11. Impacts of the COVID-19 on the Environment and Potential Sustainable Strategies

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Abstract:

The outbreak of any global pandemic or epidemic event have direct or indirect relationship with different environment factors. On 11 March 2020, Coronavirus disease 2019 (COVID-19) was declared as pandemic outbreak by World Health Organization (WHO). Consequences of COVID-19 showed various positive and negative impacts on the environment and correlated socio-ecological interaction significantly. Positive development by the increase in shorter chain supply, helped in sustainable production and provided resilience and flexibility to socio-ecological systems. Improvement in air quality, water quality and favorable impacts on wildlife have added to the positive effects. In addition, negative effects included increase in biomedical waste, more municipal waste generation and its haphazard disposal on the environment. Various potential environment strategies could play a very crucial role in the restoration of environmental health on its proper execution.

Keywords: COVID-19, Environmental impacts, GHGs emission, Biomedical Waste, Environmental sustainability.

11.1 Introduction:

Earth is a very dynamic system, where a constant interaction between social beings with its biophysical environment occurs. Sometime these socio-ecological interactions may lead to extreme variations, as a consequence disaster may arise. The Intergovernmental Panel on Climate Change (IPCC) has defined "a disaster as an event, which severely alters the functioning of a community due to hazardous physical, biological or human related impacts leading to widespread adverse effects on multiple scales and systems (environment, economic, social)". Over a wide geographic area, pandemic can increase morbidity and mortality at high rate and lead to a notable amount of economic, social and political disruption (Madhav *et al*., 2017).

The World Health Organization (WHO) has declared the novel coronavirus disease (COVID-19) outbreak as pandemic on 11 March, 2020 (Cucinotta and Vanelli, 2020). The COVID-19 pandemic has provided various impacts on environment along with many substantial challenges. COVID-19 has first appeared in November 2019 in Wuhan (China), found to be caused by Severe Acute Respiratory Syndrome corona virus-2 (SARS-CoV-2), from there it continued to spread rapidly all over the world (Jin *et al.*, 2020). COVID-19 has claimed to cause around 876,616 deaths from 26,763,217 confirmed cases and affected almost every country on the planet (216 countries). The global health emergency committee called for its early detection, isolation and rapid treatment to minimize transmission (Sohrabi *et al.*, 2020). The COVID 19 has caused more uncertainty than previous epidemic and pandemic outbreaks took place between 2000 and 2019, including Severe Acute Respiratory Syndrome (SARS) (2002–2004), H1N1 influenza (2009), Middle East respiratory syndrome (MERS) (2012–2020), the West-African Ebola virus epidemic (2013–2016), the Zika fever (2015–2016) and Avian influenza (2008–2014).

11.2 Various Impacts on the Environment:

From the very beginning of the crisis, environmental impact of the COVID-19 pandemic upraised an adequate amount of attention. Virus alone itself has not caused all the impacts on the environment but resulted along with consequences from economic sectors like heavy industry, transport or hospitality businesses. The pandemic lead to various positive development by increasing shorter supply chains which help in the sustainable production. It also provide flexibility to the socio-ecological systems, along with potential improvement in environmental quality. Whereas the negative impacts include an increases in non-recyclable biomedical wastes, huge organic waste formation due to decrease in exportation of agricultural and fishery products. Various impacts could range from immediate, short-term and long-term (Cheval S *et al.*, 2020).
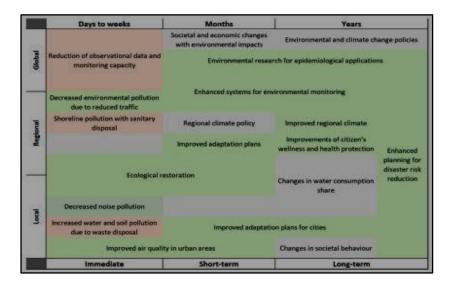

Figure 11.1: Matrix of observed and potential impacts of COVID-19 on environment and climate change. Red blocks are negative impacts, green are positive and grey stands for neutral effects.

