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# Application of Biofloc Technology for the Temperate Coldwater Areas

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## Introduction

Aquaculture, recognised as one of the fastest growing food production sectors is a crucial component of the global fishing industry, providing an essential source of proteinaceous food, employment, trade, economic well-being and recreation to the people all around the globe. The total fisheries and aquaculture production in 2020 was observed to be 214 million tonnes, comprising of 178 million tonnes of aquatic animals and 36 million tonnes of alga. Aquaculture, which constitutes the main driver of growth of total production, alone comprised of 122.6 million tonnes with 87.5 million tonnes of aquatic animals (49.2%) and 35.1 million tonnes of algae. The per capita consumption of aquatic foods has reached a record high of 20.5 kg in 2019. The average growth rate of aquaculture industry was about 4.6% during a period of 2010-2018. However, a decrease in its growth rate in the last two years(3.3% in 2018-2019 and 2.6% in 2019-2020) has been observed (FAO, 2022).

Although growth is a complicated interplay between an animal and its environment, the maximal growth rates of poikilotherms are strongly governed by water temperature (Brett, 1971). Thus, the growth regime is defined by seasonal change in water temperature and how it is distributed throughout space. The growth rate of fish is constrained by low temperature conditions, which also serves as a constraint for the expansion of fish production in the regions of cold climate. Apart from various heating facilities provided in such areas to keep the fish growth normal, modern technological advancements in the form of biofloc technology can be advantageous in the areas of colder climate to augment the fish growth and, consequently, overall fish production. This article highlights the importance of biofloc technology as a sustainable alternative for the fish production in the areas of cold climate.

## Low temperature and growth restriction

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Temperate climates of the earth are characterized by relatively moderate mean annual temperatures, with average monthly temperatures above 10°C in their warmest months and above -3°C in their colder months (Trewartha & Horn, 1980).Temperature has been demonstrated to cause a dome-shaped response in realised growth rates (Childress and Letcher, 2017; Lusardi et al., 2020; Armstrong et al., 2021). Low temperatures restrict the feeding rate of poikilothermic fish because of the decreased metabolism and changes in energy allocation. For example, with increased altitude and decreasing temperature, growth performance and mortality of common carp decreased (Vilizzi et al., 2015).Carps in subtropical/tropical polyculture can achieve 0.6 to 1.0 kg body weight in one season. However, growth is slower in temperate climates, with the fish reaching 1.5 kg bodyweight after three raising seasons (Flajšhans&Hulata,2007).This consequently causes the reduction in growth rate and the overall productivity(Azaza et al., 2008; Ma et al., 2015; Corrêa et al., 2017, 2018). Besides the reduced metabolism and slow growth, fish immunity is largely compromised at the low temperatures (Chang et al., 2006) which make the fish susceptible to various infections and diseases.

***Carassius carassius* raised in a biofloc system**

## Role of nutrition

Apart from genetic factors, nutrition acts as a controlling factor in determining the temperature range at which fish feeding is influenced (Ma et al., 2015; Abdel-Ghany et al., 2019).Nutrition has been shown to improve thermal tolerance in many fish species, including channel catfish (Ictalurus punctatus) (Murray et al., 1977), rainbow trout (Oncorhynchus mykiss) (Wdale et al., 1995), common carp (Yamamoto et al., 2003), Atlantic salmon

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(Jobling and Bendiksen, 2003), and seabream (Richard et al., 2016).Dietary lipids which are an important component of biological cell membranes, play a significant role in maintaining the permeability and fluidity of cells, especially at low temperature(Weber and Bosworth, 2005). Lipid components like polyunsaturated fatty acids (Corrêa et al., 2017, 2018; Nobrega et al., 2017, 2019, cholesterol (Sissener et al., 2017) and phospholipids (Hazel and Williams, 1990) are largely known to improve the thermal tolerance to low temperatures.

**Technological deficits**

A significant progress in the fish production has been made in the state like Jammu and Kashmir from the past decade primarily due to aquaculture of trout and carps species adapted to cold waters. Inspite of the increase in fish production by the introduction of various trout and carp seed and rearing units, the production is still very low compared to the all-India average. The underlying cause of this predicament in the country has been a lack of planning assistance and a belief among authorities that hill fishing is mostly a recreational sport that does not necessitate R&D funding.

