Archives of Current Research International

Volume 24, Issue 7, Page 142-151, 2024; Article no.ACRI.120543
ISSN: 2454-7077

Impact of COVID-19 on River and Fisheries: A Comprehensive Guide

Durgesh Kumar Verma [a], Shravan Kumar Sharma [b*], Ridhdhisa R. Barad [c], Rajesh Jayaswal [a], Pragati Inwati [d], Ishwar Chandra [e], Vivek Kumar [f], Akanksha Kurmi [g] and Binal Rajeshbhai Khalasi [d]

[a] ICAR-Central Inland Fisheries Research Institute, Regional Cantre, Prayagraj, Uttar Pradesh (211002), India.
[b] ICAR-CIFT, Research Centre, Navi Mumbai, Maharashtra (400 703), India.
[c] Department of Aquaculture, College of Fisheries Science, Kamdhenu University, Veraval, Gujarat (362265), India.
[d] College of Fisheries, Mangalore, Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar, Karnataka (575002), India.
[e] ICAR- Central Institute of Fisheries Education, Regional Centre Rohtak, Haryana (124411), India
[f] Faculty of Fisheries Science, Kerala University of Fisheries and Ocean Studies, Kochi, Kerala (682 506), India.
[g] Department of Fisheries Resource Management, College of Fishery Science, Nanaji Deshmukh Veterinary Science University, Jabalpur, Madhya Pradesh (482004), India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/acri/2024/v24i7839

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/120543

Review Article

Received: 06/06/2024
Accepted: 10/08/2024
Published: 28/08/2024

**Corresponding author: Email: shravansharmacofsn@gmail.com;*

Cite as: *Verma, Durgesh Kumar, Shravan Kumar Sharma, Ridhdhisa R. Barad, Rajesh Jayaswal, Pragati Inwati, Ishwar Chandra, Vivek Kumar, Akanksha Kurmi, and Binal Rajeshbhai Khalasi. 2024. "Impact of COVID-19 on River and Fisheries: A Comprehensive Guide". Archives of Current Research International 24 (7):142-51. https://doi.org/10.9734/acri/2024/v24i7839.*

ABSTRACT

Impact of COVID-19 on Rivers and Fisheries: A Comprehensive Guide is a review article that discusses the effects of the COVID-19 pandemic on the aquaculture sector (including financial assistance, input sub/sides, social protection, support for access to new markets, and other measures) aquatic environments, including rivers and fisheries. The authors highlight a significant reduction in tourism, which has led to a decline in the Indian economy. They also discussed the impact of the pandemic on the aquaculture industry, which has been severely affected by the reduction in demand. This review article further discusses the changes in water quality parameters, including increased plastic waste, improved water quality index due to reduced human activities and reduced availability of nutrients due to decreased agricultural activities. The authors also discussed the impact of the pandemic on fish biodiversity, including population restoration due to reduced industrial pollution and changes in the reproductive state of fish. The article concludes by discussing the impact of the pandemic on the exploitation of fish and the aquaculture and fishing industries, including increased fishing effort and harvest with prolonged lockdowns and decreased fish production.

Keywords: COVID-19; economy; environment; fisheries; river; aquaculture; fish biodiversity.

1. INTRODUCTION

A pandemic is an outbreak of an infectious disease that has spread across a large area, such as multiple continents or the entire world and has a significant impact on many people. The disease has spread worldwide and affects many people [1]. It is called an epidemic and millions of people die in this epidemic' [2]. In China, the first case of severe acute respiratory syndrome was diagnosed in November 2002; however, it became a global epidemic in March 2003, with occurrences in Hong Kong, Vietnam, Singapore and Canada. During the epidemic, nearly 8,000 suspected SARS cases and almost 800 deaths were recorded by the WHO in 29 countries, indicating a four-month global outbreak [3].

A virus called Middle East Respiratory Syndrome coronavirus (MERS-CoV) is transmitted from infected dromedary camels to humans [4]. Several Middle Eastern, African and South Asian countries have detected MERS-CoV in dromedaries. Since 2012, cases have been reported in 27 countries and the virus has caused death in 858 people [5].

