Importance of Water Quality in Mariculture

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Marine cage aquaculture industry is gaining greater demand worldwide, due to its contribution as an alternate livelihood and also because of its protein and export value, for coastal communities. Water quality is the most important determinant for maintaining sustainable marine cage farming. The most important physico-chemical and biological parameters to be considered in cage aquaculture include water temperature, turbidity, salinity, pH, dissolved oxygen, ammonia, nitrates, nitrites, phosphates and algal blooms. It is also understood that the effects of marine finfish cage aquaculture on water quality are of great concern to the development of an ecologically viable mariculture industry. In India, cage farming of marine finfish is successful with a record production of Asian seabass, *Lates calcarifer* and cobia, *Rachycentron canadum* in 6 m and 10 m dia. steel cages respectively. To achieve a sustainable culture of these species, management of good water quality in the cage farm is of prime importance. This chapter summarizes the most predominant water quality parameters which are to be considered for management of marine cage farming.

Temperature : Water temperature has the maximum effect on fish and can be considered as a primary factor affecting the economic feasibility of a commercial aquaculture venture. Extreme temperatures can induce stress in the animal, and the metabolic activities of fish are affected, which ultimately affects the growth and health of fish. In cage culture, optimum water temperature depends on the type of cultivable species i.e., 26–32 °C for most tropical species and 20–28 °C for most temperate species. Some of the fish species can survive even at varied temperatures but the growth of the fish may be affected due to temperature fluctuations. The sudden change in water temperature will affect fish metabolism, oxygen consumption, ammonia and carbon dioxide production, feeding rate, food conversion, as well as fish growth. The best solution is to select fast growing species and avoid the culture period during the months with unsuitable temperature.

Salinity: Salinity is the most important factor which can influence the ionic balance in the fish and extreme changes in salinity values further affect the growth of fish. In general, the optimum salinity required for cage culture of finfishes ranges between 10-30 ppt. However, the optimum salinity varies with the type of species cultured. Asian seabass can tolerate salinity ranging between 0-33 ppt, whereas, the salinity tolerance of cobia, pompano, snappers and groupers range between 15-35 ppt, 5-35 ppt, 15-33 ppt and 10-33 ppt respectively. Optimum salinity required for culture of Asian seabass, cobia, pompano, snappers and groupers, which are the potential candidate species for cage farming in India, are 15, 25, 15, 25 and 15 ppt respectively. It is suggested to have the culture of these species during the suitable season required for these fishes and also the area suitable and kind of water bodies. It is also suggested to culture Asian seabass in marine as well as brackishwater bodies, as the species can tolerate extreme salinity conditions. The culture of Asian seabass can be practised as in brackishwater areas and in controlled pond conditions as coastal farming. Cobia farming can be done preferably in marine water bodies as the growth rate of cobia is high under high saline conditions in marine water bodies. Pompano, *Trachinotus blochi*, can be cultured both in marine and brackishwater areas in cages and also in ponds as it tolerates all the salinities and the growth rate is more in brackishwater bodies.

Hydrogen ion index (pH): The suitable pH for most marine species is from 7.0 to 8.5. The pH values vary directly or indirectly with other water parameters like salinity and temperature, which also influences the dissolved oxygen and ammonia levels. Extreme values of pH can directly damage gill surfaces, leading to death of fish.

Dissolved oxygen: Dissolved oxygen is one of the prime factor that influences the fish health and growth in marine farms. DO is found to be a very essential element for the maintenance of osmotic activity and also digestion and assimilation of food. DO levels are mainly influenced by other environmental factors, such as temperature and salinity, and the levels decrease with increase in temperature and salinity. Ideal dissolved oxygen levels required for cage culture of marine fish range between 6-9 ppm. However, the oxygen consumption of fish varies, with species, the pelagic fish like snapper and seabass requiring more than demersal species such as grouper. In general, dissolved oxygen should preferably be around 6 ppm or more and never less than 4 ppm for pelagic fish or 3 ppm for demersal species. In the case of cage culture, benthic organisms and sediment wastes may also reduce the oxygen level. Depletion of DO always occurs during night time at neap tide in summer. It is a known factor that the algal community forms a net oxygen consumer and the occurrence of algal blooms more in the areas where nutrient flux is more, and this can lead to the oxygen depletion in water columns. Hence, it is always suggestible to culture the fish in the open waters with sufficient currents that can remove the settled particulate matter and wastes at the bottom.