11.1.1 Positive Impacts:

A. Reduction of Air Pollution and Effects of Green House Gas Emission:

Good quality of air is very essential for people's health and a significant percentage of global mortality is a consequences of air quality deterioration. A considerable decrease in the use of transportation and decline in industrial processes during lockdown has directly brought a sudden drop of greenhouse gases (GHGs) emissions. From the industrial activities and transport system about 54% of the non-methane volatile organic compounds (NMVOC), 51% of the NOx, 30% of PM2.5 and 25% of SOx emissions were found to be released in many European countries. During lockdown nearly 50% reduction in air pollution been reported in New York when it is compared with last year. Morbidity and mortality has a stochastic association with NO_2 (He *et al.*, 2020). Nearly 57% reduction in NO_2 been found in Turkey, when mean data between 2019 and 2020 were calculated (Kaplan *et al.*, 2020). In USA, 25.5% decrease in NO_2 with decline of 4.8 ppb observed as its concentration was compared with before pandemic phases (2017–2019) (Berman *et al.,* 2020).

People of any age group when exposed to a long-term air pollution may face a high risk of developing chronic and infectious respiratory diseases. Particularly for the elderly, higher and consistent exposure to Particulate matter (PM) may lead their respiratory system to compromise before the onset of the virus. In Delhi, almost 70% decline in NO_2 and PM2.5 concentrations were observed and also an overall of 46% and 50% reduction in PM2.5 and PM10 respectively was reported.

Aviation attributes to 1–2% of global greenhouse gas emissions very year (Harrison *et al.*, 2015) and it add to 3–5% of global CO2 emissions (Kivits *et al.*, 2010). Almost 72% and 11% of GHGs emission were contributed by vehicles and aviation respectively. Decrease in both short-term and mid-term aviation travel lead to decline in CO_2 level, which will in turn decrease air temperature. In China, approximately 17% of national CO2 emissions been decreased due to reduction of almost 50–90% capacity of departing and 70% domestic flights during pandemic.

B. Reduction of water pollution:

In countries like India and Bangladesh, domestic and industrial wastes are disposed directly into rivers without any treatment, causing large water pollution in daily basis (Islam and Azam, 2015; Islam and Huda, 2016; Bodrud-Doza *et al.*, 2020; Yunus *et al.*, 2020). Major industrial pollution load been observed to decline during lockdown (Yunu*s et al.*, 2020). Due to the absence of industrial waste dumping on the river Ganga and Yamuna during lockdown have shown a potential increase in water purity. It is found that, water from 27 stations met the permissible limit for 'bathing' and 'cultivation practice of fisheries and wildlife' among the 36 real-time monitoring units along river Ganga (Singhal and Matto, 2020). Due to unexpected decline in visitors and less production of sewage and industrial effluents; eventually improved water quality at Haridwar and Rishikesh (Somani *et al.*, 2020). A reduction in the pH concentration (1–10%), electric conductivity (33–66%), dissolved oxygen (51%), biochemical oxygen demand (45–90%) and chemical oxygen

demand (33–82%) were found during lockdown period in Yamuna River (Arif *et al.,* 2020). According to a report by Central Pollution Control Board (2020) a significant decrease of ~ 51.46% for DO, ~74.69% for BOD and ~78.57% for COD, observed in rivers at Palla stations. From a data of the Uttarakhand Pollution Control Board (2020) showed different parameter's result including pH (7.4–7.8), DO (9.4–10.6 mg/L), BOD (0.6–1.2 mg/L) and total coliform (40–90 MPN/100 mL) during real time water quality monitoring analysis.

The water of Vrishabhavanti River of Bengaluru turned clearer. Significant improvement in water quality have been observed in Beas River (Punjab), proved by sighting of Indus river dolphin (one of the World's rarest mammals). Kallayi River of Kozhikode (Kerela), also showed a large recovery in water quality. The Grand Canal of Italy showed much more improvement in quality and many aquatic species were reported to reappear, due to the lockdown of COVID-19.

The amount of industrial water consumption is also reduced, especially from the textile sector around the glove. Closure of Textile and Tannery processing industries lead to the stoppage of waste disposal into the Kalingarayan canal of Erode of Tamil Nadu. However, due to reduction in movement of merchant ships and decline in export- import business globally, reduced emission as well as decreased marine pollution.

C. Reduction of noise pollution:

Elevated levels of sound generated from different human activities including machines, vehicles, construction work creates noise pollution. It may produce an accumulative unfavorable effects in human health resulting into degradation of a fruitful environment with correspondence to economic and well-being losses (Goines and Hagler, 2007; Zambrano-Monserrate *et al.*, 2020). Noise exposure adversely affect our physiological health, along with cardiovascular disorders, hypertension, sleep shortness and may uplift cholesterol level (Kerns *et al*., 2018).

