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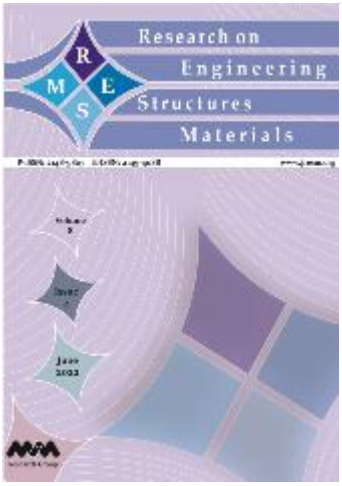


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*Review Article*

# Optimistic and pessimistic impacts of COVID-19 scenario on waste management in developing nations: A review

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**Abstract**

During the lockdown period due to the Covid-19 pandemic, the heaps of unusual wastes of packaging from panic buying, medical wastes from Covid-19 centres and isolation places, as well as discarded single-use safety gears like personal protective equipments are posing challenges not only for health hazards but also escalating the probability of the spread of diverse variants of Novel Corona Virus SARS-COV-2. Unfortunately, the containment of the spreading of the COVID-19 pandemic and subsequent lockdown measures are impacting waste management adversely like anything in almost all corners of the world, especially, in developing nations where there exists lesser awareness with regard to this deadly disease and orderly disposal of these pandemic wastes. Also, the waste hierarchy of the "4R concept", i.e., Reduce, Reuse, Recycle and recovery is negatively influencing during the prevailing epidemic circumstances which hinder the methodical waste disposal useful to save the environments and human health. The scenario of haphazard dumping of this waste is found worst in developing nations which are not fully prepared to face such thorny and all of a sudden difficulty of disposal of piles of these new risky wastes with their limited facilities and staff. However, the developing nations have instituted policies to ensure sustainable management of waste but it proved inadequate against the giant pandemic situations. Surprisingly, both - optimistic and pessimistic, types of impacts are being monitored on environments during the Covid-19 lockdown. Particularly, in the context of developing nations, the present review manuscript assesses both the optimistic and pessimistic impacts of the COVID-19 epidemic on the waste management sector and environment comprehensively along with the ways to address this gigantic Covid-19 waste crisis systematically.



## 1. Introduction

Generally, global waste management deals with many types of wastes such as municipal solid wastes, hazardous industrial wastes, bio-medical wastes, electrical and electronic wastes (E-wastes), radioactive wastes, and so on. Normally, these kinds of wastes are being disposed of in harmony with the "waste hierarchy" through the "4R concept", which includes reduce, reuse, recycle and recovery. That means it gives top priority for an awareness to reduce the use of non-biodegradable and harmful compounds in the first place which is highly essential. Similarly, the reuse of items instead of dumping them is also an effective measure to mitigate the piles of waste. However, recycling is the most modern and fully efficient route to convert the "waste to wealth" notion scientifically. Recovery refers to extracting commercially valuable materials and energy from wastes by following scientific processes. Thus, the "waste hierarchy" ranks waste management alternatives according to what is the best and most excellent for the environment.

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However, in the present Covid-19 pandemic scenario, the emergence of novel kinds of wastes, i.e., pandemic wastes, of discarded safety gears like Personal Protective Equipments (PPEs), facemasks, gloves, goggles, face shields, etc. is most challenging since it may be infectious and hence, can be considered as "hazardous". These novel gigantic healthcare wastes are generated from the medical laboratories, biomedical research facilities, Covid -19 treatment and isolation centres, hospitals, home-isolation sites, etc. Incorrect treatments of the said wastes pose grave risks of transmission of the virus to the waste workers, staff, and the community due to exposure to infectious agents. Also, in developing countries of the world, pitiable waste management emits destructive and deleterious pollutants into the atmosphere. The massive volume of the referred waste generation and its transmittable nature escorts to fear of more spreading of COVID-19 virus creating huge insecurity in the handling and succeeding recycling of the said risky wastes. The unsystematic disposal of the referred wastes may invite the further spreading of Novel Corona Virus in diverse forms having variants, namely, alpha, beta, gamma, lambda, delta plus, epsilon, eta, lota, theta, zeta, and kappa so far detected. Therefore, methodical disposal of them is highly essential in order to keep society more safe and healthy. Normally, waste management includes the collection, transport, valorization and finally the disposal of the waste. More broadly speaking, it includes any action engaged in the waste management system right from waste generation to the ultimate treatment. Sorry to say, in developing or undeveloped nations the brand-new type of hazardous wastes generated during the special circumstances of the pandemic of Covid-19, is being dumped either on open land spaces creating landfills, or in water-bodies, etc. but not going for incineration or biological reprocessing or recycling or energy recovery which are the methodical routes of its safe disposal. For this reason, the negative impact of this incorrect dumping on the environment and the possibility of the spread of deadly diseases has increased in such countries with restricted facilities for disposal of the unexpected heavy load of novel infectious wastes. This is a threat not only to the environment but also to the lives breathing on mother earth. Regrettably, at this time, there are millions of people being crushed by the giant of Covid-19 with lacs of deaths across the globe. Although the COVID-19 pandemic has contributed incredibly to mitigated air, noise and water pollution with enhanced bio-diversity as well as at sites for tourist attraction but the impact of staying-at-home and preventative measures have resulted in an alarm for a correct management of the infectious wastes. The piles of "use and throw" gloves, gowns, masks and other PPEs, etc. produced on a huge scale and converted in form of perilous waste from households and health care and quarantine facilities like hospitals and Covid-19 centres pointing towards the waste emergency escalating the possibility of spreading of COVID-19 through secondary transmission [1]. Not only have those, the uncontrolled dumping, burning in open and incineration may impact air and water quality along with health issues owing to release of toxins [2]. This situation is more perilous in developing nations having limited standard technologies and strategies to deal with a waste emergency through systematic sustainable waste management since it obviously calls for the high cost to implement it fully. Quite a lot of developing nations have adopted safety measures to battle with the referred pollution and to manage the mentioned wastes; however, the present measures taken are inadequate and differ relying upon the context of the nation. What is more to add, the WHO has publicized the guidelines for the management of medical wastes which lend a hand to managing the extremely infectious waste generated during the existing Covid-19 pandemic. The appropriate waste management may slim down the spreading of the COVID-19 virus and accelerate the recycling instead of dumping it in the landfills. Sustainable management is being encouraged by disinfection and sorting these wastes which permits their consumption for precious objectives. As we know, waste management, similar to every environmental attempt, entails stressors and receptors. The earlier are the agents which should be removed, reduced, or managed, such as the waste itself or definite components carried along viz., microbes, organic compounds, heavy metals or energy, etc.

