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REVIEW ARTICLE OPEN ACCESS

Studies on Diversity of Bacterial Diseases and Occupational Risks through Mudcrab Aquaculture in West Bengal

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Abstract

In West Bengal, the two most tradable species of mud crab (*Scylla* sp.) are available due to high market demand in local as well as foreign markets. *Scylla* sp. is an important (ecological, nutritional, and economical) bioresource in India including West Bengal. Juveniles and adult mud crabs are selectively collected by coastal area common people or fisherpersons for culturing in ponds and crabs are traded locally or internationally. Different coastal districts' people of West Bengal, mainly North-24 Parganas, South-24 Parganas, and Midnapur are inextricably linked to the crab as being culture that serves as their alternative occupation/livelihood. Various bacteria are recorded as related to mud crab as being infections. Some of the bacteria may transmit from mud crabs to humans and cause mainly gastric-related diseases and septicemia by the transmission of virulent genes and microbes from unsafe water to the crab and then to humans. Such pathogenic infections like vibriosis without proper treatment can result in mass mortality of *Scylla* sp. The potential for disease transmission to people from mud crabs has been demonstrated by a number of significant variables and the water surrounding them. Eating raw or undercooked crab, ingesting water or other substances contaminated with infected crab excrement or mucus, and coming into touch with the infectious agent through open wounds or contact skin scratches or abrasions are the main sources of bacterial infections. It is reported that bacteria transferred by consuming contaminated water with infected organisms or handling are more than 10%. Crab fisherpersons and farmers, in general, have less environmental awareness, and scientific-based knowledge and for this reason, they face various types of occupational hazards including zoonotic septicemia. The present article investigates the distribution of different zoonotic bacteria and their potential threats, both for mud crabs and the human population.

Keywords: Cultured Mudcrab, Livelihood, Bacterial Diseases, Zoonosis, Public Health

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INTRODUCTION

Zoonoses are infectious diseases which are transmitted from animals to human being and several causative agents like bacteria, viruses, protozoa, and fungi can be transmitted from animals to humans through different channels wound, ingestion, animal bite, vector bite etc.[1] Zoonoses are a dangerous threat to all over world health and cause too much damage worldwide. Zoonoses are present to high or low degree in certain population. Foodborne zoonotic diseases are common in poor population around the world. So zoonotic diseases have high impact not only on human or public health and livelihood but also on environment and ecosystem. Therefore, the overall impact of zoonoses in terms on wildlife, ecology, socio-economy, nutrition has a significant on human life. Many emerging zoonotic diseases found in aquatic animals that appeared for the first time or existed early but are readily increasing in geographic range (WHO). Today newly introduced zoonotic infections and public health are the burning topics as it is a global health threat after the COVID situation. It is reported that more than 200 diseases occur through transmission from animal to human as zoonotic diseases and over 60% of human infectious diseases are shared with wild animal or domestic animals.[1] So, human-animal interface detection is essential for understanding the emergence, spreading and possible prevention of zoonotic diseases. Zoonotic diseases can be transmitted by air, by consumption of contaminated food, by close contacts by handling infected animals or by insect bites etc. Generally, nature of zoonotic diseases are three types and among them emerging zoonotic diseases are now rapidly increasing day by day. Some common zoonotic diseases include anthrax, leishmaniasis, Ebola, AIDS, tuberculosis, taeniasis, influenza, salmonellosis, plague, rabies, lyme disease, brucellosis, SARS and now COVID-19. 2nd one is epidemic zoonotic diseases that trigger by climate alteration or natural calamities etc.[2] But 3rd one (Neglected zoonotic disease) is continuously present in selective populations with moderate degree which is poorly reported. Based on origin zoonotic diseases are categorized as – bacterial, viral, protozoan, fungal etc. Anthropological activities and destruction of natural resources easily propagate and affect the dynamics of zoonotic pathogens within environment and steady increasing growth poses a threat on human health or public health directly (occupational) or indirectly (non-occupational).