Coronaviruses belong to a large virus family. COVID-19 virus is 60-140 nm in diameter and contains single-stranded RNA as nuclear material [6]. Middle East Respiratory Syndrome (MERS), Extreme Acute Respiratory Syndrome (SARS) and less severe infections, such as the common cold, are all caused by this virus. Alpha, beta, gamma and delta strains of coronaviruses have been found in humans [7]. The COVID-19 pandemic first emerged on December 31, city, Wuhan in, China [8]. The World Health Organization (WHO) identified this new virus as a 2019 novel coronavirus on January 12, 2020. The WHO declared this virus a worldwide pandemic on January 30, 2020 [6].

The first confirmed positive case in India was announced on January 30, 2020, in a person who had already returned from China and was from the Thrissur region of Kerala [9]. As of April 14, 2020, India's Ministry of Health and Family Welfare (MOHFW) has reported 10,815 positive cases and 358 deaths in the country [10]. The Indian government suspended visas after February 15 and demanded that all incoming passengers, including Indian nationals from COVID-19 countries, such as Germany, Iran, the Republic of Korea, France, Spain and Germany, be quarantined [7]. Institutions of higher learning, commerce, sports and spirituality were shut down.

2. IMPACTS OF COVID-19 ON AQUATIC ENVIRONMENT

The tourism industry in India has been severely impacted by the pandemic, resulting in a significant reduction in tourists and a consequent decline in the Indian economy. The effects of this have been felt across all sectors from hospitality to transportation to retail. This has had a devastating impact on the livelihoods of many people who depend on tourism for income. The government has taken steps to mitigate the effects of this crisis, but it is clear that more needs to be done if India is to recover from the

economic downturn [6]. Many researchers have found a reduction in environmental noise and land surface temperature, increased plastic waste and a clean beach as a result of the reduction in human activity [11]**,** aquatic resources and supplies, the aquaculture industry and the socio-economic stability of the global population are all affected by ecological changes caused by the pandemic in aquatic and terrestrial environments. The reduction of agricultural, industrial and commercial activities in water bodies around the world has resulted in improved water quality and increased fish supply in the aquatic environment [12]. As a result of growing use, it has been noted that disinfectants (such as hand sanitizers and cleaning agents) [13] are significantly more common in natural waters through runoff and wastewater discharge. In addition, improved anadromous hilsa (*Tenualosa ilisha*) spawning migrations have been observed in India. Despite evidence of habitat restoration, fluctuations in irrigation demands and management had a significant impact on fish biodiversity [14], Small-scale freshwater fisheries were impacted by the early pandemic's reduction in demand, which led to a lower harvest, market, supply chain and loss of income [15]. In the two months following the lockdown, it was seen that the dissolved oxygen (DO) levels, phytoplankton, biological oxygen demand (BOD) and nitrate concentration in the Ganga River improved [16].

Increased total fish production, fish export, total seed production, disposition of fish catch (marketing fresh, frozen, reduction, miscellaneous, offer for reduction and others) and export of fish and fish products. Decreased marine fish production, annual fish production, decreased disposition of fish catch (curing, caning), decreased quantity and price of fish and fish products (total fish production quantity, frozen fish quantity and price, frozen squid quantity, value and price, live items quantity, value and price and other fishery products quantity and value). The number of marine fish transported onshore in 2020 was 2.73 million tons. This was 23.45% lower than the previous year because of reduced fishing days due to lock-downs imposed by the epidemic [16].

3. IMPACT OF COVID-19 ON WATER QUALITY PARAMETER

Praveena et al. [18] Reported decrease in total dissolved solids and turbidity was recorded because of fewer human activities and domestic discharges during lockdown. Water transparency has been reported to increase during this period. [11] reported that nutrient availability was also reduced due to reduced activities of agro-industries and less nutrient-rich waters from commercial and domestic sources [19], also recorded decreased concentration of heavy metal in surface and ground waters because of reduction of industrial discharges [11] and observed an improvement in water quality parameters (based on DO, BOD, COD, pH and NH_3-N) in lakes and rivers had been observed. Manufacturing contamination has also been reported to be reduced. Increased domestic sewage due to higher human activity at home, after resealing the increased non-point sources of water pollution in rivers during the lockdown period. [20] reported that SARS-CoV-2 was found in feces and wastewater. The presence of the virus has been reported to be higher in untreated sewage in many countries where facilities for water treatment are not efficient. The use of face masks and Personal Protection Equipment (PPE) has increased due to the COVID-19 pandemic, leading to an increase in biomedical waste [21]. The COVID-19-related increase in microplastics in the environment can contaminate coastal waters. Shrimp mortality has increased and top predators, including commercial species, ingest more microplastics, which could have an impact on aquaculture farming [17]. Higher use of chemical contaminants (endocrine-disrupting compounds) in hospitals 10 to 20 times during the COVID-19 lockdown while the absence of fewer recycling facilities, increased water pollution in the rivers and harmful effects on aquatic ecosystems and human health. A decline in chlorophyll and phytoplankton has been reported to be due to decreased nitrogen inflow from the land area [22]. Due to the closure of agricultural businesses, there was also a documented reduction in microbial infections (overall fecal coliform bacteria, fecal *Streptococci* and *Escherichia coli*) [19].