About 140 million Europeans are estimated to be at risk of noised-induced hearing loss. Moreover, noise pollution has negative effects on wildlife by creating hindrance between balance of predator and prey detection. Invertebrates also gets effected by undesired noise (Solan *et al*., 2016). Lockdown measures has greatly contributed in the regulation of noises in most cities (Zambrano-Monserrat*e et a*l., 2020).

The lockdown also resulted in a drastic reduction of noise pollution. During lockdown, noise level was found to be declined by 50-75 %, based on the data evaluated from five automatic ambient noise measurement stations located across Kolkata and noise level of Delhi also showed sudden drop of 40–50% (Somani *et al.*, 2020). The noise levels of Govindpuri metro station (Delhi) is declined to 50–60 dB from 100 dB responding positively to decreased vehicular transport. According to the Central Pollution Control Board (2020) of India, noise level of residential area of Delhi is reduced from 55 dB and 45 dB (during daytime and night) to 40 dB and 30 dB (during day and night) respectively. As a result, chirping of birds became hearable to metropolitans (40-50 dB). Pandemic measures also have regulated the traffic. In Germany Car traffic has declined by >50% and trains are running <25% than the usual rates and air travel has been dropped by over 90%.

D. Ecological restoration and assimilation of tourist spots:

Beaches, islands, national park, mountains, desert and mangroves are tourist's attraction place, which make these places always crowded. Lots of hotels, motel, restaurant, bar and market are built for their accommodation purpose which in turn causes exploitation of energy and use of natural resources (Pereira *et al.,* 2017). Sometimes degradation of natural beauty is caused by visitors due to dumping of waste there, which may create ecological imbalance (Islam and Bhuiyan, 2018). Adequate amount of reduction in tourist number been observed during pandemic lockdown (Zambrano-Monserrate *et a*l., 2020). Due to reduction of pollution and human disturbance nature got a sufficient amount of time for recovery, hence recently returning of dolphins was reported in the coast of Bay of Bengal (Bangladesh) and canals.

E. Impacts on wildlife species:

Restrictions during pandemic has greatly diminished stress on wild fauna caused by people visiting natural parks (Corlette *et al.*, 2020). Wild animals are found to return towards native areas from which they previously fled due presence of human (Corlette *et a*l., 2020). Several animals including Olive Ridley turtles were seen nesting on an Odisha beach after 7 years (picture1) and for the first time in 20 years, Leatherback Turtles were spotted on empty Thailand beach (picture 2). After 30 years, South Asian River Dolphins are found to return to Kolkata Ghats (picture 3) and 25-30% more Flamingos were observed to migrate to their natural habitats (compared to last year in Talawe wetland, Mumbai). Many bird species extended their stay at the Therthangal and Melaselvanoor - keelaselvanoor bird sanctuaries. Spotted deer and peacocks were seen in Thoudi and Thiruvadarai.

Figure 11.1.2.3: Things That Have-Happened-For-The-First-Time-In-Yearsduring-Coronavirus-Lockdown.

11.2 Negative Environmental Effects:

11.2.1 Increase of Biomedical Waste (BMW) Generation:

The global increase of medical waste generation during the amid of COVID-19 is one of the major threat to public health and environment. During the diagnosis and treatment of huge number of patients and in sample collection, a large amount of BMW is generated (Somani *et al.*, 2020; Zambrano-Monserrate *et al.*, 2020). Wuhan has witnessed a six times increase in BMW and it was reported to produce more than 240 metric tons of medical wastes per day during the time of pandemic, which is found to be almost 190 m tones higher (Zambrano-Monserrate *et al.*, 2020). In the city of Ahmedabad of India, at the time of the first phase of lockdown an increase of BMW from 550-600 kg/day to around 1000 kg/day been reported (Somani *et al.*, 2020) and around 206 m tones of BMW are generated every day in Dhaka (Bangladesh). In cities like Manila, Kuala Lumpur, Hanoi, and Bangkok; production of 154–280 m tones more BMW per day found when compared to before the pandemic phase. A recent published study reported that the SARS-CoV-2 virus can exist a day on cardboard and up to 3 days on plastics and stainless steel (Van-Doremalen *et al*., 2020). Waste generated from the hospitals like needles, syringes, bandage, mask, gloves, used tissue, and discarded medicines etc. needed a proper waste management to reduce further infection and environmental pollution, which is a global concern now.