Turbidity : Turbidity indicates the degree of optical clearness of sea water affected by the existence of dissolved matters, suspended particles and also tides and water currents. The suspended particles should be < 2 mg/L for cage farming of fish in marine waters. Fish wastes and the feed particulates are two major sources of turbidity in cage culture. Increase in turbidity of water results in decrease in light penetration, which in turn affects the phytoplankton production and may further affect photosynthesis of benthic vegetation, and this leads to an increase in microbial loads and in ammonia levels at the cage culture site. During monsoon season, more freshwater runoff will influence the turbidity of the water. Freshwate r runoff due to rains may lead to leaching of heavy metals from industrial effluents and suspension of organic and inorganic solids in the water column. Deposition of solid organic and inorganic materials to the bottom, due to heavy rains, may act as substrate for fouling organisms on the nets, which further prevents proper water circulation. Suspended sediments are also responsible for choking of fish gills, and may lead to mortality due to asphyxiation. Hence, in order to avoid the settlement of suspended particles in the cage, it is preferable to have the culture at sites where high flushing rate conditions are available.

Nutrients: The ammonia-nitrogen levels in the water should be less than 0.1 mg l^{-1}. Ammonia nitrogen levels in water increase by the decomposition of uneaten food and debris at the bottom, and can affect the fish. Normally in the coastal areas, sewage discharge and industrial pollution are the main sources of higher level of ammonia in seawater. The total inorganic nitrogen of water should be < 0.1 mg l^{-1} for a better fish culture operations. The excessive amount of nitrite in water leads to the oxidation of iron in fish haemoglobin, which causes hypoxia in fish. Total inorganic phosphorous plays an important role in growth of algae and other aquatic plants and it should always be < 0.015 mg l^{-1}. Excess of phosphorous levels lead to algal blooms.

Algal blooms: A number of marine algae groups form blooms, including diatoms, Cyanobacteria, prymnesiophytes and dinoflagellates, which interfere with fish gill function. Excessive algal blooms can happen whenever the suitable conditions, such as higher light intensity, higher nutrient level, warm water temperature, stagnant hydrological conditions, prevail. Algal blooms can affect fish by damaging fish gills by clogging and they also compete with fish for dissolved oxygen during night time. Red tides commonly occur in warm water, especially during summer months. Cage site should be selected in those areas where there is no occurrence of blooms and also where the waters are stagnant.

Maintaining good water quality of the marine cage culture operations is important to maintain the ecological balance and also for the health of the cage cultured fish. For maintenance of good water quality, it is essential to monitor all the parameters, which influence the growth and health of the fish, at regular intervals throughout the culture period. It is important to develop standard protocols for water quality management for the cultivation of different species. A standard policy should be clearly developed for the water quality criteria to be considered while selecting a site for cage culture operations.

Recommendations for better water quality management practice in cage culture

1. Selection of a suitable site with sufficient depth (6-10 m) is recommended to have better water exchange and to avoid the deposition of suspended wastes at the bottom. It also helps to avoid the contact of cage bottom to the sea floor which eliminates the bacterial interactions and benthic foulers.
2. Cages should be installed at a place where there is a continuous water current for good exchange of bottom fish wastes and suspended materials. The water current velocity should be between 0.05 m S-1 to 1 m S-1 with a tidal amplitude of < 1 m.
3. To avoid the fluctuations in salinity and dissolved oxygen levels, culture of marine finfish in cages should be carried out after monsoon period and also to avoid the current velocity, which further influences deposition of suspended solids at the bottom of the cage.
4. Development of nutrient and water quality threshold values.
5. Development of feeding strategies to improve the FCR and reduce the nutrient influx into the waters.
6. Regular Monitoring of water quality parameters, at weekly intervals, is essential to understand the health status of the cage environment.
7. Regular net exchange, at monthly intervals, also improves the water exchange in the cages and improves the environmental health. The nets which are with biofoulers are to be brought to the shore and should be thoroughly cleaned and can be reused.
8. Measures should be taken while using the farm vessel, and properly operated with minimum spill and leaks, which may cause pollution in the farm site, that may further lead to fish mortalities.
9. Rotation of cages should be implemented to decrease the waste deposition.
10. Fish wasters, dead organisms. debris and other suspended materials must be transported to the shore and properly disposed.

11. Usage of antifouling agents must be avoided and mechanical cleaning of nets and frames is highly suggestible.
12. Integrated Multi Trophic Aquaculture (IMTA) must be practised in combination with other species like mussels and seaweeds, which filter the waste particulates and absorb dissolved nutrients.

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