3.1 Implications of COVID-19 on Fish Biodiversity and Aquatic Resources

According to Coll M et al. [24], reduced industrial pollution may lead to population restoration, particularly for fast-growing species. Deep-water shrimp production has also been documented because of the reduced fishing pressure. Reduced international trade and travel have been blamed for the decline in the movement of invasive species [17].

Table 1. Impacts of COVID-19 on the aquatic environment

Components	Impacts/Results	Reasons
Water quality	Decrease in total solids, turbidity	Decreased the discharge, Turbidity levels 25% decrease due to less human activity in the aquatic water bodies.
	Increase suspended particulate matter	Decreased SPM by 15.9% due the human activity in the water bodies and other areas
	Improvement in water transparency	Decreasing water-based activities such truism, fishing transporting, etc. due to lockdown
	Decrease in nutrients in the aquatic ecosystem	less transporting nutrients as west materials in the natural waters after the Shutdown the agro-based industry due to the lockdown.
	Reduction of heavy metal concentrations in aquatic ecosystem such as surface and ground waters	Due to the less industrial activity and discharge
	Significant Improvement of water quality index (based on DO, BOD, COD, pH and NH3-N) in rivers and lakes	Less industrial, agricultural, Truism, Fishing, Oil transportation, and human activity due to the lockdown
Chlorophyll	Decrease of chlorophyll a	Decrease of nitrogen inflow from the land area
Bacterial loads	Reduced total coliforms, fecal coliforms, fecal Streptococci, Escherichia coli	Due to the closing of Agri industries such as poultry industry, aquaculture, livestock etc.
Resources and biodiversity	Increase production of deep-water shrimp production.	Increasing fish growth and diversity due to Less fishing pressure, reduced anthropogenic activities in the corona period.
Plastic wastes	Increase demand and production of personal protection equipment (PPE) and face masks	Higher use and Demond in relation of personal protection equipment (PPE) in the COVID-19 pandemic
Medical wastes—COVID-19 related pharmaceuticals	Increased chemical contaminants (endocrine disrupting compounds) during the COVID period and also harmful to aquatic ecosystems and human health.	Higher production and consumption of equipment wastes from hospitals—10 to 20 times higher, less recycling. Environmental concerns on antibiotics and antivirals; ivermectin and azithromycin had high effects on aquatic organisms.
	Impairment of reproductive system in fish	Abnormalities in fish ovaries

Components	Impacts/Results	Reasons
Disinfectants	Strong biocidal properties against bacteria and viruses	Formation of dioxin and other carcinogen in surface waters. High ecological risks
Water as a medium to spread viruses	SARS-CoV-2 detected in feces	Increase of COVID-19 cases and evidence its presence in waste waters
Transmission of virus from wastewater to surface water	Increased virus to surface waters due to less treated or untreated sewage	No availability or less facilities and knowledge of west water treatment plant and facilities
Use of WBE (Wastewater-based epidemiology)	No availability of high durability and powerful tools for the assessment and controlling the covid pandemic	To prevent contamination and management of surface and ground water supply for drinking water
Tertiary waste treatment facility	Able to completely remove COVID-19 virus	Complete deactivation of technologies used
Use of technologies	Contain/removal of viral particles	No knowledge and available technology Coagulation-flocculation and filtration Natural microbes—Bioremediation technology (Virus elimination via predation, antagonism, and nutrient competition) No more use microalgal technology

Source: [17]

Table. 2 Assessment of water quality from different area

Place	Water quality
Lower Gangetic Delta, India	20% Dissolved Oxygen increase during the lockdown
Surface water in the coastal city of Tuticorin Tamil Nadu	Se 42%, As 51%, Fe 60% and Pb 50% reduction respectively during the covid time
Yamuna River, Delhi	Water Quality Index: 37% improvement Coliform: 40% decline COD: 39.25% decline Faecal BOD: 42% decline

Source:[23]

3.2 Influence of COVID-19 on State of Reproductive in Fishes

Cooke et al. [12], observed that due to the improved migration activity of anadromous hilsa (*Tenualosa ilisha*) in the Indian water bodies because of the lower human activities in the river during the lockdown. He also stated that changes in irrigation demand and management have a significant impact on fish biodiversity. It also hurt the habitat of fish, such as the proliferation of illegal activities that harm fish habitats under reduced environmental enforcement.