It is reported that about 2,60,000 people in USA get sick from infected fish every year and 4815 people were ill through foodborne disease outbreaks.[3] In Andhra Pradesh of India, due to parasitic, bacterial and fungal infections nearly 40 million in monetary losses occurred in 2017-2018.[4] The demand for fish has grown recently as a result of rising global population and seafood consumption. As one of the human body's main sources of protein, seafood has contributed to the fisheries and aquaculture industries' sustained expansion on a global scale, but they are not without risk.[5,6] In addition to seafood-borne food illness, humans can potentially contract aquatic diseases. There is a possibility that certain fish and the water they are in can transmit diseases to people. (Environmental Health and Safety / Occupational Health).[7] The immune system has a major impact on how severe aquatic zoonotic diseases are Yet, there are two basic ways that human diseases manifest. Such as eating raw or undercooked fish and ingesting water or other substances contaminated with infected fish excrement or mucus are the first two causes. A second possibility is coming into contact with the infectious agent through open wounds or skin abrasions. According to 15% of zoonotic infections originated from fish and are spread by several routes, whereas 46% are transmitted orally.[7] Skin contact while handling fish and drinking water contaminated with infectious organisms are responsible for 24 and 19% of transmission, respectively.[7] Human exposure to fish illnesses pose a serious risk to one's health, notwithstanding how infrequently it occurs.[8,9] The introduction of zoonotic agents poses a significant danger to global health and results in significant harm on a global scale. The COVID-19 pandemic has once again highlighted the importance of animal-human interaction in the transmission of zoonotic diseases, particularly in regard to wild and domesticated species that can act as hosts and reservoirs. As a result of globalization, zoonotic illnesses may spread due to habitat loss, climate change, and links between wildlife

and cattle systems.[10] In the aquacultural field, bacterial diseases are one of the most important threats that cause not only economic loss but also directly affect or indirectly the health of people. Livelihood or occupation regarding to crab fishery are emerging aquacultural employment in rural West Bengal and exposure to aquatic infection can affect directly the collector, farmer and sellers. Till now no health estimations are recorded that are correlated with waterborne zoonotic bacteria diseases on fisherpersons of West Bengal. In this review paper, we want to evaluate the baseline information about bacterial diversity and hazards in fisherpersons in West Bengal. So, we want to reveal the scope of research for the future in occupational diseases.

Occupational Hazard in Aquaculture

Occupational risks are explained as the existence of a material (pathogen or pollutant) or conditions or undesired outcomes that can cause harm or affect the health of the employee. Such occupational risk is the harm or injury from a hazard that inoculates in individuals or may in groups exposed to a hazard. Farmers and other workers in aquaculture fields are susceptible to many hazards. Biological hazards include parasitic infestation and pathogenic infections (fungal, bacterial, Viral etc.). Different byproduct of aquaculture causing significant organic pollution that damage the water quality and emergence of pathogens like bacteria or viruses that contaminate farm water. Fish as well as shellfish can cause outbreaks of food-borne disease when they are handling without proper protection or consumtion raw or not properly cooked.[1,2] Generally, occupational hazardous in aquaculture are three types – physical hazards, chemical hazards and water-borne disease-based hazards. Physical hazards include injury from fish and shellfish spines, bite by aquatic animals, spoiled wet fish in storage etc. Chemical hazard includes lime, diluted chlorine, or salts and fertilizers that can affect farmers' health. The main sources of water pollution are pesticides, sewage, waste disposal, leaching of dissolved chemical fertilizer etc. Finally, most important aquacultural hazards or risks are water-borne diseases. Aquacultural field workers are due to regular interaction with water sources, one is either directly or indirectly exposed to waterborne illnesses.[11] Water bodies are polluted by pathogens and occupational such hazards can spread of communicable human infections which without proper safety concern, it may increase the risk to entire public health.[12]