Whereas the later one, by definition, receives the damage caused by the stressors. More often than not, the environmental receptors are classified as human or ecological. Therefore, if a waste carries hazardous infectious viruses that may come in contact with other general healthy public or waste management workers then it is injurious to their health. Additionally, these kinds of wastes can make threats to ecosystems and atmosphere. Debatably, the methodical disposal of waste management offers pre-eminence to human receptors and the safeguarding to public health.

Exhaustively, the current paper reviews the positive and negative impacts of the COVID-19 pandemic on the waste management sector and environment especially keeping an eye on developing countries where there are a lower rate of education, lesser awareness of the deadly disease, and very narrow treatment facilities available for organized waste management to cope up with such a novel, unpredicted, infectious, hazardous and monumental wastes generation along with the ways to get rid of this gigantic Covid-19 waste crisis systematically.

## 2. Environmental Corollaries During Prevailing COVID-19 Epidemic

Unbelievably, the ongoing COVID-19 pandemic is found impacting in both ways, i.e., optimistic and pessimistic, on the natural environment. The former includes a drop in the pollution of air, water and noise, sparkling of beaches, low GHG footprints, lower down traffic, etc. While on the other hand, the later one is very dangerous because it causes due to the boosted, novel, infectious medical and plastic wastes of safety gears, medical, disinfectants and packaging, etc.; hindrance in the recycling of wastes, redundancy, monetary crises, no functioning of educational and coaching institutes, no exercises in gyms, no entertainment in theatres and cinemas, no ritual or religious functions, limited gathering for marriage and funerals, restricted domestic and international travelling, etc. Also, in the pre-Coid-19 period, the world was facing challenges for environments, contamination generated from industrialization, pollutions of noise, water, air, soil, etc.; extreme use of chemicals for agriculture; etc.; depletion of ozone (O3) layer owing to emissions of GHGs from industries and vehicles leading to a gigantic dilemma of earth-heating, i.e., global warming [3]. Among these titanic prevalent issues, one more deadly disease appeared out of the blue before the lives of the world by which the whole universe feels down in the dumps.

The worldwide disruption resulting due to the pandemic situation prevalent owing to COVID-19 is answerable to a number of impacts on the environment and climate. On account of the complete lockdown in almost all corners of the world, the movement has restricted and a momentous hold up of socio-economic activities found. Besides the air-quality enhancement at so many places, there found a reduction in water contamination in different nations of the world. More to the point, the greater than before use of PPEs viz., facemasks, hand gloves, goggles, face shield, etc. and disinfectants like sanitizers, etc. generated massive quantity of sudden infectious wastes. After their use, they are being dumped haphazardly in nearby open spaces causing negative impacts on the environment and a probability of spread of viruses.

### 2.1. Optimistic Environmental Impacts

#### *2.1.1 Mitigation of Air Pollution and GHGs Emissions*

Optimistically, the COVID-19 lockdown scenario has lead to surprising extensive upbeat impacts on the atmosphere and climates on account of the reduced footprints of air pollution as well as GHGs emissions [4]. Among the developing nations, Indian air pollution is excessively influencing human health adversely and hence, causes roughly over 3.50 lacs new cases of childhood asthma along with about sixteen thousand premature deaths