Inorder to augment the production from Coldwater regions, it is crucial to introduce new financial regimes, physical infrastructure, and cutting-edge technical innovations in such regions. This sector needs to be expanded vertically and horizontally in order to pursue commercial opportunities and export routes. Utilising contemporary methods and putting scientific management into practise would be beneficial in making this sector more viable and profitable to support the security of food and livelihood.

**Role of biofloc technology**

Provision of heated facilities, geothermal water and green-houses insulated with plastic sheet covers can provide a suitable environment for fish growth during the low temperatures (Dan & Little, 2000). The ponds can also be covered with plastic sheets to absorb the radiations from sun and maintain the water temperature. Besides these techniques, minimizing the water exchange with the cold water seems to be very ideal to preserve the water temperature. However, this might result in the accumulation of toxic wastes in the form of uneaten feed, faeces and build-up of ammonia in the system (Piedrahita, 2003). Therefore, it is important to prevent the deterioration of water quality while opting for the minimal water exchange.

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One of the technological advancements and a practical alternative to maintain densely populated fish with minimum to zero water exchange in the regions of low temperature is the production of fish through use of biofloc technology. The concept of biofloc technology (BFT) is based on formation of dense microbial floc in suspension using constant aeration and external addition of carbohydrates to allow aerobic decomposition of the organic material (Avnimelech and Weber, 1986). This technology is considered an environment friendly alternative wherein the nutrients are continuously recycled and reused regulating the water quality, along with the production of value added in-situ microbial proteinaceous feed for the aquatic organisms (Emerenciano, Gaxiola and Cuzon, 2013).Biofloc constitutes natural food agglomerates like phytoplankton, bacteria, protozoa and living and dead particulate organic matter. By introducing organic carbon to the system and maintaining a stable C/N ratio, these microbiological communities can be artificially generated (De Schryver et al., 2008).This accelerates the nitrogen intake by bacterial growth, lowering ammonium concentrations faster than nitrification. In comparison to conventional aquaculture methods of continuous replacement of water with freshwater and feed addition, biofloc technology offers a more affordable and sustainable alternative through decreased water exchange and feed input, making it a low-cost sustainable technology for the development of aquaculture in the future (Avnimelech and Kochba, 2009; De Schryver et al., 2008). The measurement of floc volume is done using Imhoff cones.

Bioflocs are considered as nutritionally good sources of proteins and amino acids (Azim and Little, 2008), originated from its diverse microbiota, lipids-PUFA (Azim and Little, 2008; Crab et al., 2010, Liu et al., 2016, Najdegerami & Tukmechi, 2022) and Phospholipids. Protein, lipid and ash content in biofloc particles, could vary substantially from 12 to 49, 0.5 to 12.5 and 13 to 46%, respectively depending upon the carbon source used, stocking density employed, light intensity etc., (Emerenciano, Gaxiola&Cuzon, 2013). Thus, biofloc technology appears to be promising for mitigating the effects of low temperature on fish development rate, both through nutritional assistance (especially lipids recognized for their role in maintaining cellular permeability at low temperature) and by preserving the water temperature through reduced or zero water exchange. Aside from that, the technology can be utilized to cultivate tropical fish in cold climates.

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**Supporting studies**

Outdoor BFT production systems in the tropical areas are run year-round. However, few studies have been conducted to determine the performance of fish in BFT production systems in temperate areas. The channel catfish investigations were carried out during the temperate-zone growing season with a mean water temperature of 7.9 ± 0.2 ℃ in the rearing tanks. With a high rate of survival and good health, channel catfish were successfully maintained throughout the winter (Green, 2015). In another study, tilapia fingerlings were grown by over-wintering in ponds maintained with C/N ratio 20/1 by addition of starch as carbon source. The fingerlings showed high survival rates (97%) in low or no water exchange ponds with appropriate water temperature and water quality (Crab et al., 2009).

**Conclusion**

Temperate climates restrict the growth rate of the fish. Biofloc technology might represent an appropriate choice in such areas to provide the fish with good water quality, nutritious food and a viable temperature range. However, there is a wider research gap in this field and extensive research on feasibility of biofloc technology system for temperate settings is required.

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