Marine Policy 141 (2022) 105088

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Impact of COVID-19 lockdown on aquatic environment and fishing community: Boon or bane?

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ARTICLE INFO

Keywords:
COVID-19
Lockdown
Aquatic resources
Habitat restoration
Small scale fisheries
Fishermen community

ABSTRACT

COVID-19 pandemic is a serious threat for mankind having an extensive socio-economic impact. However, it is considered as an unfortunate event with some positive environmental effects where nature is retrieving itself. The water quality index in different places of the world was reported to be improved during the lockdown, which in turn whipped up the regenerative process of fishes, sea turtles, marine mammals, and aquatic birds. Additionally, ecologically sensitive areas such as mangroves and coral reefs were also seen rejuvenating during COVID-19 seal off. But these favourable implications are temporary as there is an unexpected surge in plastic waste generation in the form of PPE kits, face masks, gloves, and other healthcare equipment. Moreover, the outbreak of the pandemic resulted in the complete closure of fishing activities, decline in fish catch, market disruption, and change in consumer preference. To address these multidimensional effects of the COVID-19 pandemic, government organizations, NGOs, and other concerned authorities should extend their support to amplify the positive impacts of the lockdown and reduce the subsequent pollution level while encouraging the fisheries sector.

1. Introduction

Off late 2019, an unfamiliar pneumonia-like disease was reported from Wuhan province, China, which is believed to have a connection with the wet market of the province [109]. The sudden outbreak of the disease was immediately reported to the emergency committee of the World Health Organization (WHO). WHO has declared COVID-19 as a "Public Health Emergency of International Concern (PHEIC)" on January 30, 2020 [108] due to several threats to the humans such as high infectivity of the virus, asymptotic carrier, mild clinical symptoms, lack of pre-existing human immunity and uncertain incubation time [13]. By keeping all these in mind WHO has also suggested various pandemic risk reduction strategies like social distancing, partial and complete lockdowns, mass quarantines, extensive travel bans, and disruption of transportation systems, which could have a direct impact on local and global socio-political relations and economic growth [31]. Implementation of worldwide lockdown offers an unprecedented and unique opportunity to study the impact of anthropogenic activities on the natural ecosystem and wild flora and fauna [9]. Apart from the human suffering and economic loss caused by the pandemic, it has offered various environmental gains including remarkable improvement of the water quality index [23]. As many countries across the globe underwent lockdown to prevent the spread of COVID-19, many wild animals were seen to enjoy a pollution-free, peaceful environment without any human interference. In this regard, there are numerous reports published in various newspapers stating the appearance/sighting of wild animals in the peri-urban and urban areas, and these incidents are reported as “Nature regaining its space” [72]. Restricted human activities during the pandemic are also believed to have a positive impact on riverine water and other aquatic ecosystems. For instance, during the pre-lockdown phase, water quality studies of the Ganga and Yamuna rivers showed high levels of pollution due to industrialization, rapid urbanization, and multiple land use [32], whereas, during the lockdown period, it has been observed that the effluent discharge from the industries was completely stopped, resulting in a decreased level of water pollution [6]. Restricted business activities and tourism during the lockdown period helped to improve the water quality of Vembanad Lake, as the concentration of suspended matter decreased by several folds [111]. These shreds of evidence suggested that the heavily polluted Indian rivers became clear after decades, therefore, it resulted in a reduction in aquatic pollution and also allowed the aquatic environment to revive [82]. Considering the global context, improvement in the water quality index in China

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https://doi.org/10.1016/j.marpol.2022.105088
Received 12 April 2021; Received in revised form 7 April 2022; Accepted 26 April 2022
Available online 5 May 2022

during April 2020 has been recorded as 67.4% when compared to April 2019 [65]. Similarly, reduced waste generation and limited commercial activities in Klang valley in Malaysia have resulted in significant improvement in surface water quality [46]. Another polluted river basin 'Meriç -Ergene'(Turkey) showed remarkable amelioration in the heavy metal pollution index during COVID-19 closure [104]. However, the implementation of lockdown also has some unintended repercussions including delayed conservation measures, lower-income generation, and illegal exploitation of natural resources [66]. Therefore, this paper is focusing on bridging the knowledge gap between the existing COVID-19 challenges and their possible consequences on the aquatic ecosystem.