***Scylla serrata* Population declining threats**

Commercially important *Scylla serrata* are declining day by day due to indiscriminate fishing of mature females and below-sized crablets from their natural habitat. It was also reported that the growth of *Scylla* sp. in nature is poor due to several environmental hindrances. According to Saha and Ray, discharged untreated effluents from industry, households, the agricultural and aquacultural fields directly or indirectly mingle with water bodies (river, sea, estuary, mudflat) that finally cause a serious threat to the *Scylla* population in West Bengal.[13] Several research papers prove that the known and unknown nature of several chemical compounds induce water pollution and contaminate aquatic animals directly that result in reduced growth rate and reproduction. Such a situation makes susceptible *Scylla sp.* to pathogens and causes a steady decline in immunological health Even diseased crabs have the capacity to spread diseases to different farms nearby, adjacent farms, and even to natural ecosystems and contaminated wild seed and adult of *S. serrata* become physicochemical alteration of habitat is considered as a threat for crab population in Sundarbans.[13] Large amount of siltation and sedimentation due to erosion, reduces the natural habitat of *S. serrata* and causes decreasing the population of *Scylla* in mangrove habitat of West Bengal. Mangrove deforestation is also the major cause for reducing population of the animal due to shrinkage of territory.

Mudcrab aquaculture and Health hazards

Mudcrab (*Scylla* sp.) is a highly potential fishery of the Indo-Pacific region, especially in the coastal region of the Bay of Bengal. *Scylla* fishery in different states of India based on wild seed collection from natural habitats and fattening in cultured pond. The price of *Scylla* ranges from 250 – 800 rupees/kg depend upon the weight from 400 gms to 800 gms (above 500 gms 400 to 600 rupees/kg. and less than 500 gms 150 to 350

rupees/kg.). Mudcrab culture practiced is two types in – fattening and grow out and crablets are available round the year in natural habitat. In 1st case post-molt, crabs are put in cages and pens for short period until transfer into big size. In 2nd case crab's seeds are stocked in a pond and rare up to 5-6 months until they attain marketable size. A huge number of individuals from rural and urban areas in India are engaged in alternative livelihood as mudcrab fisheries through the collecting of wild seed, purchasing crablets, nursery culture in hapa, grow-out in pond as polyculture, box culture, supply local market, and export market.[14] Farmers typically buy mud crab seeds or crablets from wild seed collectors, and they then fatten the crabs with this feed in ponds according to body weight, either directly or through pens or cages, for about 20 to 30 days, or until the mature gonad developed as marketable, high-quality, and small-scale. *Scylla* can be housed on floating rafts made of bamboo or individual plastic containers.[15,16] The majority of farmers sell their goods directly to exporters. Fattening is primarily accomplished in box cage setups, however some grow-out is also accomplished. Mudcrabs are currently gaining popularity in India, and live crabs, crab meat, and other products are shipped to nations including Singapore, Hong Kong, Japan, the United States, and France. High temperature with low salinity in tropical climate can damage tissue and high salinity induce multiplications of *Vibrio* Sp. in saline water and environmental problems related to water quality or other stressors (high temperature, salinity, pH etc.) often contribute to the threats to *Scylla* and outbreak of disease. Environmental crisis through climatic change poses a threat to wild crab population and fluctuating climatic condition alter the water parameters like turbidity salinity, pH, dissolve oxygen and temperature etc. of natural environment of *Scylla*.[1,2] Such climatic as well as environmental crisis give opportunity to the pathogens especially bacteria to invade within animal and create diseases.[17] When exposed to high salinity water, pathogens like *Vibrio* sp. (halophilic bacteria) develop quickly and naturally in estuarine and marine environments.[18] In West Bengal, pathogenic infection (bacteria, fungus, virus, protozoa, etc.) frequently causes mass mortality in *Scylla* species, and occasionally pathogen-infected crabs may potentially spread pathogens.[19,20] Unfortunately, disease outbreaks have led to a sharp decline in productivity and significant financial loss. Mudcrabs are susceptible to a number of diseases brought on by viruses, bacteria, fungus, and protozoa, including the deadly white spot syndrome, shell disease, shell decoloration, incomplete moulting, and blackened ovary. White spot syndrome, muscle necrosis, sleeping disease and baculovirus infections are the common viral diseases that have been reported in mudcrab and infections may occur at each stage of mudcrab. Most naturally occurred viral infection the WSS in mudcrab is 5% while in cultured farm is 30%. Such viral infection generally reduces molting frequency. Most common three fungi (Lagenidium, Atkinsiella, Haliphthoros) have been reported for fungal diseases in mudcrab. Such fungal diseases generally loss the egg mass and problem in hatching.[17] *Zoothamnium, Vorticella, Epistylis* are the ciliates protozoans, present in gills. Such protozoans create problem during hatchery phase of mudcrab culture mainly on egg and larval stages.[17]