3.3 Impact of COVID-19 on Exploitation of Fishes

Cooke et al. [12] observed a reduction in fishing effort harvest during the early phase of lockdown in the corona lockdown periods and reported increased fishing effort and harvest with prolonged lockdowns, loss of income, need for food and time for entertainment.

4. EFFECTS OF COVID-19 ON THE AQUACULTURE AND FISHING INDUSTRIES

4.1 Fisheries Area

The Covid-19-related lockdown and social distance rules impacted all aspects of the fisheries and aquaculture industries, from fishing to landing, processing and marketing, as well as pond stocking. Those who are normally at a disadvantage, such as migrant workers and women, are most affected [25].

Table 3. Impacts of COVID-19 on fishery and aquaculture industries

	Components/ Elements	Impacts	Reasons/ Causes
Fisheries Sector	Landings (fresh catches)	Reduced	Less fishing operation, Restrictions on social, low Demond due to loss of job
	Revenues; loss of income, loss of livelihoods	Reduced	during the lockdown and transportation
	Fishing pressure	Reduced fishing pressure	Less fishing operation, Decreased consumer demand, sales of fish/fish
	Fish production and sea food value chain	Decrease	products, and tourism
	Fish supply through the value chain	Decrease of fish supply	Less fishing operation and transportation due to commercial and domestic
	Decline in exports	Decline	consumption
	Demand for fish	Reduced	Less demand, no fishing and
	Income of fishers		transportation during to covid
	Illegal fishing	Increase	Lax in enforcement, less surveillance
	Fishery sustainability		Reduced fishing activity allows fish stocks to recover
Aquaculture Sector	Supply chain	Disrupted supply chain	No transportation and supply mainly feed, chemicals, and seeds) in the fisheries sector
	Demand for aquaculture products	Decreased.	Low consumption and demand by people
	Food safety and security	Decreased	Closure of feed mills, and fish processing plants due to Low inputs and outputs
	Microplastics	Increase in mortality of culture animals	Due to higher domestic pollutants

Source: [17]

Increased total fish production, fish export, total seed production, disposition of fish catch (marketing fresh, frozen, reduction, miscellaneous, offer for reduction and others) and export of fish and fish products. Decreased marine fish production, annual fish production, decreased disposition of fish catch (curing, caning), decreased quantity and price of fish and fish products (total fish production quantity, frozen fish quantity and price, frozen squid quantity, value and price, live items quantity, value and price and other fishery products quantity and value). The number of marine fish transported in 2020 was 2.73 million tonnes. This was 23.45% lower than the previous year as a result of fewer fishing days due to lockdowns brought on by the epidemic [16]. A 34% reduction in fishing efforts was recorded because of a decrease in fishing operations [26] and its impact on fishing efforts. Due to the covid lockdown's prohibitions on social movement and distance, it was also noted that landings of fresh catch were down 40% in the USA and 49% in the Mediterranean [27]. Due to the lack of product consumption in the corona lockdown, there has been a decline in fish production, fish/ fish product sales, ecotourism and seafood value chains [24]. A reduction of 70% and a decrease of 40% in the domestic consumption of fish supply through the value chain in Indonesia has also been reported [28]. Noticed also decreased 43% of exports in the USA, which was affected by the covid (White *et al.,* 2021). Recorded 30%, reduction in fish demand in Malaysia and 70% in restaurant consumption [29] and increased illegal fishing due to WHO enforcement and less surveillance during the lockdown of corona periods.

4.2 Aquaculture Sector

A fishery value chain is defined as a series of connected value-adding processes that convert inputs into outputs, resulting in increased profits and competitive advantage. Inbound distribution or logistics, manufacturing activities, outbound distribution or logistics, marketing and selling and after-sales support are typical value chain components. The shutdown or reduced activity of hatcheries, farms, feed mills and fish/fishery product processing facilities has resulted in supply chain disruption and operational challenges (WHO, 2020). Poorer consumers have less demand for hotels because of the reduced consumption of aquaculture products [30].