11.2.2 Safety Equipment Use and Haphazard Disposal:

For protection from the viral infection, people use face mask, hand gloves and other safety equipment, which increase the amount of healthcare waste. The use and manufacturing of plastic based PPE is increased worldwide during pandemic (Singh *et al.*, 2020). China increased the production of medical masks to 14.8 million since from February 2020. Face mask and other plastic based protective equipment are reported to be a potential source of micro plastic fibers in the environment (Fadare and Okoffo, 2020). Polypropylene is used to make N-95 masks and Tyvek in the making of protective suits, gloves, and medical face shields; these substances release dioxin and toxic elements and can persist for long in the environment (Singh *et al.,* 2020). Haphazard dumping creates clogging in water ways and increase environmental pollution (Singh *et al.,* 2020; Zambrano-Monserrate *et al.,* 2020).

Mixing up of these wastes increases the risk of disease transmission and exposure to the virus of waste workers (Somani *et al.,* 2020; Singh *et al.,* 2020), therefore proper disposal of these safety equipment is very essential.

11.2.3 Municipal Solid Waste Generation, and Reduction of Recycling:

Increase of both organic and inorganic municipal has direct and indirect effects on environment. Quarantine policies during lockdown has increased the demand of online shopping leading to the increase in amount of household wastes from shipped package materials (Somani *et al.*, 2020; Zambrano-Monserra*te et al.*, 2020). Waste recycling is a most effective way to reduce pollution, save energy and conserve natural resources (M*a et al*., 2019) but due to the pandemic many countries has postponed the waste recycling procedures to diminish the transmission of viral infection.

Many European countries prohibited infected residents from sorting their waste (Zambrano-Monserrate *et al.,* 2020), which in turn has led to the increase landfilling and environmental pollutants worldwide.

11.2.4 Other Effects on the Environment:

To reduce the spread of coronavirus, large amount of disinfectants is applied into roads, commercial, and residential areas. Which may also eliminate non-targeted beneficial species, may create ecological imbalance. Direct drainage of municipal waste effluents into nearby aquatic bodies and rivers without treatment is a challenge for developing countries like Bangladesh but it is very crucial. China has already increased use of chlorine in disinfectants to prevent SARS-CoV-2 virus spreading through the wastewater but its increase in amount may lead to the formation of harmful by-product (Zambrano-Monserrate *et al.*, 2020).

11.3 Some Sustainable Strategies of the Environment:

The current COVID-19 situation has elicited a global response and made us to work together to win against the inevitable environmental crisis. Some of the major issues relating the sustainability of environment are describing as follows-
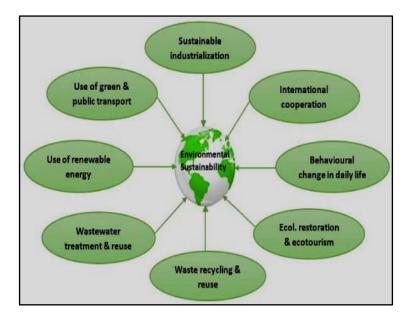

Figure 11.2: Proposed Strategies of Sustainable Environmental Management

Source- http://doi: 10.1016/j.heliyon. 2020. e 0496

- Use of green and public transport: Public transport must be the first choice over private vehicles, when it comes for sustainability of nature. Besides people must use bicycle for a short distance travel and use public bike sharing (PBS) system should be encouraged. It is both environment friendly and beneficial for health.

- Use of renewable energy: Burning of fossil fuels like coal, crude oil, natural gases increases GHGs emissions. Switching to the use of renewable energy sources like solar, wind, hydropower, geothermal heat and biomass can meet the energy demand and reduces the GHGs emission.
- Wastewater treatment and reuse: Proper treatment of both industrial and municipal wastewater is essential before discharging them to water bodies. Besides, excess water loss can be reduced by reusing treated wastewater in non-production processes like toilet flushing and road cleaning purposes.
- Waste recycling and reuse: Proper guidance for management of biomedical waste and other hazardous waste is very crucial. Government should implement extensive awareness campaign through different mass media, regarding the proper waste segregation, handling and disposal methods. Both industrial and municipal wastes should be recycled and reused.
- Ecological restoration and ecotourism: Nature needs restoration periodically; shutdown of tourist place must be done with a proper duration of time. Ecotourism practice must include the promotion of sustainable livelihoods, cultural preservation, and biodiversity conservation.
- Behavioral change in daily life: People must optimize the consumption of resources which contribute to global carbon emission and encourage to use locally grown food, make compost from food waste, switch off or unplug electronic devices when not used. Must practice for the use a bicycle for shorter distances instead of a vehicle.