2. Impact of COVID-19 lockdown on aquatic ecosystem

Although the COVID-19 pandemic is a curse to mankind, it can potentially act as a blessing for different aquatic ecosystems which are already under stress due to heavy exploitation and increased pollution. As 90% of the fish species are over or fully exploited, this global pause may be one of the unexpected opportunities for their revival [38]. Historically, it was observed that a pause in the commercial fishery during the second world war resulted in a significant increase in fish landings throughout the globe [11]. Therefore, in the current scenario, unintended COVID-19 lockdown may escalate the recovery of fish stock and their habitat such as coral reefs, mangroves, river beds, etc. In this context, several studies were carried out to evaluate the impact of lockdown on aquatic resources and the overall health of various aquatic ecosystems during the lockdown phase (Table 1). However, the impacts of the COVID-19 pandemic on aquatic biodiversity and fishing communities are subjective and discussed below.

2.1. Impact on freshwater ecosystem

COVID-19 lockdown is modulating different existing threats to freshwater ecosystems such as the introduction of invasive species, pollution, fragmentation, flow regulation, habitat loss, and exploitation [22]. Invasive species spread between different regions have been altered due to COVID-19 lockdown. Reductions in travel mostly lead to a subsequent reduction in alien species introduction associated with ballast water exchange, air transportation, movement of fresh foods, and recreational activities [36]. For example, decreased shipping traffic among all the global ports leads to a significant reduction in species invasion associated with ballast water exchange [89].

Reviewing the status of water pollution, it has been observed that discharge of contaminants such as heavy metals, nutrients, and toxic chemicals to water bodies have potentially reduced due to complete and partial closure of industrial activities [95]. Temporary recovery of urban surface water quality parameters (reduced NO_2) was observed over Europe, China, USA, and India during the COVD-19 lockdown [48]. Nationwide surface water quality transects of China showed a 'good' level between January to May 2020 [20]. These reductions in water pollution or improvement in the water quality will surely have some positive impacts on aquatic biota and their habitats. However, somehow or the other this pandemic has also caused various undesirable changes in the freshwater ecosystem. For example, interrupting the food supply chain in the United Kingdom during this pandemic has led to the dumping of food wastes including milk and other foodstuffs, which ultimately entered into the water bodies, potentially causing oxygen depletion through eutrophication [1]. Aquatic biodiversity has been also affected due to several factors that arise from the pandemic such as sewage treatment collapse [105]; increased use of disinfectants such as hand sanitizers and cleaning products [115]; excessive use of packaging and personal protection equipment [3] and single-use plastics [64].

Freshwater biodiversity especially migratory fishes are threatened due to the fragmentation of freshwater systems [35]. Although, the major concerns related to increased fragmentation in freshwater systems are the construction of the dam and hydroelectric power supply [114], but decelerated hydropower projects activities during the pandemic

Table 1
Comparison of water quality and pollutants between pre-lockdown and during-lockdown phase.