5. EVALUATION OF THE IMPACT OF COVID-19 ON THE SAFETY AND MANAGEMENT OF AQUATIC FOOD

5.1 Ecological Hazards in Fisheries and Aquaculture

- Ecological hazards in fishing and aquaculture are defined as interactions with other living aquatic animals, the immediate environment, or connections between living aquatic species and the environment that pose a threat or cause harm. Ecological risks in fisheries and aquaculture are defined as interactions between biotic and abiotic components in aquatic environments.
- The excessive and erratic use of various chemicals throughout the COVID-19 pandemic, along with their long-term effects on water pollution and human exposure to chemicals.
- The potential to disrupt the marine ecosystem is due to inadequate awareness of how to properly manage discarded face masks and gloves [31].
- There are not enough disposal facilities to handle biohazard contaminants, an uncommon form of marine contamination that affects both human health and marine ecosystems. Good management techniques, good manufacturing processes and proactive policies and regulatory frameworks (GMP): The consumption of single-use plastics has increased [32].
- Transportation regulations have decreased the availability and accessibility of inputs (such as feeds, seeds, aerators and fish health items) decreased. Risk mitigation includes pre-stocking, essential input, utilizing available supplier relationships and negotiating.

5.2 Human Health/ Food Safety Hazards in Fisheries and Aquaculture

- A microbial, biochemical, or physical agent discovered in or present in human or fish food that can harm humans is referred to as a food hazard. The incidence and severity of adverse health impacts in populations exposed to dietary hazards were calculated as hazards, but on the other hands. At every stage of the production process, even on the farm, risks can contaminate the food. These hazards

can then be extended throughout fish handling and preparation processes. It is challenging to determine intervention measures for maintaining food safety when microbiological risks cause diseases in humans, but not in fish, as in the case of some naturally pathogenic *Vibrio* spp. or the uncontrollable infection of fish farms by *Salmonella* spp. in some fish operations [33].

- Face masks and related microparticles are easily swallowed by fish and aquatic living species, thereby impacting the marine food chain. Risk reduction techniques include, for example, good management practices, good hygienic practices (GHP), excellent quality standards (GMP), product safety precautions, consumer awareness and integrated approaches that include health promotion, vector control and targeted community chemotherapy (for parasitic infections).
- SARS-CoV-2 transmission to aquatic food animals or goods, including packaging and storage conditions, that are covered in ice or frozen. Food safety controls; consumer knowledge; combination of strategies connecting physical condition education, vector management and discriminating inhabitants chemotherapy, risk mitigation good management practice, good aquaculture practice (GAP), good quality hygienic practice (GHP), first-class industrialized perform (GMP), food safety controls, consumer awareness, sustainable strategies involving health education, vector control and selective population chemotherapy (for parasitic infections).

5.3 Financial Hazard in Fisheries and Aquaculture

Financial risk in fisheries and aquaculture refers to the risk of losing money on fishing or aquaculture investments. Fishery investments can be public or private and they can be made on behalf of a variety of stakeholders, including individual farmers, shareholders, agricultural companies, economic and financial institutions and government agencies. During the lockdown period, per capita fish consumption decreased dramatically [8]. To die with financial stress, businesses were reduced or stopped operations and lying off or contracting fewer temporary workers [34]. patterns of food consumption were also changed and reading to consumers became more difficult.

6. CONCLUSION

The Impact of COVID-19 on Rivers and Fisheries: A comprehensive guide discusses the effects of the COVID-19 pandemic on aquatic environments, including rivers and fisheries. The authors highlight a significant reduction in tourism, which has led to a decline in the Indian economy. They also discussed the impact of the pandemic on the aquaculture industry, which has been severely affected by the reduction in demand. The review article further discusses the changes in water quality parameters, including increased plastic waste, improved water quality due to reduced human activities and reduced availability of nutrients due to decreased agricultural activities. The authors also discussed the impact of the pandemic on fish biodiversity, including population restoration due to reduced industrial pollution and changes in the reproductive state of fish. The article review concludes by discussing the impact of the pandemic on the exploitation of fish and the aquaculture and fishing industries, including increased fishing efforts and harvest with prolonged lockdowns and decreased fish production. The review article was published as a research article and was based on data available up to 2020.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

Competing interests

Authors have declared that no competing interests exist.