Scylla serrata Diseases and Public Health

Environment, animals and human these three have an important role for emerging and transmission of diseases including zoonotic diseases and most of the human infectious diseases (almost 60%) are zoonotic in characterization.[1] Vibrio based human zoonoses can be classified into two groups – cholera diseases (*Vibrio cholerae*) and non-cholera diseases (*Vibrio parahaemolyticus*, *Vibrio vulnificus*, *Vibrio mimicus, Vibrio alginolyticus, Vibrio anguillarum, Vibrio harveyi, Vibrio fluvialis* etc.) and generally non-cholera bacteria may show clinical feature like wound infection, gastroenteritis, sepsis or septicaemia etc. in humans by ingestion of *Vibrio* sp. contaminated sea food like fish and shellfish (primary septicaemia) or rough handling of marine animals like fish and shellfish with wound (secondary septicaemia) (Table 1 and 2).[1] Currently, more than 10 species of Vibrio are documented to be attached with human diseases due to consumption of contaminated foods and water and these species have zoonotic potential transmission power (Table 1 and 2).[1,2] According to Colville and Berryhill, *V. parahaemolyticus* and *V. vulnificus* are the

Table 1. Bacterial Diversity and Zoonotic Diseases in *S. serrata*[1,12]

No.	Pathogenic Bacteria	Diseases in Mud crab	Human Zoonotic Diseases
1.	*Vibrio alginolyticus*	Septicemia, Bacteremia (adult), Shell disease (Juvenile and Adult), wound infection.	• Gastroenteritis • Infection in wound skin
2.	*Vibrio anguillarum*	Vibriosis, Shell disease (Juvenile and Adult)	• Food poisoning
3.	*Vibrio vulnificus*	Bacteremia (adult), Shell disease (Juvenile and Adult) wound infection,cutaneous lesions.	• Watery diarrhea • Abdominal cramping
4.	*Vibrio harveyi*	Luminescent Vibriosis (eggs and larvae), Shell disease (Juvenile and Adult), high mortality.	• Nausea • Vomiting
5.	*Vibrio fluvialis*	Shell disease (Juvenile and Adult)	• Fever
6.	*Vibrio mimicus*	Shell disease (Juvenile and Adult)	• Chills
7.	*Vibrio cholerae*	Vibriosis, Bacteremia (adult)	
8.	*Vibrio parahaemolyticus*	Septicemia, Bacteremia (adult), Shell disease (Juvenile and Adult)	
9.	*Aeromonas* sp.	Wound infection, Septicemia	

Table 2. Pathogenic *Vibrio* sp. in human body[1,12]

No.	*Vibrio* sp.	Target in human body
1.	*V. alginolyticus*	Wounds, Cutaneous tissues
2.	*V. vulnificus*	Blood, Wound, Gastrointestinal tract, Cutaneous tissues
3.	*V. fluvialis*	Gastrointestinal tract
4.	*V. mimicus*	Gastrointestinal tract
5.	*V. cholera*	Gastrointestinal tract
6.	*V. parahaemolyticus*	Gastrointestinal tract
7.	*Aeromonas* sp.	Gastrointestinal tract, Wound