Country	Aquatic systems	Study period		Water Quality Parameter	Impact	References
		Pre-lockdown phase	During- lockdown phase			
India	Lower Gangetic Delta, India	Mean DO (1984–2019)	April, 2020	DO: 20% increase	Positive	[16]
	Yamuna River, India	March, 2020	April, 2020	COD: 33–82% reduction pH: 1–10% reduction EC: 33–66% reduction BOD: 45–90% reduction	Positive	[4]
	Yamuna River, within Delhi	January-March, 2020	April 2020	BOD: 42% decline COD: 39.25% decline Faecal Coliform: 40% decline Water Quality Index: 37% improvement	Positive	[81]
	Subsurface water in coastal city of Tuticorin	February, 2020	April, 2020	Se, As, Fe and Pb: 42%, 51%, 60% and 50% reduction respectively NO_3, total coliform and fecal coliform: 56%, 52% and 48% reduction respectively	Positive	[94]
Nepal	Bagmati River Basin	Monsoon, 2019	Monsoon, 2020	DO: increased by 1.5 times, BOD:1.5 decreased COD: decreased by 1.9 times	Positive	[80]
Turkey	Surface water quality in the Meriç -Ergene River Basin, Northwest	Mid-January 2020	Early June 2020	DO: 25.3% decrease BOD: 12% increase HPI and HEI: improved	Moderate	[104]
China	Lower Min River	November, 2019	April, 2020	TSS: 48% fall	Positive	[110]
	River water quality	March, 2019	March, 2020	DO: 19.5% increase COD: 14.4% decrease NH_4^+-N: 31.5% decrease Water Quality Index: improved	Positive	[65]
Italy	Venice Lagoon	January, 2020	April, 2020	TSM: 50% reduction	Positive	[77]

DO: Dissolved Oxygen; BOD: Biochemical Oxygen Demand; COD: Chemical Oxygen Demand; EC: Electrical Conductivity; pH: Potential of hydrogen; Se: Selenium; As: Arsenic; Fe: Iron; Pb: Lead; NO3: Nitrate; HPI: Heavy metal pollution index; HEI: Heavy metal evaluation index; TSS: Total Suspended Solid; NH4 + -N: Ammonium Nitrogen; TSM: Total Suspended Matter;

have resulted in a temporary suspension of further fragmentation of freshwater ecosystems in many developed countries and developing nations [24]. Due to reduced industrial activities and developmental work, aquatic habitats may get a chance to revive in different regions. For example, in India, reduction in pollution and commercial activity is predicted to improve habitat quality in the River Ganges, facilitating spawning migrations of the anadromous hilsa (Tenualosa ilisha) [22]. Cecchi [15] experimented to analyze volatile organic compounds including plasticizers, volatile fuel components, and corrosion inhibitors used in vessels. This study concluded that more than 40% of organic pollutants identified during 2019 have disappeared from the Venice lagoon water in the post lockdown phase. The sudden reduction of pollutants in the lagoon water due to tourism and water traffic halt is very encouraging. Lesser pollution triggered the water of Venice Lake to turn so clear that even the fishes were visible underwater [21].

On other hand, many examples persist where the natural habitats have suffered damage during COVID-19 lockdown due to lack of governance and policy enforcement. In this aspect, some of the unwelcomed consequences are also documented which include freshwater habitat destruction in India due to increased sand mining [61]; and a hike in the deforestation rate in Amazon Forest by 55% from January 2020 to April 2020 when compared with last year [14,91].

2.2. Impact on coastal/marine ecosystem

The coastal ecosystem (ocean-land interface zone) covers approximately 10% of the total oceanic surface area and plays a vital role in maintaining the oceanic biogeochemical cycle, especially the carbon cycle [44]. Generally, coastal areas tend to receive a high load of anthropogenic materials which sometimes leads to alteration of aquatic ecology and eutrophication [93]. Influx of anthropogenic contaminants to the coastal environment also exerts a significant effect on the deep-sea ecosystem [47]. Several studies suggested that human-induced pollutant influx is the key source of coastal/marine water pollution [69]. Having said that, the lockdown imposed during the COVID-19 pandemic has completely arrested or restricted tourism, fishing activities, industrial operations, agriculture, and aquaculture practices [69]. Henceforth, as anticipated, the level of coastal pollution has dropped significantly due to reduced anthropogenic influx. In this instance, coastal ecosystems across the globe including Barcelona (Spain), Acapulco (Mexico), Salinas (Ecuador), Tangier (Morocco), Gulf of Mannar (India), and Jakarta (Indonesia) have experienced much cleaner, more transparent, and improved water quality during lockdown period than the pre-lockdown phase ([2,19,37,111,113]). Improvement in the coastal environment has also conferred a significant positive impact on various ecologically sensitive ecosystems such as coral reefs and mangroves.