The Covid-19 has generated various impacts on the environment; both positive and negative, which directly or indirectly, affecting human life and the global economy. Both social and ecology is an interdisciplinary factor, when we talk about our planet. Hence, this outbreak has reminded us how we have neglected the environmental components and enforced human induced climate change. Moreover, the global response of COVID-19 also teaches us to work together to combat against the threat to mankind. COVID-19 is address rehearsal to deal with climate change in the future.

11.4 References:

1. Arif, M., Kumar, R. & Parveen, shagufta (2020). Reduction in Water Pollution in Yamuna River Due to Lockdown under COVID-19 Pandemic. *ChemRxiv*. https://doi:10.26434/chemrxiv.12440525.v1
2. Berman, J. D., & Ebisu, K. (2020). Changes in U.S. air pollution during the COVID-19 pandemic. *The Science of the total environment*, *739*, 139864. https://doi.org/10.1016/j.scitotenv.2020.139864.
3. Bodrud-Doza M., Islam S.M.D., Rume T., Quraishi S.B., Rahman M.S., Bhuiyan M.A.H. Groundwater quality and human health risk assessment for safe and sustainable water supply of Dhaka City dwellers in Bangladesh. Groundwater Sustainable Development, 10,100374. https://doi.org/10.1016/j.gsd.2020.100374.
4. Cheval, S., Mihai Adamescu, C., Georgiadis, T., Herrnegger, M., Piticar, A., & Legates, D. R. (2020). Observed and Potential Impacts of the COVID-19 Pandemic on the Environment. *International journal of environmental research and public health*, *17*(11), 4140. https://doi.org/10.3390/ijerph17114140
5. Corlett, R. T., Primack, R. B., Devictor, V., Maas, B., Goswami, V. R., Bates, A. E.,

Koh, L. P., Regan, T. J., Loyola, R., Pakeman, R. J., Cumming, G. S., Pidgeon, A., Johns, D., & Roth, R. (2020). Impacts of the coronavirus pandemic on biodiversity conservation. *Biological conservation*, *246*, 108571. https://doi.org/10.1016/j.biocon.2020.108571

6. Cucinotta, D., & Vanelli, M. (2020). WHO Declares COVID-19 a Pandemic? *Acta biomedical: Atenei Parmensis*, *91*(1), 157–160. https://doi.org/10.23750/abm.v91i1.9397

7. Fadare, O. O., & Okoffo, E. D. (2020). Covid-19 face masks: A potential source of microplastic fibers in the environment. *The Science of the total environment*, *737*, 140279. https://doi.org/10.1016/j.scitotenv.2020.140279.

8. Goines, L., & Hagler, L. (2007). Noise pollution: a modem plague. *Southern medical journal*, *100*(3), 287–294. https://doi.org/10.1097/smj.0b013e3180318be5

9. Harrison, R.M.; Masiol, M.; Vardoulakis, S. Civil aviation, air pollution and human health. *Environmental research lette*r, 10, 041001.

10. He, M. Z., Kinney, P. L., Li, T., Chen, C., Sun, Q., Ban, J., Wang, J., Liu, S., Goldsmith, J., & Kioumourtzoglou, M. A. (2020). Short- and intermediate-term exposure to NO_2 and mortality: A multicounty analysis in China. *Environmental pollution (Barking, Essex: 1987)*, *261*, 114165. https://doi.org/10.1016/j.envpol.2020.114165

11. Islam S.M.D., Azam G. Seasonal variation of physicochemical and toxic properties in three major rivers; Shitalakhya, Buriganga, and Turag around Dhaka city, Bangladesh.*Journal of Biodiversity and Environmental Sciences*, 7(3):120–131.

12. Islam, S.M.DU., Bhuiyan, M. A. H. Sundarbans mangrove forest of Bangladesh: causes of degradation and sustainable management options. *Environmental Sustainability* **1,** 113–131 (2018). https://doi.org/10.1007/s42398-018-0018-y

13. Islam S.M.D., Huda M.E. Water pollution by industrial effluent and phytoplankton diversity of Shitalakhya River, Bangladesh. *Journal of scientific research*, 8(2):191–198. https://doi.org/10.3329/jsr.v8i2.26402.

14. Jin, Y., Yang, H., Ji, W., Wu, W., Chen, S., Zhang, W., & Duan, G. (2020). Virology, Epidemiology, Pathogenesis, and Control of COVID-19. *Viruses*, *12*(4), 372. https://doi.org/10.3390/v12040372.