annually. This huge air pollution is assigned to the presence of fossil fuel burning in open and largely from the exhaust of vehicles in India discharging nitrogen dioxide (NO2) and particulate matter ranging from 2.5-10 μm diameters [5]. There exist plenty of air-pollutants in nature, however, the major among are nitrogen dioxide (NO2), carbon monoxide (CO), Sulphur dioxide (SO2), Ozone (O3), fine (PM 2.5), and coarse particulate matters (PM10), etc. The chief sources of the referred kinds of contaminants are predominantly from diverse industries and the exhaust from automobiles. The poisonous Carbon monoxide (CO) gas emissions are found mainly released from the burning up of fossil fuels and from the operations of heavy machinery. On the other hand, Sulphur dioxide gas (SO2) comes primarily from motor vehicles, power generation plants, domestic heating, etc. These emissions of the said air-pollutant gases into the atmosphere impact harmfully on the human respiratory system, lungs, mucus secretions, etc. The elevated levels of NO2 can influence negatively by causing damage to the respiratory tract of people and augment the susceptibility of a particular individual to and the harshness of respiratory infections and asthma too. Additionally, the long-standing exposure to higher levels of NO2 emissions can pilot to chronic lung diseases. Not only have that, when NO2 reacts with atmospheric air it liberates ozone (O3), which is a key component of smog and can be responsible for worsening bronchitis and emphysema, asthma, permanent injury to lung tissues, etc. Exposure to O3 of the troposphere is considered answerable for an estimated about 10, 00,000 premature death annually. On the other hand, particulate matter (PM) is the main product of acid rain, which can cause deadly diseases of cancer since it can pierce inside the cells of the lungs with ease. There exists two types of PM, i.e., PM10 and PM2.5, relying on the size of the matter. Precisely speaking, the type PM10 possesses a size smaller than 10 mm e.g., the pollens, moulds and dust, etc. While the PM 2.5 is even much smaller than the PM10 creating pessimistic impacts on health such as chronic obstructive pulmonary disease and lower respiratory infection leading to the death of more or less 30, 00,000 persons internationally. Also, Ozone (O3) is one more significantly toxic contaminant generated from destructive gases discharged by vehicles and/or industries, which cause stern breathing predicaments, fall in functions of lungs, triggering asthma and lung-related crises. During the ongoing Covid-19 epidemic, government authorities in almost all parts of the world, especially in developing nations where the spread of the novel Coronavirus is intensive, have compelled the authorities to shut down markets, industries, transportation, etc. during lockdown leading to an abrupt fall in the amount of emissions of greenhouse gases (GHGs). That means, the drastic reduction with regard to air pollution in developing countries is the direct result of the complete shutdown of most of the industries and diminish in automobile traffic reduction during the COVID-19 period [6,7]. So far, the data of levels of air pollution for New York are found in decreasing order when compared to the period prior to lockdown while Covid-19 initiated. Approximately 50% of air pollution is reduced owing to the measures implemented to control the spreading of the Novel Coronavirus. In the same way, an estimation of nearly 50% reduced N2O and Carbon Monoxide (CO) is made for China due to the pack up of heavy industries [8]. Also, the $NO_2$ emission is one of the significant pointers of international monetary actions indicating mitigation in so many nations, namely, the U.S.A., Canada, China, India, Italy, Brazil etc. owing to the shutdown [3,9]. By and large, NO2 is being released from fossil fuel burning, about 80% of which comes from motor-vehicle exhaust [10]. It is well-known that NO2 is responsible for acid rain through interacting with O2 and H2O, and also for numerous respiratory issues to humans [10]. In accordance with the European Environmental Agency (EEA), the COVID-19 lockdown period is fallen down in the range from 30% to 60% in so many European cities such as Barcelona, Rome, Madrid, Paris and Milan [11]. While in the U.S.A., an emission of NO2 is found declining by 25.5% in the course of the COVID-19 lockdown time in comparison with preceding years. Significantly, the case of Ontario State of Canada displayed the level of NO2 with a decline from 4.5 to 1 ppb [parts per billion (10-9)] [12]. Analogously, the

reduction of up to 54.3% in NO2 emission is recorded in Sao Paulo, Brazil [13]. An assumption is made that vehicles and aviation are the chief contributors for GHG emissions figuring to about 72% and 11% correspondingly. Internationally, the measures taken in the context of the containment of the Coronavirus have exhibited a striking impact on the aviation segment. Several nations imposed restrictions on international travellers to enter, depart or even transit resulting in a drop in movement of air passengers. Therefore, the scheduled flights have been cancelled by commercial aircraft companies worldwide. For illustration, China decreases roughly 50% to 90% capacity for International departure and 70% for domestic flights because of the virulent disease when the comparison is made from January 20, 2020, finally resulting in a cut of almost 17% of the CO2 emissions [14]. What's more, it is found recorded that 96% of air travel has been plunged from a comparable time preceding year worldwide owing to the harsh situation of COVID-19 pandemic, that eventually has influenced the environment. Taken as a whole, the very much lesser use of fossil fuels has slimmed down the GHG emission lending a hand for open battle against universal climate alteration. In harmony with the International Energy Agency (IEA), the exigency for oil has declined by 435,000 barrels internationally in the early 3 months of 2020, when comparison made with the same spell of a period of the preceding year. More to the point, worldwide coal consumption is also trimmed down since lesser demand for energy met within the lockdown period due to the Covid-19 pandemic.

The coal-based Indian power generation plants slimmed down by 26% with a 19% drop of total power generation subsequent to the movement restrictions. While China stood first as the uppermost coal consumer internationally, however, with a decline of 36% when comparing it with the same spell of time of the earlier year from February to the middle of March [5]. In accordance with the climate science and policy website Carbon Brief, U.K.; the ongoing tragedy of COVID-19 has reduced 25% CO2 emission in the Republic of China, and nonetheless below the normal limit more than two months after the country entered lockdown [15]. Also, they estimated that the epidemic period could drop 1,600 metric tons of CO2, equal to beyond 4% of the total global emissions of CO2 in 2019.

*2.1.2 Reduced Water Pollution*

Sorry to say, water pollution is a most common happening in developing countries, especially in Bangladesh and India. This is mostly because the domestic and industrial wastes are dumped into rivers directly without subjecting them to any methodical treatment [16]. The key sources of emissions of gases and generation of chemical kind of pollutants from industries have been reduced tremendously or fully stopped during the Covid-19 lockdown era lending a hand to minimize the pollution [17,18]. Also, it is reported that the pH-concentration, electric conductivity (EC), Oxygen Demand (DO), Biological Oxygen Demand (BOD) and chemical oxygen demand [COD] have slimmed down greatly in dissimilar monitoring stations during the in-progress Covid-19 lockdown in comparison with the pre-lockdown normal era [17,18]. The chief industrial contaminating sources have either get reduced or entirely shut down during the covid-19 lockdown period helping to mitigate the pollution load as witnessed in the case of the Indian Holy river Ganga, Yamuna, etc. The rivers of the developing nations have touched a noteworthy purity level in the absence of industrial pollution due to the shutdown. In India, in the context of the Holy River Ganga, the observation readings of total of thirty-six real-time monitoring stations were recorded by a government body calthe led Uttarakhand Pollution Control Board of India (UPCB). Incredibly, out of these 36 stations' readings, the river water from twenty-seven stations is found within the acceptable limit [19]. Amazingly, after a gap of 30 years, the dolphins, South Asian River Ganges, are also spotting back in the Holy River Ganga. In Navi Mumbai city, India, tens of thousands of flamingos are reported to gather around. Generally, the birds migrate each year to this area, however,