REFERENCES

1. Weerarathna IN, Luharia A, Tivaskar S, Nankong FA, Raymond D. Emerging Applications of Biomedical Science in Pandemic Prevention and Control: A Review. Cureus. Published online August 24, 2023.
DOI:10.7759/cureus.44075

2. Kelly H. The classical definition of a pandemic is not elusive. Bull World Health Organ. 2011;89(7):540-541.
DOI:10.2471/BLT.11.088815
3. WHO. Google Search. Published; 2003.
Available:http://www.who.int/csr/sars/archive/2003_03_12/en/
[Accessed on March 7, 2022].
4. Christian N, Nadia H, Fidele B, et al. The coronavirus disease 2019 (COVID-19) - A global health emergency. Published; 2020.
Available:https://rbc.gov.rw/publichealthbulletin/articles/read/55/The%20coronavirus%20disease%202019%20(COVID-19)%20-%20A%20global%20health%20emergency
[Accessed July 26, 2024].
5. FAO. Middle East respiratory syndrome coronavirus (MERS-CoV). Published; 2019.
[Accessed on July 26, 2024].
Available:https://www.who.int/news-room/questions-and-answers/item/middle-east-respiratory-syndrome-coronavirus-(mers-cov)
6. Ghosh A, Nundy S, Mallick TK. How India is dealing with COVID-19 pandemic. Sens Int. 2020;1:100021.
DOI:10.1016/j.sintl.2020.100021
7. Sharma P, Kaur DM, Narwal G. Other side of the COVID-19 Pandemic: A review. Pharma Innov J. 2020;9(5):366-369.
Available:https://www.thepharmajournal.com/archives/?year=2020&vol=9&issue=5&ArticleId=4719
[Accessed February 16, 2022]
8. Mandal I, Pal S. COVID-19 pandemic persuaded lockdown effects on environment over stone quarrying and crushing areas. Sci Total Environ. 2020; 732:139281.
DOI:10.1016/j.scitotenv.2020.139281
9. Ghobakhloo S, Miranzadeh MB, Ghaffari Y, Ghobakhloo Z, Mostafaii GR. Association Between Air Pollution, Climate Change, and COVID-19 Pandemic: A Review of the Recent Scientific Evidence. Health Scope. 2022;11(4).
DOI:10.5812/jhealthscope-122412
10. Saxena A, Shivani C. Artificial intelligence and machine learning in healthcare 9811608105, 9789811608100 – DOKUMEN.PUB. Published; 2021.
Available:https://dokumen.pub/artificial-intelligence-and-machine-learning-in-healthcare-9811608105-9789811608100.html
[Accessed July 26, 2024.]
11. Yusoff FM, Abdullah AF, Aris AZ, Umi WAD. Impacts of COVID-19 on the aquatic environment and implications on aquatic food production. Sustainability. 2021;13 (20):11281.
DOI:10.3390/su132011281
12. Cooke SJ, Twardek WM, Lynch AJ, et al. A global perspective on the influence of the COVID-19 pandemic on freshwater fish biodiversity. Biol Conserv. 2021;253: 108932.
DOI:10.1016/j.biocon.2020.108932
13. Mallik A, Chakraborty P, Bhushan S, Nayak BB. Impact of COVID-19 lockdown on aquatic environment and fishing community: Boon or bane? Mar Policy. 2022;141:105088.
DOI:10.1016/j.marpol.2022.105088
14. Avtar R, Singh D, Umarhadi DA, et al. Impact of COVID-19 Lockdown on the Fisheries Sector: A Case Study from Three Harbors in Western India. Remote Sens. 2021;13(2):183.
DOI:10.3390/rs13020183
15. Balamurugan M, Kasiviswanathan KS, Ilampooranan I, Soundharajan BS. COVID-19 Lockdown Disruptions on Water Resources, Wastewater, and Agriculture in India. Front Water. 2021;3:603531.
DOI:10.3389/frwa.2021.603531
16. CMFRI K. CMFRI Annual Report 2020 केंद्रीय समुद्री मात्स्यिकी अनुसंधान संस्थान वार्षिक प्रतिवेदन 2020. Published; 2021.
Available:http://eprints.cmfri.org.in/15458/
[Accessed on July 26, 2024].
17. Yusoff FM, Abdullah AF, Aris AZ, Umi WAD. Impacts of COVID-19 on the Aquatic Environment and Implications on Aquatic Food Production. Sustainability. 2021;13 (20):11281.
DOI:10.3390/su132011281
18. Praveena SM, Aris AZ. The impacts of COVID-19 on the environmental sustainability: a perspective from the Southeast Asian region. Environ Sci Pollut Res. 2021;28(45):63829-63836.
DOI:10.1007/s11356-020-11774-0
19. Selvam S, Jesuraja K, Venkatramanan S, et al. Imprints of pandemic lockdown on subsurface water quality in the coastal industrial city of Tuticorin, South India: A revival perspective. Sci Total Environ. 2020;738:139848.
DOI:10.1016/j.scitotenv.2020.139848
20. Albastaki A, Naji M, Lootah R, et al. First confirmed detection of SARS-COV-2 in untreated municipal and aircraft