2.2.1. Coral reefs

The coral reefs are one of the most sensitive ecosystems on earth and provide shelter to millions of aquatic animals. Coral reefs are not only confined in the shallow tropic regions but also, can very well thrive in the aphotic cold-water areas at a depth of 40–2000 m [99]. In contrast to cold-water corals, tropical corals possess the symbiotic algae 'Zooxanthellae', which confer white to orange colour to the coral polyps [26]. Coral reefs are considered 'biodiversity hotspot' as it serves as breeding and rearing grounds for fish and shellfishes [49] and also facilitate nitrogen and carbon recycling in the aquatic ecosystem [27]. But due to the industrial revolution, ocean warming, increased CO_2 emission, and ocean acidification, coral reefs are under threat and cause massive coral bleaching [34,70]. However, a recent study suggested that the prevalence of high-intensity noise can affect the ecology and the physiological behaviour of coral reef organisms [42]. Noise generated from fishing operations has negative impacts on the coral reef and leads to reduced recruitment of coral larvae and reef fishes [6]. Anthropogenic noises such as vessel noise can influence the reproductive behaviour of the reef fishes and create sensory confusion among the reef animals. During the COVID-19 lockdown most of the industries such as coal-based power generation, automobile, and public transport facilities were seized; emission of greenhouse gases and particulate matter concentration has been reduced drastically, and also decreased commercial and private shipping activities has resulted in the reduction in noise intensity. In this context, a study was conducted in 'Tisler reef' located near a 'ferry highway' that connects Sweden and Norway. The study revealed that there was a significant drop in noise pollution due to COVID-19 closure [25]. Again, Lecchini et al. [63] observed that in Bora-Bora Island, French Polynesia, the density of reef fishes increased significantly by 143% during March-May 2020, due to restricted tourism activities and suspension of international flights. Tianna [103] also reported the rebound of the coral reef ecosystem in Hawaii as the researchers observed an increase in the baby coral population when compared to the pre-lockdown phase. Similarly, Edward et al. [37] conducted an underwater visual census in the Gulf of Munnar region during the pre-and post-lockdown phase. It has been reported that restricted fishing activity, travel, tourism, and religious activities during the COVID-19 pandemic have resulted in increased reef fish density from 406 no. 250 m^{-2} to 510 no. 250 m^{-2}. The report suggested that reduced fishing mortality/ fishing stress during the lockdown period is directly correlated with increased fish abundance in the reef areas. Also, a reduction in CO_2 emissions by 17% during the lockdown period as compared to the previous year, facilitates coral regeneration and overall improvement of the marine ecosystem [62].

2.2.2. Mangroves

Mangrove ecosystems, salt marshes, and seagrass meadows are collectively known as 'Blue Forest' and are considered as one of the most productive coastal ecosystems in the world [52]. Mangroves play a vital role in carbon sequestration and also reduce greenhouse gas emissions as they are utterly important for climate adaptation and mitigation purposes [55]. But unfortunately, mangrove ecosystems are under threat due to different human/anthropogenic affairs and urban development including tourism, construction, fishing activities, etc. Due to complete or partial lockdown, fishing activities and vessel operations have largely been reduced, and it may be helpful for mangrove restoration [33]. It has been observed that restriction in the anthropogenic activities and tourism halt in the Sundarban mangrove area is significantly contributing to the betterment of environmental quality and mangrove fauna diversity [17]. Similarly, Edward et al. [37] investigated the impact of COVID-19 lockdown on the water quality of the Gulf of Mannar region (India) and found a significant improvement in coastal health. They concluded that if this positive scenario persists for long, it will contribute to the recovery process of various dynamic ecosystems such as seagrasses and mangroves.