major halophilic bacteria causing vibriosis in people and multiply in warmer water.[21] Some opportunistic Vibrio bacteria (*Vibrio vulnificus, Vibrio cholera, Vibrio damsela*) cause a virulent effect on humans as a pathogen and human infections.[22] *Vibrio parahaemolyticus* and *Vibrio vulnificus* have been reported from shellfishes like crabs, shrimp etc. molluscans like clams, scallops, and mussels; fin fish like mackerel, tuna, sardines, seawater; sediment; and plankton. It is reported that near about 80,000 people in USA become affected with Vibriosis and near 100 people die in every year due to consumption seafood or wound exposure to *vibrio* contaminated seawater when temperature become high. Most of the foodborne infections and diseases are caused by *V. parahaemolyticus, V. cholerae* and *V. vulnificus*. Different sero-groups of Vibrios are connected with pathological features and clinical symptom of disease and there is evidence to support the theory that vibrios are the most frequent bacteria causes food poisoning brought on by consumption of shellfish, particularly *S. serrata*. The *Vibrio* sp. cling so firmly to the *Scylla* intestinal system that washing the animal does not remove them, and neither does freezing, which allows the *Vibrio* to survive in frozen *Scylla* for several months.[21] *Vibrio* sp. that can result in a severe health problem in human beings like fever, chills, nausea, hypotensive septic shock, secondary lesion, infection, cellulitis, blistering skin lesions, most often on the legs and arms, particularly on the palms, fingertips and soles of the feet etc. as zoonotic transmission of diseases (contact or foodborne). *Vibrio* sp. can penetrate into the intestinal wall and get into the blood stream that causing septicemia and associates with the damage of intestinal wall causing diarrhea (severe gastroenteritis).[21] If *Vibrio* sp. invades through a wound, the skin around the wound can break down causing the skin lesions same as ingestion and infection without proper treatment can increase mortality.

Bacterial Diseases in mud crab aquaculture and occupational risks

Scylla is generally found in coastal waters, intertidal mudflats, and mangrove forests. *S. serrata* are one of the important commercial aquaculture species in India, mostly as a source of food for humans and animals as an important source of protein. Bacterial infection is common

in mud crab aquaculture and different types of bacteria involved in to declining of the crab population in aquaculture.[1,2] Most of the bacteria of mud crabs can also invade the human body through different routes (mouth, skin, eye, nail etc.) Pathogenic gram-negative *Vibrio* sp. and *Aeromonas* sp. are leading cause of food-borne and as well as water-borne diseases that are one of the most important causes of acute gastroenteritis disease in Asia.[24] When environmental temperature falls, *vibrio* are primarily found in sediments or stacked to the surfaces of shellfish like mudcrabs by specific enzymes or lectins. Mudcrab zoea are very sensitive to luminous bacteria (*V. harveyi*) that cause major contributor to luminescent bacterial diseases and *V. alginolyticus* and *V. parahaemolyticus* have the pathogenicity to zoea of *Scylla* sp.[1] The potential for pathogen transmission from bacteria-infected crabs to different raising facilities, neighboring farms, and the environment exists, and widespread death of farmed mud crab stocks has repeatedly been documented.[25,26] The main problem in hatchery technology of *Scylla* still seems to be related to bacterial infection (majorly by gram-negative and minorly gram-positive), natural feed such as fish, mollusks, farm waste etc. and also facilitating the entry of microbial pathogens in broodstock tank or grow-out ponds when crab are immunologically weak.[20,27] At the time of capture, the crab may have been injured, had a limb amputated, or had been handled roughly. The widespread bacterial disease

Table 3. Association between bacterial colonization and cancer development[23]