their presence has boosted extraordinarily during Covid-19 period as observed by local residents. Wonderfully, the UPCB authorities have accounted that water from "Har-ki-Pauri ghat" on the bank of river Ganga – a place near Haridwar is found "potable for drinking" subsequent to chlorination because of the absence of the usual industrial wastes drainage into the river water during Covid-19 shut down period of industries [20]. This sudden and unexpected improvement in the quality of water near the cities of Haridwar and Rishikesh was assigned to the abrupt fall in the number of tourists [19]. In harmony with the real-time monitoring results for water quality, the physic-chemical parameters of the river Ganga are found as, pH from 7.4 to 7.8, biochemical oxygen demand (BOD) from 0.6 to 1.2 mg/L. All of them are falling within the limit of the surface water quality norms set by the Indian government authority. However, in some monitoring stations, with the exception of the total coliform figure, the rest of the other parameters had been found even in agreement with the Indian national drinking water quality standard, which can be utilized devoid of conventional treatment subsequent to disinfection. It is noteworthy that the pH concentration, Oxygen demand, electric conductivity (EC), Bio-chemical Oxygen Demand (BOD) and chemical oxygen demand(COD) have been found to decline significantly in diverse monitoring stations when compared with the figures of the same for Covid-19 lockdown and the pre-lockdown time [21]. Furthermore, the unnecessary gathering of people in public places is prevented by the rules, which has decreased the quantity of tourists and water activities at so many places [22]. There are reports of turning the Canal water clear and reappearances of so many aquatic species during the lockdown. More to add, water pollution is found reduced in the beaches of Malaysia, Indonesia, Thailand, Bangladesh, Maldives, etc. [23]. The food waste quantity is decreased during the COVID-19 lockdown, which in turn, slimmed down the contamination of soil and water. The consumption of water by the industries, particularly by the textile industry, has also been trimmed down due to shutdown during Covid-19 [24]. By and large, the massive quantity of water and soil polluting trashes generated in construction and manufacturing processes are also found to decrease during the lockdown period of a pandemic. What's more, there found a reduction in the emission of polluting gases and marine pollution because of the lesser movement of merchant ships and other vessels in the seas and oceans since the export-import business was affected very badly due to the Covid-19 epidemic.

*2.1.3. Reduction in Noise Pollution*

Normally, in the pre-Covid-19 era, the key global cities, particularly, of developing nations, are found extremely polluted by elevated noise pollution generated because of the human hustles and bustles viz., automobile traffic on roads, higher volume speakers in markets, and sound of a range of industrial plants and factories, etc. causing loads of uneasiness and health crises to humans and other lives on the earth. Psychologically, noise pollution influences animals and more than ever the birds since they are exceedingly thin-skinned. However, at the present, the chief densely populated cities of the developing nations are experiencing an unexpected and all of a sudden giant fall in noise level pollution as a straight outcome of the imposed COVID-19 lockdown by the government authorities which brought about the incredible decline in all kinds of transport modes and mercantile as well as industrial activities [22]. Generally, noise pollution is the result of the elevated levels of sound, generated from a range of human activities like operating machines, driving vehicles, working for construction, aviation, etc. It may pilot to influence human beings and some other living organisms adversely [22]. In fact, the pollution of noise badly affects bodily processes and injurious to human health creating hypertension, cardiovascular disorders, sleep shortness, etc. which are dangerous if long-standing. It is estimated that approximately 360 million populace is susceptible to hearing loss owing to long-term noise pollution [25]. The World Health Organization (WHO) made an estimate that worldwide over 100 million individuals are facing the challenge of higher noise levels beyond the

recommended border line single-handedly in Europe. Not merely humans, the anthropogenic pollution of noise has impacted pessimistically on even wildlife by altering the balance to detect and avoid the predator and prey. Also, it influences negatively the health of invertebrates that play a significant role to control the environmental course of actions in order to bring about the eco-system balance. During the Covid-19 lockdown period, the patients and their contacts were quarantined and normal people stayed in homes as well as a reduction in communication and economic activities in almost all parts of the world have altogether eventually lowered the noise level to an unbelievable level [22] e.g., the noise level of the capital city of developing country India, i.e., New Delhi, is found with a drastic reduction of about 40% to 50% in the recent Covid-19 lockdown. On the other hand, because of the restrictions on the movement of the vehicles of the general public during the Covid-19 lockdown, the noise levels of Govindpuri metro station, in Delhi is found to represent a reduced noise level of 50 to 60 dB only, otherwise, it was figuring around 100 dB in pre-lockdown time [26]. In harmony with the Central Pollution Control Board of India, the noise level of a residential zone, New Delhi, is incredibly found dropped in the daytime as 40 dB from routine 55 dB while 30 dB in the night from usual 45 dB. Consequently, it has become possible for citizens to enjoy the chirping of birds which they never think about before the Covid-19 lockdown. Moreover, the domestic and international travel restrictions have controlled the transport and aviation industries by reducing the flights and traffic on road drastically in almost all corners of the world piloting to a great reduction in the level of pollution of noise, e.g., Germany has cutback the air-passengers by over 90%; car traffic by more than 50% and trains by >75% than their usual ones [25]. Taken as a whole, the COVID-19 pandemic lockdown together with only lesser financial activities have drastically reduced global noise pollution as a positive impact on the environment and human health. The factors during the Covid-19 pandemic like quarantine, lockdown, work from home, limited global commercial activities, restrictions on domestic and international travels, etc., have altogether trimmed down the noise level in most cities of the world, in particular, in developing countries [22].