3. Impact on aquatic species

Over the past decades, there is an on-growing concern about the presence of agricultural and industrial contaminants in the aquatic ecosystem and their consequences on aquatic species as well as on human health [8]. It has been recognized that the most obvious outcome of aquatic pollution is the 'fish kill'. The fish egg and larval stages are more susceptible to various pollutants and have a substantial influence on their reproduction and thus affect the fish population [59]. But in this pandemic situation, enforcement of lockdown is a blessing in disguise as it facilitates the reclamation of the aquatic environment. Gilby et al. [45] reported a positive impact of COVID-19 lockdown on the species richness, revival of biodiversity, improved ecosystem, and even distribution of coastal vertebrates in the sunshine beach region, eastern Australia.

On the contrary, implementation of a nationwide lockdown created immense pressure on the wild fish population, especially in an impoverished country like India [39]. Reduced monitoring and strict enforcement of lockdown may end up in an increased Illegal, Unreported, and Unregulated (IUU) fishing activity and cause disruption of small-scale fisheries [102]. High prices and decreased fish availability in the market encouraged the local people to exploit the wild fish population. As a result, most of them count on destructive and illegal fishing methods and to some extent nullified the positive impact of the lockdown on the aquatic ecosystem, forcing them to move a step toward extinction [82].

3.1. Fish species and aquatic mammals

Most fish species and aquatic mammals are sensitive to noise pollution. Sound can travel a significant distance through the water and potentially resist the aquatic animals to catch their prey, connecting with their mates, hampers the migration process, and making them vulnerable to predation [112]. Noise can synergistically function along with other environmental stressors and cause damage to the aquatic ecosystem [107]. In the marine environment, noise pollution is mainly caused by natural sound sources and anthropogenic sound sources as well [51]. But due to the COVID-19 lockdown, most of the anthropogenic sound sources such as commercial shipping, recreational activities, and navigation are entirely seized, and the pollution level has reduced drastically [6]. Hence, many fishes are finding shelter in the reef area. Studies conducted by "Suganthi Devadason Marine Research Institute" (SDMRI), Tamil Nadu, revealed that restricted human activities are helping the coastal ecosystem and fish density of the Gulf of Manner to resuscitate and reduced usage of fishing traps allowed the population of parrotfish (Scarus ghobban) to increase by 39%. As the parrotfish plays a vital role to maintain coral health, hence increase in the parrotfish population indicates the extension of coral cover [76]. Also, several research conducted during the pandemic has highlighted the fact that reduced fishing efforts may have some positive impacts on overexploited fish stocks in the ocean. For example, this pandemic accelerated the regeneration of fish populations like whitefish, flatfish, and herring in European water and tuna in Chinese water [67].

Talking about marine mammals, increased noise pollution resulted in a decreased population of dolphins and whales. Many oceanic creatures such as Baleens whales make use of sounds in the water to hunt for food, navigate and communicate [106]. A study suggested a close association between reduction in noise pollution and level of stress-related hormones, i.e., glucocorticoids in Eubalaena glacialis (North Atlantic whales). Scientists predicted that underwater silence offered various advantages to whales and other aquatic mammals [87]. Therefore, reduction in noise pollution may result in the recovery of the endangered right whale population [87]. A study from the Hauraki Gulf Marine Park, New Zealand showed that reduced vessel activity leads to increase communication ranges of fishes and dolphins [83]. It has been perceived from this study that decreased noise from small vessels during lockdown increases communication ranges of fish and dolphins by 65%. For example, at sites nearer Auckland City, communication ranges increased approximately 18 m (22%) or 50 m (11%) for every 10% decrease in vessel activity for fish and dolphins, respectively [83].

During the lockdown period, dolphins were spotted playing in the coastal water of different urban areas such as in the Arabian Sea, near Marine Drive, Mumbai [97], and in the harbor of Italy [88] and reduced pollution levels made it easier to spot those. Similarly, in "Vikramshila Gangetic Dolphin Sanctuary" (VGDS), Bihar, Gangetic dolphins were seen thriving peacefully [57]. In Putrajaya Lake, Malaysia, the presence of marine otters was reported during lockdown due to fresh air and improved environmental conditions [28]. Whereas, dugongs (sea cows) were seen in the 'Ko Libong' island in Southern Thailand [100]. Furthermore, Lombrana [68] reported an increasing trend in the population of sea mammals such as seals, killer whales, and dolphins, especially in those regions where they were not seen for decades.

