offices, commercial spaces and educational institutes being shut, resulting in betterment of air quality, reduction in energy demands and better water quality. But the truth of the situation is that once the pandemic is over, all the negative effects will add up causing disastrous consequences on the global environment. With the growing mismanagement of the plastic and bio-medical waste generated and keeping in view our inefficient waste disposal systems, the consequences of the pandemic over the environment need to be re-assessed and policy makers must work on remediation measures. The pandemic has indirectly helped in preserving a few of the UN Sustainable Development Goals (SDGs) proposed by global leaders such as good health, clean water and sanitation, sustainable cities but the increased antimicrobial resistance have threatened to create a long-term imbalance in the ecosystem. Therefore, while combatting the devastating effects of this virus, appropriate steps must also be taken parallelly to restore our ecosystem as well.

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Conflict of Interest

The authors declare no conflict of interest.

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