Helicobacter pylori	↑ Gastric cancer
Uropathogenic *Escherichia coli*	↑ Prostate cancer
Escherichia coli (strain CP1)	↑ Prostate cancer
Escherichia coli	↑ Bladder cancer
Bacteroides vulgatus, Bacteroides stercoris	↑ Colorectal cancer
Lactobacillus acidophilus, Lactobacillus S06, and *Eubacterium aerofaciens*	↓ Colorectal cancer
Fusobacteria, Leptotrichia genus	↓ Pancreatic cancer
Porphyromonas gingivalis, Aggregatibacter actinomycetemcomitans	↑ Pancreatic cancer
↑↑↑ Enterotoxigenic *Bacteroides fragilis*	Colorectal cancer
↑↑↑ *Fusobacterium nucleatum*	Colorectal cancer
↑↑↑ *Porphyromonas gingivalis, Fusobacterium nucleatum*	Oral squamous cell carcinoma
↑↑↑ Enterobacteriaceae	Stomach cancer
↓↓↓ Bifidobacteriaceae	Rectal neoplasm
↑↑↑ Capnocytophaga, Veillonella (in saliva)	Lung cancer

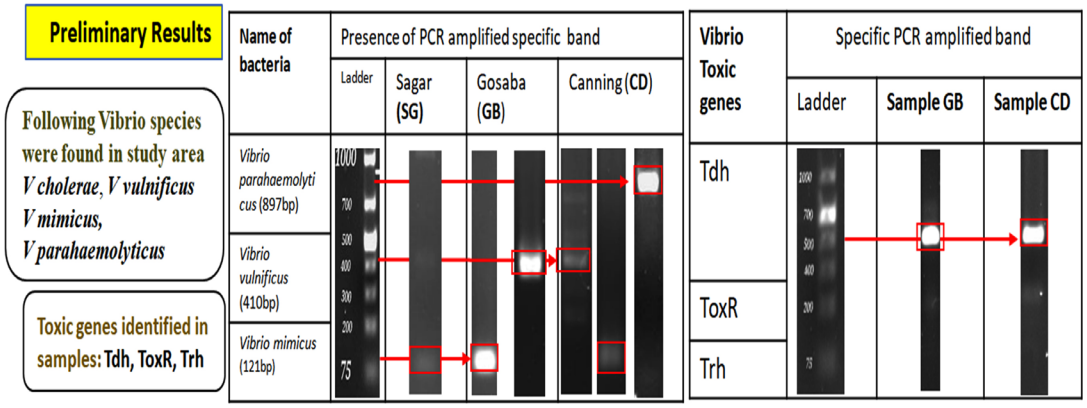

Figure. Presence of *Vibrio* sp. and its toxic gene in West Bengal[1,2]

that affects larvae and adults and is also known as "shell disease," "black spot," "brown spot," "burnt spot," etc. Several bacterial infections in mudcrabs were brought on by bactericemia, for example. Chitinoclastic bacteria include *Vibrio*, *Aeromonas*, and an entity like Rhodobacteriales.In crabs housed in captivity, shell sickness is a frequent issue that results in the development of a fuzzy mat made up of numerous species, including blue-green algae, bacteria, ciliates, flagellates, and even worms.[17] Leucothrix mucor, *Thriothrix* spp., and *Flexibacter* spp. are filamentous bacteria that can sometimes kill by discolouring the gills and causing secondary illnesses. A serious, economically significant bacterial infection, luminal bacterial disease is brought on by bacteria from the genus *Vibrio* as well as other bacteria. *Vibrio*-based human zoonoses can be divided into two groups: cholera diseases (*V. Cholerae*) and non-cholera diseases (*V. parahaemolyticus, V. vulnificus, V. mimicus, V. alginolyticus, V. anguillarum, V. harveyi, V. fluvialis,* etc.). Generally, non-cholera bacteria may show clinical features like wound infection, gastro (secondary septicaemia).[1,12] Currently, more than 10 species of *Vibrio* are documented to be attached with human diseases due to consumption of contaminated foods and water and these species have zoonotic potential transmission power.[21] According to Colville and Berryhill, *Vibrio parahaemolyticus* and *Vibrio vulnificus* are the two major halophilic bacteria causing for *vibrio*sis in people and multiply in warmer water. Some opportunistic Vibrio bacteria (*V. vulnificus, V. cholera, V. damsela*) show lethal effect for human as pathogen and human infections.[22] *V. parahaemolyticus* and *V. vulnificus* have been reported mostly from marine fish and shellfish (lobsters, crabs, and shrimp).[1] The most common foodborne pathogens are *V. parahaemolyticus*, *V. cholerae,* and *V. vulnificus*. *Vibrio* sp. can cause significant health issues in people, including fever, chills, nausea, hypotensive septic shock, secondary lesions, infections, cellulitis, blistering skin lesions, most frequently on the legs and arms, especially on the palms, fingertips, and soles of the feet, etc (contact or foodborne).[28] *Vibrio* sp. can penetrate into the intestinal wall and get into the blood stream that causing septicemia and associates with the damage of intestinal wall causing diarrhea (severe gastroenteritis).[21] Ingestion and infection without effective treatment can result in increased mortality if Vibrio sp. enters through a wound, as the skin around the site can deteriorate and cause skin sores. Gram negative *Aeromonas* sp. bacteria can produce septicemia in infected mudcrab. Human can be infected with *Aeromonas* sp. and shows a variety of clinical signs nausea, vomiting, diarrhea, wound infections etc.[4] *Aeromonas* sp. cause three forms of diseases –