3.2. Aquatic birds

Migratory aquatic birds generally travel from one place to another to capitalize on the available seasonal resources. While emigrating, they cross the political boundaries of various nations, as the sky is the limit for them. This migration dramatically influences their survival and annual life cycle. But climate change is most likely to impact the aquatic ecosystems as well as the population of migratory birds [71]. Improved environmental parameters and decreased human interventions may have a greater positive impact on the diversity of migratory birds [7]. Imposed worldwide lockdown encouraged many migratory birds to thrive in the ocean, lakes, and other water bodies. Birds were able to communicate and fly freely as a result of decreased human interferences. Amid the COVID-19 lockdown chirping of birds was a regular phenomenon [6]. In April, an unexpected sighting of Greater Adjutant, a migratory bird was seen near the bank of River Kosi and Ganga, Bihar [101]. As per the report by the Bombay Natural History Society (BHNS), creeks of Mumbai Metropolitan Region (MMR) registered a 25% increase in flamingo migration populations in 2020 compared to 2019, which is mainly due to the restricted human activities during COVID lockdown [53]. Similarly, since sea eagles are sensitive to human presence [85], studies have shown that reduced human activities during the lockdown, led to a 7-fold increase in the sea eagle population in the Baltic Sea [50]. Many other migratory bird species such as Peregrine Falcon near the Chathanoor area [30], night heron, and open bill stork in Kulik Rajganj wildlife sanctuary, North Bengal [54] were also seen flourishing during the lockdown phase. In this context, Nishan [78] also observed a recovery sign in the red knot bird (Shorebird) population in the Delaware Bay of Eastern US, which mainly feeds on the eggs of the horseshoe crab.

3.3. Sea turtles

Monitoring of sea turtles is considered as one of the most difficult ventures due to their complex life cycle. During the COVID-19 lockdown reduction in marine tourism has resulted in a positive impression on the wildlife population [43]. When the entire human race is fighting against COVID-19, the empty Rushikulya beach of Orissa's Ganjam district, India, witnessed the mass nesting of Olive Ridley turtles. Orissa Wildlife Organization (OWO), reported that half of the Olive Ridley turtle's population tends to come here (Rushikulya beach) for nesting [58]. Sixty million eggs were laid by the sea turtles during this period, as the lockdown provided a perfect pollution-free environment for them due to decreased human interruption. The nesting beaches were tourist-free, and there was no disposal of plastic debris and reduced incidents of accidental crushing of turtle eggs. Therefore, these sea turtles had enough time for egg incubation, resulting in a higher hatching rate [56]. In global context, Quesada-Rodríguez et al. [84] has also observed a relatively stable nesting activity of leatherback sea turtle in Pacuare Reserve, Costa Rica. Also, Soto et al. [98] experimented 29 tourist beaches in seven Latin- American countries to assess the impact of lockdown on the relevant anthropogenic stressors. The study reported the 'nesting phenomenon' of endangered Green Turtle species, Chelonia mydas, in Caracas beach (Puerto Rico). Similarly, throughout COVID-19 isolation, population increment of leatherback turtles in Thailand and Florida [10], nesting of sea turtles in the bare Brazilian beaches [68], and successful nesting of critically endangered hawksbill turtles in the southern Philippines [73] were witnessed.