#### *2.1.4. Restoration of Ecosystem and Assimilation of Tourist Destinations*

Remarkably, the global tourism sector is developing fast in developing countries owing to the progressions in transports and technology contributing notably to the Gross Domestic Product (GDP), i.e., the total market or financial value of all the services and the finished goods produced inside the national border in a definite period of time. However, Lenzen et al [27] has made estimated that the tourism industry is answerable for about 8% of global Green House Gases (GHG) emissions. More often than not, the interesting tourist sites of natural beauty like beaches, national parks, mountains, islands, deserts, mangroves, etc. catch the attention of the tourists. In order to accommodate and facilitate them, there are scores of motels, hotels, restaurants, bars and markets, etc. existing or being developed consuming natural resources and plenty of energy. Puig et al. [28] worked out the carbon footprint in the coastland hotel services, Spain and accounted electricity and other fuels burning up playing a key role for pollution with the highest contribution of the carbon emissions from 2-star hotels. Furthermore, a few tourists make an enormous harsh and dump haphazardly a range of wastes impairing natural beauty and thus, leads to imbalance the eco-system. On account of the local COVID-19 restrictions, the tourists are reduced in quantity all over the world which has impacted negatively on the tourism industry to a great extent [22]. For illustration, Phuket, Thailand, is the most popular destination for international tourists with an average of 5,452 visiting tourists per day witnessing the bad days due to the recent Covid-19 lockdown [29]. Likewise, Cox's Bazar sea beach - the longest unbroken natural sandy sea beach in the world, is also appearing lonesome because of the ban by local administration on public gatherings and tourist travel. Consequently, the colour of seawater is altering from turbid to its original pure appearance

in the absence of any kind of pollution from swimming, playing, riding motorized boats, bathing, etc. On account of the reduction in pollution, surprisingly, a return of dolphins has been encountered along the coast of Bay of Bengal, Bangladesh after so long time [23]. This simply means that nature is getting time to assimilate human annoyance which is resulting in optimistic impacts on ecology.

#### *2.1.5. Sparkling Beaches*

Marvellously, the beaches are regarded as an imperative natural resource located in the coastal zones. The beaches are the source of sand, land, fishing grounds, etc. helping the survival of the coastal populace. They contribute to the government with a good source of revenue from tourism. However, normally, the majority of beaches are found densely contaminated on account of anthropogenic actions. In opposition, presently, so many beaches of the world are found sparkling since most of the nations have imposed Covid-19 lockdown to trim down the movement and travel of tourists and public in and in the region of the coastal zones piloting to have cleaner beaches in comparison to the pre-lockdown time and also found spotless and clean waters around the neighbouring regions [22].

### 2.2. Off-Putting Impacts of COVID-19 Scenario on Environments

#### *2.2.1. Escalation in Wastes*

Internationally, the generation of a new-brand type of bio-medical wastes is extensively escalated subsequent to the flare-up of the COVID-19 pandemic which is a prime threat to not merely the general public's health but also to the environment. In spite of the guidelines of authorities concerned and the experts with regard to the correct dumping and segregation of risky medical wastes and plastic-based PPEs as well as organic domestic wastes, the mixing up of all these wastes is knowingly or unknowingly made by some people especially unaware individuals in developing countries with narrow literacy rate are boosting the jeopardy of Covid-19 transmission, and its virus exposure to waste management employees [30]. Furthermore, the colossal quantities of discarded bottles of disinfectants which were utilized to wipe out the novel coronavirus from public places, industries and at residences have not only accumulated in form of piles of wastes with the possibility of being infectious since they may come from isolation and/or treatment centres as well as hospitals for Covid-19. Currently, in this period of deadly virulent disease of Covid-19, a large quantity of used disinfectants are found laying extensively on roads and in markets as well as around residences useful to eradicate novel Coronavirus. This widespread use of disinfectants may be dangerous to the health and lives of some other non-targeted innocent useful species creating an ecological imbalance [31]. These extensive applications of disinfectants may obliterate some other useful organisms which can contribute optimistically to maintaining ecological balances [32]. What is more, the SARS-CoV-2 virus was found present in the faeces of COVID-19 patients and also in municipal wastewater in so many nations like India, etc [33]. For this reason, still further measures for wastewater treatment are the need of the hour, which is a challenging job for developing nations like Bangladesh, etc. where municipal wastewater is directly drained into nearby water-bodies and rivers with no treatment [34]. Particularly, China has already made the procedures stronger for disinfection by using chlorine increasingly to put off the spread of the SARS-CoV-2 virus via the wastewater. However, it is also noteworthy that too much use of chlorine in water may generate destructive by-products at the same time [22]. Likewise, globally, during the present Covid-19 pandemic, the governments have issued guidelines by time to time to wear PPEs as safety gear like a facemask, gowns, hand gloves and other safety equipments in order to protect the general public from the novel coronavirus infection escalating to the healthcare waste quantity at the domestic level [35]. Especially, the generation of this new-fangled waste in form of used plastic-based PPEs has amplified internationally as [32] the case with China where the daily boost in the

