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Review Article

Impacts of climate change on aquaculture and human health

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ABSTRACT

There is no doubt that climate change has a great impact on our planet. One of the biggest problems the world faces right now is climate change. It is a multifactorial and complex phenomenon. Currently, climate change is a risk to global food production and a major threat to the quantity and quality of production. The Vibrio species are considered marine bacteria that exist in estuaries all over the world. Many Vibrio species cause serious human infections. We have summarized an overview of the current threat facing the world as a result of climate change which consequently affect humans and aquaculture. Little is understood regarding possible consequences of global warming on marine prokaryotic communities due to a paucity of historical data. The biggest biological biomass in the ocean is made up of prokaryotes, which also play a vital role in the occurrence of diseases in humans and other animals as well as the cycling of nutrient elements.

INTRODUCTION:

We can define "climate change" as referring to a considerable change in climate over time; the change may involve air pressure, temperature, humidity, wind patterns, and precipitation, among other measures. **(Agriculture and Climate, 2022).** Climate change has become more accelerated than in the past. Following the preindustrial era, humans depended on fossil fuels as an energy source. Recently, about 80% of the world's power has been generated from fossil fuels. (ACIA 2004), also forest degradation and deforestation, which emit greenhouse gases (GHGs) into the atmosphere. **(Riphah, 2015).**

The accumulation of GHGs, including carbon dioxide (CO_2), nitrous oxides (N_2O), methane (CH4), and fluorinated gases, in the atmosphere over the years has been associated with these human activities. **(Cook and Zolnikov, 2019)**

It is clear that climate change policies are very important, as this phenomenon has multifaceted impacts. For example, the global warming of the earth is already influencing human health, environments, food production, infrastructure, and economies. **(Climate change**

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impacts, 2021).

Climate change's detrimental effects on aquaculture

Climate change could have a negative impact on aquaculture operations because they are more susceptible to heat waves, cold snaps, and rising water and air temperatures. Due to global warming, temperature variations are more frequent in tropical and subtropical areas and have a significant impact on fish output. Increasing temperatures would have an impact on the ecosystem of freshwater ponds **(Woodward et al. 2010).**

The majority of fish, especially cold-water species like Atlantic halibut, salmon, cod, and intertidal shellfish due to thermal stress, are expected to have increased mortalities with the predicted 1.5 °C rise in average world temperature this century **(Gubbins et al. 2013).**

Climate change is expected to have a severe effect on aquaculture worldwide. Increased temperatures affect the physiology of both fish and pathogens and have the possibility of leading to significant increases in disease outbreaks within aquaculture systems, resulting in severe financial impacts. **(Cascarano et al. 2021).**

The scientists predicted that the effect of climate change, particularly on agriculture, will appear in decreases of between 2% and 15% in agricultural productivity by 2050 if climate change continues in its current progression **(Delincé et al. 2015).** Greenhouse gases and climate change lead to modulation of acidification, temperature, and increasing deoxygenation in marine aquaculture **(Godbold and Calosi 2013).**

Mimura 2013 pointed out that climate change and greenhouse gas emissions (GHGE) cause modification of the marine environment.

There are other adverse effects related to GHGE, such as the rise in sea level and storm intensity, which led to changes in the chemistry of water circulating in the marine environment (**Russell et al. 2012).**

The changing of climate has a great effect on aquaculture production, either directly or indirectly **(De Silva and Soto 2009).** The direct effects occur through influencing the physiology and physical characteristics of finfish and shellfish production systems, while the indirect effects include altering the structure of the ecosystems, primary and secondary productivity, and input supplies, or by affecting aquaculture producers, product prices, fish oil costs, fishmeal, and other services needed by fishers **(Adhikari et al. 2018).** All ecosystem components will be influenced by global change involving bacteria, protista, and archaea (**Genner et al. 2004).**

Aquatic environment is considered suitable and ideal medium for growth of microorganisms (**Lafferty et al. 2015).**