i) Diarrheal diseases
ii) Wound infections
iii) Opportunistic systemic disease

Intestinal disease can present as acute watery diarrhea, dysenteric diarrhea with abdominal pain. It is reported by the assessment of Global Burden of Disease (GBD) that gastrointestinal infections are the most important zoonotic disease in India.[29]

Crab fishery occupation and farmer of West Bengal at risk????

Occupational risk or hazards are explained as the existence of a material (pathogen or pollutant) or conditions or undesired outcomes that can cause harm or effect on health of employee (Table 3).[30] Such occupational risk is the harm or injury from a hazard that inoculate in individuals or may in groups exposed to a hazard. Farmers in fishery fields are susceptible to many hazards (physical, chemical or waterborne).[12] Biological hazards included parasitic infestation and pathogenic infections (fungal, bacterial, Viral etc.) and the different byproduct of aquaculture causing significant organic pollution that damage the water quality and the emergence of pathogens like bacteria or viruses that contaminate farm water.[1,12] Fish as well as shellfish can cause outbreaks of food-borne disease when they are handled without proper protection or consumed raw or not properly cooked.[1,2,5] Fishery workers are directly or indirectly exposed to waterborne diseases due to frequent contact with water bodies and can spread communicable human infections (risk to entire public health) (Table 3). Mangroves provide valuable bioactive substances; create natural barriers by absorbing storms; remove salt by ultra-filtration through their roots, prevent erosion; stabilize the coastal ecosystem; provide a favorable habitat for the proliferation of zooplankton, fishes, shrimps, crabs; an intricate

mesh of mangrove roots for nursery habitat of juvenile organisms. Capture fishery is a major livelihood of the coastal village people of West Bengal which encloses three districts. Collection of natural seeds of shellfish and selling for aquaculture are one of the potential supports for some coastal people.[12] So strengthening of occupation depends on its resilience, flexibility, and adaptability in the dynamic coastal climate of West Bengal. Being close to the Bay of Bengal, which is frequently visited by major depressions and violent storms, the coastal region of West Bengal is cyclonic prone, making it exceedingly difficult for the local populace to survive and successfully engage in their employment. With the lack of professional knowledge of fishermen faces challenges in unsafe environments that hinder their activities. Apart from these with warmer oceans, critically low oxygen levels are occurring more frequently. There are more cases of fish poisoning in people when the sea is warmer. Increasingly frequent hazardous algal blooms and bacteria have a negative influence on human health (Figure).[1,2,12,13] The survival of larval fish and other plankton is being impacted by increased ocean acidity brought on by the absorption of additional CO2 and warmer sea surface temperatures and changes in ocean currents due to climate change have an impact on fish production replenishment and spawning success and fisheries productivity is being impacted by changing fish distribution ranges and species availability.

Hazards or Risks Assessment and Prevention in Aquaculture

Aquacultural hazards or risks can be assessed through different tools and methods for assessing the hazardous risks. At present, the risk factors for increasing waterborne and animal health become recharged. Chemical and microbiological dangers pose substantial health risks to people. The four main parts of risk analysis are hazard recognition, risk assessment, risk management, and risk communication. Several techniques are typically employed to assess the occupational risk of bacteria that are present in water, food, and the environment.