production of medical masks as 14.8 million since February 2020, which is much greater than before [36]. The lack of awareness for such a novel infectious waste dumping leads to its randomly throwing away the used face masks, hand gloves, gowns, other PPEs, etc. by most of the people in open spaces or mixing it with other usual household wastes. Thus, the incorrect dumping of these trashes results in blockage in the route of waterways and futhe environmental contamination [22]. The face mask and other plastic-based PPEs are considered as the potential source of micro-plastic fibres in the atmosphere [36]. Generally, Polypropylene is used to manufacture N-95 face masks, and protective Tyvek suits, gloves, as well as face shields, on the surface of which the novel Coronavirus can survive for a long-term period and discharge the dioxin and toxic elements into the atmosphere. Essentially, the guidelines by authorities and health experts suggest that there should be correct disposal and segregation of organic domestic waste as well as of the plastic-based PPEs which are perilous medical wastes. Moreover, the medical waste should not be a mix up with household wastes since it will boost the jeopardy of Covid-19 virus transmission [1]. During the courses of the testing of the suspects of COVID19, diagnosis, treatment of an enormous number of confirmed patients at centres and/or hospitals, as well as disinfection, there found generation of scores of new kinds of infectious and bio-medical wastes [22]. The escalating quantity of the referred wastes is creating a dilemma for its systematic waste management e.g., in Wuhan, China; there is a record generation of over 240 metric tons in a single day for the duration of the outbreak [3], which is approximately 190 m tonnes greater than the pre-Covid-19 period [22]. In developing nations this predicament of methodical waste management is more serious due to limited resources e.g., in Ahmedabad, India, the quantity of generation of medical waste is boosted from 550 to 600kg per day to about 1000 kg per day at the time of the initial phase of Covid-19 lockdown [37]. Therefore, this abrupt and swift ascend of infectious wastes of medical and safety equipment have turned out to be a key quandary for the local waste management authorities of developing nations. In one more capital of developing country Bangladesh, i.e., Dhaka city, these sort of wastes is found generated during COVID-19 as nearly 206 m tonnes of per day [38]. In the same fashion, some other cities, namely, Kuala Lumpur, Manila, Bangkok and Hanoi also experienced an enhancement in generating 154 to 280 m tonnes more medical wastes every day than in the pre-pandemic normal time. Such an unwanted, unpredicted, uninvited, all of a sudden, and infectious hazardous medical wastes generation have alarmed the world, especially developing nations for their correct disposal with restricted facilities. As described earlier, the Covid-19 restrictions on movements and "stay at home" strategies by governmental authorities in almost the whole of the world has piloted to enormous boost in both organic and inorganic kind of wastes. Conveniently, in this present pandemic period, people are buying essential commodities and in some cases foods from online platforms with the home delivery facility, which has accelerated the wastes of packaging mostly in form of plastics and papers leading to the incredible rise in the quantity of household wastes. Not merely have that, the massive medical wastes of used gloves, face masks, disposable aprons and PPEs, syringes, etc., also found generating in treatment centres and hospitals for Covid-19. This unexpected, gigantic and pressing issue created by the present circumstances has put the waste management authorities in the world in a confusing state, especially, in developing countries where the facilities for the same are confined. In the context of developing nations where people are not fully educated, the unawareness of some sections of the society results in random dumping of the said wastes. The haphazard disposal of the referred wastes in landfills or the streets or water bodies, etc., may lead to severe predicaments of human health since these wastes may be infectious and still can carry traces of viral pollutants [35]. Thus, proper waste management has become a momentous challenge for the local waste management authorities, particularly in developing nations. The anxiety fuelled when it has been revealed through the freshly published literature that the novel Coronavirus can exist for a prolonged period on surfaces of diverse objects of day

to day use. Consequently, at this moment, it is a matter of great global concern that the bio-medical wastes generated from the hospitals and/or Covid-19 treatment centres in form of infectious, discarded masks, needles, syringes, bandages, gloves, used tissue, and leftover medicines, etc. should be disposed of appositely with a view to mitigating further spreading of infection of Covid-19 virus and contamination of environments. The enhancement in the quantity of both organic and inorganic kinds of municipal wastes generation is impacting directly or indirectly on the environment through polluting the air, water and soil. In the referred epidemic period, the panic online shopping with home delivery facilities is increased tremendously on account of the quarantine and lockdown policies in many nations piloting to augment the shipped packaging materials waste in form of household wastes [22].

*2.2.2. Diminution in Waste Recycling*

Due to the curse of the Covid-19 virus spreading in almost all corners of the world, the recycling facilities are affected badly in particular in developing nations. At the present time, this has proved to be a major crisis since waste recycling can not only prevent contamination but also save energy and preserve limited natural resources. As stated earlier, the rising domestic and medical wastes from Covid-19 facility centres and quarantine facilities may bear traces of virus contaminants posing a threat of infection to the workers and staff involved at recycling sites. For this reason, the recycling waste management functions are closed down in so many parts of the world. However, the endeavours are going on to address this challenge by most of the nations for safe and systematic disposal of infectious COVID-19 wastes because waste management of these waste is turning out to be a burning issue and seems to be thorny to practice. Nevertheless, the recycling of waste is an efficient route to put a stop to contamination, save energy, and preserve the restricted natural resources [1]. However, at the moment, a number of nations put off waste recycling to mitigate the transmission of the Covid-19 virus e.g. the U.S.A. narrowed down the recycling programs to nearly 46% at different places since the US government is concerned about the jeopardy of COVID-19 even at recycling units [37]. Worldwide, taken as a whole, there has been noted down an increase in the landfilling and environmental contaminations owing to a disorder of routine municipal waste management, recovery as well as recycling. This situation must bring to an end by opening the recycling plants faster and the recycling must be made at its acme in order to get rid of this hazardous waste keeping the staff and workers safe.