4. Impact on fisherfolk

Fishermen communities are the most vulnerable sections to the COVID-19 lockdown in terms of social and economic status. The probability of disease transmission is likely to be higher for them as they live in a congested, unhygienic place and also due to their migratory natures [40]. Healthcare facilities were not easily accessible to the fisherfolk communities, even in pre-COVID circumstances [79]. Therefore, under the COVID-19 situation, they face further difficulties to access sanitation supplies, testing processes, and treatments during the time of urgency

[12]. Nevertheless, due to the complete shutdown of fishing activities, people were suffering financially as well. According to FAO [41], the fisheries sector was also affected in a number of ways such as reduced fishing activities due to lockdown, social distancing norms, declining demand or price of fish, closers of restaurants, hotels, etc. Revenue generated from the fish and shellfish industries is greatly affected as the hotels and restaurants were closed [68]. The negative implications of COVID-19 on small-scale fisheries are quite obvious (Fig. 1). Most of the fishing activities were completely seized to maintain social distancing, which is considered to play a significant role to slow down the spread of the virus. Closure of transportation facilities undoubtedly helped to minimize the disease transmission, but at the same time, it has completely cut off the communication between semi-urban and urban fish markets [12]. Likewise, the fishing effort to catch Peruvian anchovy (the world's second-largest by catch fishery by volume) has dropped around 80% after the Peruvian government declared a stay-at-home order in response to the COVID-19 pandemic on March 16, 2020 [5].

Furthermore, the fisheries industry is facing various challenges like perishability, compliance, catch weight, lot and portion control, commodity pricing, storage conditions, etc. Hence, the sustainability of the fisheries industry demands a business chain to maximize margins, minimize costs, streamline operations and meet deliveries to ensure the effectiveness of the value chain [29]. The notable implications of the COVID-19 outbreak and enforcement of worldwide lockdown on culture and capture-based fisheries sector need precise monitoring to evaluate the crisis and therefore enable the process of recovery. To strengthen the resilience capacity of the sector, special attention should be given to the aquaculture farmers and other fishing communities through the value chain [41].

5. Potential risk of COVID-19

Since the outbreak of COVID-19 in China, WHO has declared various preventive measures to restrict the further spread of this pernicious virus across the globe [74]. Usage of personal protective equipment (PPE) and disposable face masks help to reduce the rate of human transmission of the virus. Disposable face masks are composed of polystyrene, polypropylene, polyester, or polyethylene [92]. While acknowledging the role of plastics to halt the transmission of COVID-19, it is necessary not to sabotage the sustainable use of plastic materials [96]. The extensive use of PPE kits resulted in a massive increase in the supply chain and reduced waste disposal management facilities of the plastics. Demand for the PPE kits, including masks, gloves, respirators, life support equipment, and disposable syringes are expected to reach high during this global pandemic [60]. But single-use plastic materials can significantly cause aquatic pollution and reduction in recreational and aesthetic worth leading to environmental and social instability [90]. Worldwide improper disposal and mismanagement of face masks and gloves are estimated as 129 billion and 65 billion per month respectively, causing potential environmental contamination [96]. The presence of plastic litter in the environment potentially contributes to carbon emissions and possesses a greater threat to the aquatic food chain [86]. It has been observed that fragmented face masks can be easily ingested by the fishes and other aquatic organisms and finally through the food chain it reaches humans, causing various health implications [18]. Before the emergence of the COVID-19 pandemic, plastic waste disposal was considered a major environmental issue because of its on-growing effects on terrestrial and aquatic ecosystems. It is already very challenging to get rid of the existing problems of plastic waste, whereas, a sudden surge in the supply of plastics can amplify the level of plastic pollution in the COVID-19 situation [60]. Excessive use of sanitizers and disinfectants to prevent the spread of COVID-19 can also cause toxicity to the aquatic environment and possess a significant threat to wildlife [75]. Lack of proper guidelines while using disinfectants on a large scale is one of the main reasons for aquatic contamination (Fig. 2).