1. 1st is to control infection; one should identify and monitor the hazardous effect.
2. 2nd step is to control infection and transmission, workers should be taken antibiotics or be immunized.
3. 3rd step is to control infection, all fishing equipment should be sterilized with disinfectants and nets should be placed in an appropriate clean location to avoid contamination.
4. 4th step is to control infection, chlorination, limestone ($CaCO_3$) and bleaching powder of aquaculture ponds should be performed. The chlorine dose could vary depending on pH and the concentration of organic matter.
5. 5th step, farmers should be wel ltrained and should have personal protective gear.
6. 6th step, further research is needed to improve the situation in the future.

To improve the afflicted population's resistance to illness, better environmental and biological conditions should be made available to them. The steps below might be used to do this: a) Effective physical measures to improve the environment include increasing aeration, regulating temperature, altering the feeding schedule, removing sludge and organic matter, and treating wastewater. b) Effective chemical measures include controlling pH and salinity, reducing ammonia and nitrite levels, and applying antibiotics. c) To develop advantageous microbial communities under culture conditions by using efficient biological techniques, namely the use of probiotics that include different bacterial species.

CONCLUSION

Fishing is one of the fastest-growing and employment-generating sectors in India. Approximately four lakh fishermen directly and six lakhs indirectly engage and depend on this industry in West Bengal. Inland and marine fishing have an important role in the socio-biology-economic development not only in India but also in West Bengal. Fishing is the riskiest and health hazardous occupation that involves physical hazards (Injury from spines, string, bite, fracture in body parts, sunburns, acidification, mechanical accidents, environmental calamities, rise sea level, erosion etc.), chemical hazards (poisonous gas due to long storage, accumulation of pollutants,

pollutants contamination) and biological hazards (work stress, allergy, parasite and pathogenic infection, skin and lip cancer).[31] According to ILO, nearly 24000 fishermen or fishery industry people are killed every year globally due to their occupational hazards. A high degree of mortality in wild and cultivated crab is caused by bacterial and parasitic infections, some of which are zoonotic in nature (bacteria transmitted from animal to human).[30] Gram-positive bacteria (Mycobacteria, Streptococcus etc.) and gram-negative bacteria (*Aeromonas*, Vibrio etc.) are the most common zoonotic bacteria and parasites (cestodes, trematodes, nematodes) that are harmful to fish and humans (public health).[4] Maximum fishermen have no proper knowledge about the environment, health and training in their occupation, increasing their life threat during fishing.[11] They don't know how to protect themselves from different hazards or disasters due to the knowledge gap. The income of fishermen is also related to educational level, house type, occupational status, health status and general social condition. So sufficient income for a fishermen's family is the most important index for maintaining the socio-economic status. On the other hand, income depends upon the availability of fishery resources that are hampered by climate changes or anomalies.[2] From the above result, we can establish that the estuarine aquatic ecosystem regulates the survival, distribution and transmission of pathogenic bacteria from the natural saline habitat to farms and fisherpersons. Thus, it is crucial to manage and control the bacterial population and the related diseases. Prevention is the main mitigating element since it helps prevent the start of infectious processes and, consequently, the formation of disease. A thorough disease control strategy should include measures like using strong stock animals, enhancing immunological resistance through nutrition, and maintaining high water quality. While cutting-edge biotech developments like immune priming, quorum sensing disruption, and phage therapy may have an effect on vibriosis outbreaks, further research is needed to confirm their biosafety and effectiveness at the farm scale.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTION

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DATA AVAILABILITY

All datasets generated or analyzed during this study are included in the manuscript.

ETHICS STATEMENT

This study was apporved by Institutional Animal Ethical Guideline and Approval no.: 763/GO/Re/SL/03/ CPCSEA and 795/GO/R/S/03/CPCSEA (WBUAFS).

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