*2.2.3. Long Persistence of Novel Corona Virus*

Exceptionally, the hottest research in print literature in the context of the behaviour of novel Coronaviruses has revealed that they are capable enough to survive on the cardboard all day while on plastics and stainless steel surfaces for up to 3 days [37]. For this reason, the wastes generated from hospitals, treatment centres, and quarantine facilities should be effectively handled with a view to reducing the spreading of infection and pollution of the environment since it is turning out to be a worldwide concern at this moment.

## 3. Prospective Measures for Sustainable Environments

To date, nobody can predict the end of the Covid-19 pandemic era and that's why; the prospective measures to keep sustainable environments are the need of the hour in order to maintain the health of lives on the mother planet earth and other natural eco-balances. Therefore, this is a crucial time to make the correct strategies for long-term benefits to manage a sustainable environment scientifically. International response to fight against the COVID-19 pandemic has elicited making mankind united to triumph over the colour changing chameleon type novel coronavirus. Accordingly, with a view to safeguarding the

global environment and human health, joint efforts by all the nations are essential [37], hence, a few potential strategies are being proposed to uphold the sustainability of universal environments.

### 3.1 Eco-benevolent Industrialization

For any nation, industrialization is the backbone of progress which leads to financial development but at the same time, it should not be perilous to the lives on the earth. Therefore, the pandemic has compelled the world to think about eco-friendly industrial development. Sustainable industrialization necessitates essentially switching over to lesser energy-intensive industrial aspects, employing cleaner fuels and green technologies, and stronger energy competent policies. More to add, the industrialization should be made in some definite zones, keeping a conception in mind that the wastes generated from one industry can be employed as the raw materials for another leading to a lessening of landfills and the green concept of "use of waste for the best" will also be followed to "Go Green" [39]. With the condition not to hinder the national economical growth, industrial zones should be shut down at regular intervals of time as a circular route with the objective of reduction in emission of contaminating gases. As an effective measure towards sustainable industries, the giant industries with lots of workers and staff presence e.g., in the case of readymade garments plants, etc.; essential appropriate distancing and disinfected environment should be maintained in order to trim down the spreading of any contagious hazardous disease like Covid-19.

### 3.2 Transportation with Abridged Footprints of Pollutions

It is quite noteworthy that the global transportation industry is a great source of polluting the environment through vehicular exhaust mainly. In the interest to cut down these emissions of poisonous gases, etc., it is highly essential to promote the eco-benign transport system like the use of bicycles for shorter distances, public bike and taxi sharing locally as found in China, and people should prefer public transport rather going in their own private individual vehicles for a long journey. More to the point, awareness in people should be brought about to encourage mass usage of transport so that low footprint of contaminating agents will be observed which will be proved not only eco-welcoming but also lend a hand for the sound health of general public of the world especially of developing nations where the pollution on roads has reached its acme.

### 3.3 Application of Renewable Energy

Indubitably, the application of renewable energy will slim down the exigency of fossil fuels viz., Petroleum oil; coal; natural gas; etc. will play a significant role to trim down the emissions of Green House Gases (GHG) [40]. The worldwide exigency for energy is dropped resulting in the lowered emission and escalated ambient air quality in a number of areas during the COVID-19 pandemic time [22,37]. However, with a view to upholding the everyday requirements and international monetary growth, it is not practical to trim down demand for energy, therefore, the application of sources for renewable energy such as biomass, solar, hydropower, wind, geothermal heat, etc. can meet up the energy demand and mitigates the GHG-emission into the atmosphere.

### 3.4 Treatment and Reuse of Wastewater

With the purpose to control the water pollution challenges, both municipal and industrial wastewaters should be treated suitably prior to discharge. Moreover, reuse of treated waste water in a non-productive course of actions such as cleaning of roads and flushing of toilets can lighten the burden of surplus water removal.

### 3.5 Recycling and Reuse of Wastes

As stated above, the circular global economy systems for implementation the production procedures can help to lesser the consumption of raw material and, consequently, waste generation for diminishing the load of wastes and contamination of environments [39]. Both wastes of industrial and municipal origins should be recycled and reused as well as unsafe and communicable medical wastes should be orderly managed as per the guidelines of systematic disposal. In developing nations, many people are with little education and hence, lack an understanding of the Covid-19 virus behaviour and spreading routes, segregation of medical wastes and its final methodical disposal [38]. As a result, the government authorities should bring about full awareness on each and every topic related to the Covid-19 virus and the pandemic period by campaigning through diverse mass media with respect to the fitting waste segregation, its handling and ultimate disposal techniques.

### 3.6 Restoration of Environments and Eco-tourism

The global tourist sites should be closed at regular intervals of time in order to restore the ecological system. Also, the eco-tourism practices should be made stronger with a view to encouraging sustainable living, cultural safeguarding, and biodiversity protection.

### 3.7 Behaviour Modifications in Day-to-Day Life

In the interest to trim down the carbon footprint into the atmosphere by means of lesser emissions of GHG globally, some measures have to be taken by bringing behaviour modifications in our day-to-day life viz., optimal consumption of resources, replacing processed food with locally grown food, preparation of compost from the wastes of foods, switching off or unplugging the electronic devices when not in use, as well as ride a bicycle in place of a car locally.

### 3.8 Global Teamwork

With an objective to meet with the sustainable environmental and conservation of world environmental resources like the universal climate and bio-diversity, joint international endeavours are quite essential. Therefore, at this stage, an effective role of UNEP is much desirable for preparing state-of-the-art policies, making plans for international get-togethers, and harmonization of international leaders for appropriate execution.