wastewater in Dubai, UAE: The use of wastewater based epidemiology as an early warning tool to monitor the prevalence of COVID-19. Sci Total Environ. 2021;760:143350. DOI:10.1016/j.scitotenv.2020.143350
21. Benson NU, Fred-Ahmadu OH, Bassey DE, Atayero AA. COVID-19 pandemic and emerging plastic-based personal protective equipment waste pollution and management in Africa. J Environ Chem Eng. 2021;9(3):105222. DOI:10.1016/j.jece.2021.105222
22. Mishra DR, Kumar A, Muduli PR, et al. Decline in Phytoplankton Biomass along Indian Coastal Waters due to COVID-19 Lockdown. Remote Sens. 2020; 12(16):2584. DOI:10.3390/rs12162584
23. Mallik A, Chakraborty P, Bhushan S, Nayak BB. Impact of COVID-19 lockdown on aquatic environment and fishing community: Boon or bane? Mar Policy. 2022;141:105088. DOI:10.1016/j.marpol.2022.105088
24. Coll M, Ortega-Cerdà M, Mascarell-Rocher Y. Ecological and economic effects of COVID-19 in marine fisheries from the Northwestern Mediterranean Sea. Biol Conserv. 2021;255:108997. DOI:10.1016/j.biocon.2021.108997
25. Gopal N, Edwin L, Ravishankar C.N. Covid-19 throws the indian fisheries sector out of gear. Published online. 2020;8.
26. Coll M, Ortega-Cerdà M, Mascarell-Rocher. Ecological and economic effects of COVID-19 in marine fisheries from the Northwestern Mediterranean Sea - ScienceDirect. Published; 2020. Available:https://www.sciencedirect.com/science/article/pii/S0006320721000495 [Accessed on March 8, 2022].
27. Alam GMM, Sarker MNI, Gatto M, Bhandari H, Naziri D. Impacts of COVID-19 on the Fisheries and aquaculture sector in developing countries and ways forward. Sustainability. 2022;14(3):1071. DOI:10.3390/su14031071
28. Love DC, Allison EH, Asche F, et al. Emerging COVID-19 impacts, responses, and lessons for building resilience in the seafood system. Glob Food Secur. 2021; 28:100494. DOI:10.1016/j.gfs.2021.100494
29. White ER, Froehlich HE, Gephart JA, et al. Early effects of COVID-19 on US fisheries and seafood consumption. Fish Fish. 2021;22(1):232-239. DOI:10.1111/faf.12525
30. FAO. The Impact of COVID-19 on Fisheries and Aquaculture Food Systems, Possible Responses. FAO; 2020. DOI:10.4060/cb2537en
31. Mejjad N, Cherif EK, Rodero A, et al. Disposal behavior of used masks during the covid-19 pandemic in the moroccan community: Potential Environmental Impact. Int J Environ Res Public Health. 2021;18(8):4382. DOI:10.3390/ijerph18084382
32. Azra MN, Kasan NA, Othman R, et al. Impact of COVID-19 on aquaculture sector in Malaysia: Findings from the first national survey. Aquac Rep. 2021;19:100568. DOI:10.1016/j.aqrep.2020.100568
33. Reilly A, Käferstein F. Food safety and products from aquaculture. J Appl Microbiol. 1998;85(S1):249S-257S. DOI:10.1111/j.1365-2672.1998.tb05305.x
34. FAO. How Is COVID-19 Affecting the Fisheries and Aquaculture Food Systems. FAO; 2021. DOI:10.4060/ca8637en

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/120543