Aquaculture sustainability is affected by climate change, and there is considerable interest due to the sector's significant contribution to global food security, nutrition, and livelihoods **(FAO, 2020).**

The correlation between climate change and bacterial pathogens in fish:

Different environmental factors have a direct effect on the physiology of fish, such as salinity, temperature, and light **(Moyle and Cech 2004).** Temperature is the most prominent factor that affects fish, and variations in temperature due to climate change will drive a shift in the geographical distribution of the natural population, acidification is considered one of the important environmental stressors that would be altered in the context of climate change. Acidification as a consequence of increased dissolved CO_2 levels has been known to be a major obstacle for fish in their acclimation process **(Pörtner 2001).**

Fish pathogens have been suggested as potential bio-indicators to monitor anthropogenic activity in the environment and climate change **(Palm et al. 2011).**
Climate change, particularly ocean warming, increases the dangers posed by Vibrio species to the health of humans, animals and the environment **(Vezzulli et al. 2013).**

According to numerous reviews, there is a connection between fish disease and climate

change on a worldwide scale (**Groner et al. 2016).**

Farmed aquatic animals and fish are poikilothermic, therefore they are sensitive to the variation of ambient temperature **(Maulu et al. 2021)**.

Opportunistic bacteria become more dangerous when fish have insufficient immune barriers and are exposed to environmental stressors **(Cabillon and Lazado, 2019**). Rising water temperatures alone or in combination with a decreased level of oxygen can cause adverse effects on various physiological processes in fish, such as metabolism and immune defense against pathogens **(Islam et al. 2022).**

A bacterial pathogen (Vibrio) serves as a tangible and vital barometer of climate change in the marine system.

Recently, many studies declared that Vibrio-associated diseases are increasing worldwide with climate warming **(Harvell et al. 2002).**

Vibrios have recently been found in places where they were previously undetected or only seldom reported **(Baker-Austin et al. 2010).**

Vibrios can be found linked to chitin-containing organisms in the aquatic environment, particularly zooplankton, which is one of the most significant environmental reservoirs for these bacteria in nature (**Vezzulli et al. 2010).**

Baker-Austin et al. (2010) pointed out that *V. vulnificus* can frequently be found in estuaries, which are subject to various climatic and human-caused changes. The geographic range of the majority of estuarine environments is anticipated to change due to climate change and sea level rise, as well as the ecological range of several organisms, including harmful bacteria. It is expected that when water temperatures rise and saline water seeps farther into historically freshwater portions of coastal rivers, the geographic range of V. vulnificus will expand as well as the growing season may be prolonged.

Although the temperature optimum for *V. cholerae, V. vulnificus, and V. parahaemolyticus* is approximately 37°C, infections can start to occur around 15°C for *V. parahaemolyticus and at 20°C for V. vulnificus***. (Martinez-Urtaza et al. 2010).** So, any rises in environmental temperature, whether long-term or short term, have respectable effects on the concentrations of these pathogens in the water and in seafoods. According to **Takemura et al. (2014),** temperature is the factor that is most commonly associated with the presence, concentration, and infection rate of Vibrio. According to **Vezzulli et al. (2005**), the family Vibrionaceae contains heterotrophic bacteria that are found in a variety of aquatic settings, including marine, freshwater, and estuary ecosystems.

The researchers found that the rise in the intensity and frequency of named storms, such as nor'easters, hurricanes, tropical storms, and cyclones, brought on by increased climatic energy, can have a variety of effects on the chance of contracting Vibrio infections. Increased rainfall causes coastal systems to become fresher, which can reach the range of diseases that are often found only in marine waters **(Esteves et al. 2015).** Storms or strong winds may move the salinity front further upstream than usual, enabling non-cholera vibrios, which need less salinity, to colonise new areas **(Hsieh et al. 2008).**

There is a lot of interest these days in the effect of climate change in promoting the spread of aquatic infectious diseases including those caused by bacteria. Vibrios, one of the most important genera of pathogenic bacteria, is a major cause of sickness in human and aquatic animals worldwide (**Baker-Austin et al. 2017).**