As we know, the pandemic is influencing either directly or indirectly the lives on the earth, international economy, the environments, atmosphere, waste management, etc. very adversely. Nowadays, the environmental components are impacted badly resulting in enforced human-influenced modifications in the atmosphere and climate. More to add, it is a pressing need of the hour to work jointly in order to fight against the threat of COVID-19 to mankind. Nobody knows how far the pessimistic impacts of the Covid-19 pandemic will prolong on the environment; hence, the cohesive and time-oriented strategies can make stronger the sustainability for environments by saving the earth from the impacts of worldwide climatic alterations.

## 4. Conclusion and Discussion

In developing nations of the world, the practices for sustainable waste management were already challenging in the pre-Covid-19 era, which has shockingly turned out to be more exigent and thorny in a prevailing pandemic scenario which is changing not only the national socio-economic conditions but also impacting vigorously on environments, human health, and different essential sectors too. The gigantic escalation of infectious medical, plastic of PPEs and household wastes from Covid-19 quarantine and treatment centres as well as packaging wastes from panic online buying and foods have altogether

compelled us to be cautious of them and find a way to get rid of them methodically. With a view to addressing this fiery dilemma, the developing nations have to look into the matter sincerely and concerned government authorities should take necessary actions for control of generation of such wastes so far it is possible; the systematic collection and segregation of wastes from household organic items, packaging materials, and plastic-based protective equipments and hazardous infectious medical wastes and their orderly disposal; increase in their recycling facilities in order to dispose of finally with no harm to workers and staff of waste management industry. Unknowingly, if there occur mixing up of Covid-19 wastes with the normal day-to-day wastes, it boosts the jeopardy of transmission of this deadly disease and exposes the waste workers and associated staff to the novel Coronavirus which must be avoided. This is a multi-dimensional quandary that necessitates economics, technology, and socio-cultures to go together to get rid of it. This review has found that though the prevalent Covid-19 pandemic circumstances have helped out optimistically through lesser pollutions of noise, water and air where lockdown is imposed or still continue which can be considered as its pros, however, the cons are very horrifying such as a huge increase in plastic pollution through haphazardly dumped single-used plastics in form of wastes of PPEs, medical and packaging, etc., which are more serious and badly impacting on environments and human health as well as waste management staff, especially in the developing nations of the world where the populace is more and literacy rate is less. More to add, the colossal wastes of used disinfectants should also be dumped scientifically and the users must be aware not to destroy non-targeted beneficial organisms helpful to address ecological imbalances in nature. The actions for waste management whereby certain emissions of detrimental gases are found discharging into the atmosphere which is impacting badly on the air-quality resulting into lots of health hazards to the lives on the planet. Analogously, the appropriate measures for wastewater treatment are also turned out to be a need to prevent further spreading of a virus of Covid-19. Not only that, the eco-compassionate industrialization and transport system, as well as stronger eco-tourism practices, can help to a great extent. The utilization of sources for renewable energy can meet up the exigency for energy and thus, reduces the emissions of GHG. There is a pressing need for making aware the general public especially in developing nations fully on every single topic associated with Covid-19 disease through diverse mass media. It is also necessary to know how to deal with the novel wastes during this pandemic. Incredibly, during the Covid-19 lockdown period, the air-contaminants are found reduced dramatically, beaches are sparkling again, restoration of eco-system and assimilation of tourist destination are a few as the positive effect of this pandemic. Significantly, the advanced research works are highly necessitated with the objectives for the development of bio-degradable and eco-benevolent PPEs viz., face masks, gowns, face shields, gloves, etc. to pick up the pace for the agenda en route for attaining the sustainable production of safety gears while mitigating pessimistic impacts on environments. Admirably, the on-hand modern scientific technologies are trying their level best to control the air pollutants, however, still not enough and necessitate more novel effective routes in this direction. More progress of the industries equals more release of air pollutants into the atmosphere, i.e., economic progress is regrettably associated with ostensibly stubborn predicaments, e.g. Global Green House Gases and several toxic compounds are constantly heating the mother earth and consequently, the global temperature is rising day-by-day, which is signalling to a horrible situation and risks to lives living on it in future since the threatening to eco-systems is persistently going-on. The emerging challenges are not readily addressed by the old-fashioned "command and control" approach and therefore, still more improved technologies together with healthier regulations and stringent rules are needed to breathe in fresh and cleaner air. Unquestionably, the improvements for systematic global waste management approaches, especially, in developing nations will certainly translate into enhanced air quality. In the prevailing epidemic circumstances, there is a burning global need for methodical waste management of domestic, quarantine households, medical

treatment centres, hospitals, and other toxic waste generating sources, etc. to be treated as crucial service to the community with a view to mitigating the spread and negative impact of this deadly disease on health, environment and of course, economy. For this reason, the recycling plants must be made fully operative with safety gears to workers and the said wastes must be converted to wealth by accelerating fitting recycling processes. The United Nations Environment Program (UNEP) has also guided the world in ensuring sustainable waste management during this hard period via the treatment of residual wastes like discarded tissues, handkerchiefs and similar organic and packaging wastes, etc. by means of incineration at an elevated temperature of about 1000°C to destroy the novel Coronavirus safely and totally. Thus, a competent role of UNEP is sought-after to a large extent for drafting state-of-the-art policies in this regard. That means, the guidelines are should be followed stringently along with full awareness and joint endeavours by all the nations going hand in hand with a few potential competent strategies to mitigate not only the spread of Covid-19 but also to maintain the environments " Clean and Green".

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