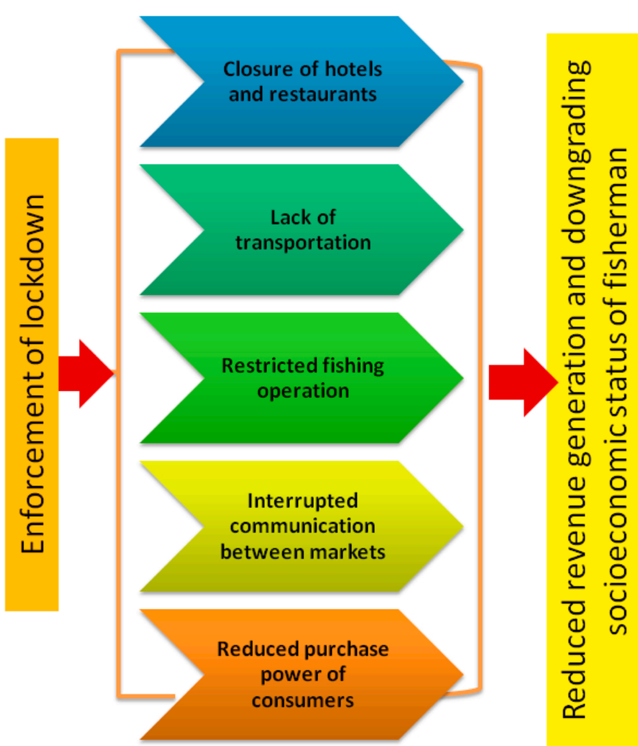

Fig. 1. Effects of lockdown on small scale fisheries.
(Adopted from [41]).

6. Conclusion

Implementation of lockdown during the COVID-19 pandemic has its own positive as well as some negative impacts on the environment. During the entire course of lockdown, our mother nature is trying very hard to bounce back. Although enforcement of lockdown helped to reduce the level of environmental pollution and triggered the revival of aquatic resources, it has also led to a sudden increase in plastic pollution and also affected the small-scale fisheries sector leading to unemployment and reduced revenue generation. The actual repercussions of the COVID-19 outbreak and worldwide lockdown are yet to be determined.

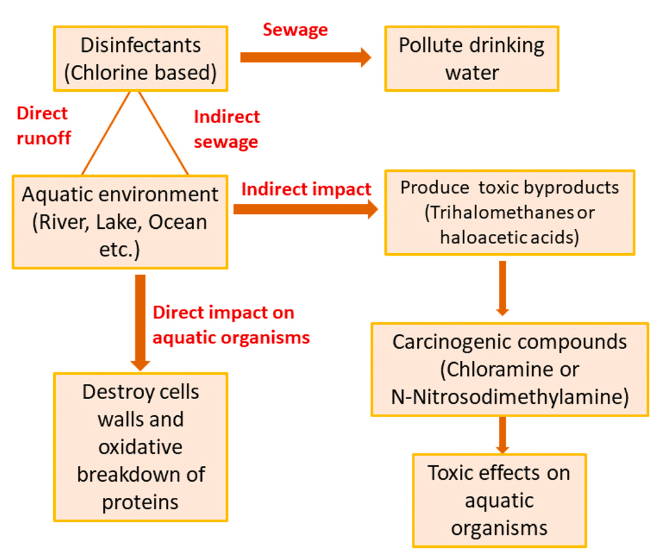

Fig. 2. Excessive use of disinfectants during COVID-19 and its consequences on aquatic ecosystem.
(Adopted from [115]).

In this context, the American Space Agency, NASA, is giving more emphasis to studying the impact of COVID-19 on the environment by using satellite imagery and hoping to draw a relationship between lockdown and pollution level. Several pieces of evidence related to the impact of COVID-19 lockdown on the aquatic ecosystem are very crucial in formulating future conservation policies. Additionally, a scientific baseline data is required which can improvise general human perception to endorse appropriate coastal fishing, tourism, and pollution management strategies in the post-pandemic phase. Thereafter, this review paper will provide a proper understanding of the current scenario and will help to avail the benefits of the global pause in a true sense.

CRediT authorship contribution statement

Abhijit Mallik: Writing – original draft. **Puja Chakraborty**: Writing – review & editing. **Shashi Bhushan**: Preparation of draft & Supervision. **Binaya Bhushan Nayak:** Supervision.

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