Global warming of ocean waters has been linked to an increase Vibrio spp infections, which will be exacerbated by future climate change **(Chowdhury et al. 2017; Logar-Henderson et al. 2019).**

In aquatic environments, Vibrio species are the most prevalent opportunistic bacteria **(Sanches-Fernandes et al. 2022).** The largest known group of species belongs to the genus Vibrio, and recently 147 species and 4 subspecies of Vibrio were discovered **(Sampaio et al. 2022).**

Since Vibrio is known as the "microbial barometer of climate change," its prevalence has grown whenever sea surface temperatures have increased **(Harrison et al. 2022).**

According to studies by **Baker-Austin et al. in 2020 and Abioye et al. in 2021**, *Vibrio* species are growing well and reacting quickly to favorable environmental factors including high temperature, salinity, and dissolved oxygen.

Physiologically Vibrios are eurythermic (5 ◦C to >40 ◦C), grow well in alkaline conditions (pH 6.5–9.0) and warm waters more than 18◦C (Percival and Williams 2014),although *vibrio* species grow at warm temperature some species can be present whole the year while others were only detected at a specific temperature, or are less affected by this parameter. *V. alginolyticus and V. parahaemolyticus* were present even at temperatures around freezing point (**Böer et al. 2013**).

The spread and increase of *Vibrio* species worldwide and locally is thought to be correlated with climate change variations and new oceanic patterns that alter the salinity profile along the longitudinal axis of coastal rivers and introduce warmer waters into colder regions and (**Baker-Austin et al. 2016**).

Influence of climate change on human vibrio infection:

Vibrio cholera, *V vulnificus*, and *V. parahaemolyticus* are the three primary species of Vibrio that are researched and they are typically known as foodborne pathogens that can infect wounds and cause human illness when they consume seafood. By way of open wounds in contaminated water, for instance, *V. vulnificus* has been shown to produce severe and even fatal injuries **(Oliver 2005).**

According to **(CDC, 2006)** The most important vibrio species in terms of their effects on human health are *V. cholerae*, which is the cause of human cholera, *V. vulnificus*, which causes both gastroenteritis and horrifying infections of the extremities, and *V. parahaemolyticus*, which is only recently being recognized as an important player by those researching vibrioses. Due to the heat susceptibility of Vibrio spp., eating raw or undercooked fish or shellfish is the primary cause of food-related gastroenteritis. The infectious dose (ID) in contaminated water is significantly larger compared to when Vibrio spp. are taken with food because food consumption shields the organism from the bactericidal effect of stomach acid. For instance, when consumed with food, 10^4-10^8*V. cholerae* is needed for an ID, whereas 10^8-10^{11}*V. cholerae* in water is needed (**Almagro-Morenoand Taylor 2013)**

Vibrio species are heterotrophic bacteria present naturally in estuaries worldwide. Vibrio can be a virulent human pathogen and is one of the only pathogens with increasing rates of illness in the USA **(CDC 2016).**

Vezzulli et al. (2016) recorded that in the temperate North Atlantic, this study is the first to present experimental proof of a connection between multidecadal climatic variability, Vibrio prokaryote abundance, and Vibrio-associated human disease.

Vibrio species are able to respond fast to sudden changes in environmental circumstances including flooding, freshening, and heatwaves because they have such short generation times (replicating in just 20 minutes or less). As a result, there is a chance that Vibrio blooms could occur as a result of these modifications, which would pose a serious health risk to anyone who engages in recreational activities there or consumes seafood that has been caught there (**Froelich and Daines 2020)**

CONCLUSION

Considerable steps must be taken to slow climate change, such as reducing CO2 emissions as the primary tool for regulating global temperatures and avoiding the startling rise of 3–4 °C by 2030. Many cautious actions can be done to reduce the risk of vibriosis in addition to increasing awareness of the potential risks. First, try to avoid coming into contact with any waters that may have Vibrio. Also, make sure that drinking water has been cleaned up, and cook seafood properly.

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