15. Kaplan, G., Avdan, Z.Y., 2020. COVID-19: Spaceborne nitrogen dioxide over Turkey. *Eskişehir Technical University Journal of Science and Technology A-Applied Sciences and Engineering,* 21 (2), 251–255. https://doi.org/10.18038/estubtda.724450.

16. Kerns, E., Masterson, E. A., Themann, C. L., & Calvert, G. M. (2018). Cardiovascular conditions, hearing difficulty, and occupational noise exposure within US industries and occupations. *American journal of industrial medicine*, *61*(6), 477–491. https://doi.org/10.1002/ajim.22833.

17. Kivits, R., Charles, M. B., & Ryan, N. (2010). A post-carbon aviation future: Airports and the transition to a cleaner aviation sector. *Futures*, *42*(3), 199-211. https://doi.org/10.1016/j.futures.2009.11.005.

18. Ma B., Li X., Jiang Z., Jiang J. Recycle more, waste more? When recycling efforts increase resource consumption. Journal of cleaner production, 206:870–877.

19. Madhav, N., Oppenheim, B., Gallivan, M., Mulembakani, P., Rubin, E., & Wolfe, N. (2017). Pandemics: Risks, Impacts, and Mitigation. In D. T. Jamison (Eds.) et. al., *Disease Control Priorities: Improving Health and Reducing Poverty*. (3rd Ed.). The International Bank for Reconstruction and Development / The World Bank. https;//doi:10.1596/978-1-4648-0527-1_ch17.

20. Pereira R.P.T., Ribeiro G., M., Filimonau V. The carbon footprint appraisal of local visitor travel in Brazil: a case of the Rio de Janeiro–São Paulo itinerary. *Journal of*

Cleaner Production, 141:256–266.
https://doi:10.1016/j.jclepro.2016.09.049

21. Rahman, M. M., Bodrud-Doza, M., Griffiths, M. D., & Mamun, M. A. (2020). Biomedical waste amid COVID-19: perspectives from Bangladesh. *The Lancet. Global health*, *8*(10), e1262.
https://doi.org/10.1016/S2214-109X (20)30349-1.

22. Rume, T., & Islam, S. (2020). Environmental effects of COVID-19 pandemic and potential strategies of sustainability. *Heliyon*, *6* (9), e04965.
https://doi.org/10.1016/j.heliyon.2020.e04965.

23. Singh, N., Tang, Y., & Ogunseitan, O. A. (2020). Environmentally Sustainable Management of Used Personal Protective Equipment. *Environmental science & technology*, *54*(14), 8500–8502.
https://doi.org/10.1021/acs.est.0c03022

24. Sohrabi, C., Alsafi, Z., O'Neill, N., Khan, M., Kerwan, A., Al-Jabir, A., Iosifidis, C., & Agha, R. (2020). World Health Organization declares global emergency: A review of the 2019 novel coronavirus (COVID-19). *International journal of surgery (London, England)*, *76*, 71–76.
https://doi.org/10.1016/j.ijsu.2020.02.034

25. Solan, M., Hauton, C., Godbold, J. A., Wood, C. L., Leighton, T. G., & White, P. (2016). Anthropogenic sources of underwater sound can modify how sediment-dwelling invertebrates mediate ecosystem properties. *Scientific reports*, *6*, 20540.
https://doi.org/10.1038/srep20540.

26. Somani, M., Srivastava, A. N., Gummadivalli, S. K., & Sharma, A. (2020). Indirect implications of COVID-19 towards sustainable environment: An investigation in Indian context. *Bioresource technology reports*, *11*, 100491.
https://doi.org/10.1016/j.biteb.2020.100491.

27. van Doremalen, N., Bushmaker, T., Morris, D. H., Holbrook, M. G., Gamble, A., Williamson, B. N., Tamin, A., Harcourt, J. L., Thornburg, N. J., Gerber, S. I., Lloyd-Smith, J. O., de Wit, E., & Munster, V. J. (2020). Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1. *The New England journal of medicine*, *382*(16), 1564–1567.
https://doi.org/10.1056/NEJMc2004973.

28. Yunus, A. P., Masago, Y., & Hijioka, Y. (2020). COVID-19 and surface water quality: Improved lake water quality during the lockdown. *The Science of the total environment*, *731*, 139012.
https://doi.org/10.1016/j.scitotenv.2020.139012

29. Zambrano-Monserrate, M. A., Ruano, M. A., & Sanchez-Alcalde, L. (2020). Indirect effects of COVID-19 on the environment. *The Science of the total environment*, *728*, 138813.
https://doi.org/10.1016/j.scitotenv.2020.138813.