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Cage culture system principles and practices in India: A review

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Abstract
Cage culture system is one of the emerging techniques of Aquacultural engineering discipline employed for commercial culturing of aquatic species especially fishes in different aquatic environment. Natural resources such as land and fresh water are scarce resources throughout the world. Population burden is increasing day by day especially in developing countries such as China, India and African Countries thus demands for protein rich food sources are increasing. This increase in demand for protein rich food can be fulfilled by using culturing of fishes with some aquaculture techniques such as cage culture and pen culture. The objective of this paper is to try to review the different aspects of cage culture such as its principles, construction, different types and operation in different developing countries of the world especially India, which provides an alternative to land resources and utilized our vast water resources which are present in forms of different ocean, seas, rivers and lakes. India is having different aquatic environment such as freshwater, brackish water and marine water.

Keywords: Cage culture, gravity cage, rigid cage, mooring system, anchor system, service system

Introduction

India is seventh largest country of the world with approximately 2.4 percent of total land resources and 4 percent of total water resources, with these limited natural resources it has to feed the second largest population of the world after China and also feed largest cattle population of the world. India needs to optimize used of its natural resources in order to feed its increasing population, if it will not able used it within a limited time then it will be having a devasting effects on country population as well as on country economy. More than half of its population is directly or indirectly engaged in the agricultural sector, a sector which is already facing various issues such as farmer's not getting appropriate amount for their produce, underdeveloped agricultural infrastructure, fewer and unequal wages of agricultural labours, fragmented less per capita availability of land etc. Developing country like India should utilized its all the forms of aquatic environment such as freshwater which is present in forms of rivers, lakes, brackish water resources such as brackish lagoons, marshes, deltas lake, and marine water resources such as seas and ocean surrounding Indian peninsula which is one of the largest peninsula of the word.

However it is well known fact that fish is rich source of protein and various essential amino acids. It is also a good source of calcium, vitamin A and B12 and omega-3 fatty acids. People especially those who do not get sufficient nutrients from cereal-based diets, would be benefited by including fish in their diet. Aquaculture industry not only supplies various nutrients for human consumption, but it also provides excellent opportunities for employment and income generation, especially in the more economically backward rural areas. Sixty million people around the world are directly or indirectly engaged in primary production of fish, either by fishing or in aquaculture, supporting the livelihoods of 10-12% of world population (FAO, 2016) [10]. Aquaculture currently accounts for over 50% of the global food fish consumption (Subasinghe *et al.*, 2009) [28]. According to the Food and Agriculture Organization of the United Nations, aquaculture has been the world's fastest-growing food production method in the past 40 years (FAO, 2018) [9]. Global fish production stands at 167 million t, of which 44% (73.8 million t) is contributed by the aquaculture sector (FAO, 2016) [10]. Global capture fishery is presently at crossroads with over 70% of the resources exploited and therefore aquaculture is the only option to fill up the gap of much of the future demand for fish.

Aquaculture is the fastest growing animal food-producing sector, growing at a rate more than 7% annually. Many studies have pointed towards a positive scenario for the role of aquaculture in providing the much-needed animal protein to the world population (Tidwell and Allan, 2001) [29].

Globally India stands at second position in culture fisheries after China. Indian aquaculture has demonstrated a six and half fold growth in production over the last two decades, with freshwater aquaculture contributing the major share. The carp culture in freshwater and shrimp culture in brackish water constitutes the major activity in Indian aquaculture systems. In India freshwater aquaculture contributes over 95% of the total aquaculture production. India is having a good base for aquaculture with 3.15 million ha of reservoirs, 2.36 million ha of ponds and tanks as well as 0.19 million ha of rivers and canals. Freshwater aquaculture with a share of 34% in inland fisheries in mid 1980s has increased to about 80% in recent years (DADF, 2017) [5]. The technologies of induced carp breeding and polyculture in static ponds and tanks have brought about remarkable upward trend in aquaculture productivity and turned the sector into a fast growing industry. The research and development programs of the Indian Council of Agricultural Research (ICAR), as well as the development support provided by the India Government through a network of Fish Farmers' Development Agencies (FFDA) have been the most important steps for this development. Additional support has been provided by several other organizations, state departments and financial institutions. So far, about 0.65 million ha of water area has been brought under fish farming covering 1.1 million beneficiaries. Currently the average annual yield is around 3 t/ha/yr earlier it was used to be 0.6 t/ha/yr(1974). Many farmers have demonstrated productivity levels as high as 8-12 t/ha/yr (Jayasankar, 2014) [18]. At the same time, training has been imparted to about 0.8 million fishers (DADF, 2017) [5]. Andhra Pradesh, West Bengal, Bihar and Chhattisgarh are among the top producers of freshwater fish through aquaculture. Andhra Pradesh producing around 15 lakh t of fish of which 92% is supplied to other states and West Bengal with a current production of around 13 lakh t of fish and still sourcing fish mainly from Andhra Pradesh are the two top producers of freshwater fish in the country (Jayasankar, 2014) [18].

Aquatic products play very important role in human balanced diet, and fish are still considered as one of the most widely traded commodities in the world (Emerenciano *et al*., 2017) [7]. In recent years, with the increasing demand for animal protein and the serious decline in traditional fishery resources, the world's fisheries with marine fishing as the main body are gradually transforming to aquaculture, and mariculture has become the main way for the continuous supply of aquatic products (Lucas and Southgate, 2019) [19]. In the past two decades, the output of marine cage aquaculture has gradually expanded globally, and the total output of Chinese aquaculture accounts for approximately 70% of the world's total aquaculture output, ranking first in the world (Li *et al*., 2018) [21]. Aquaculture enterprises are expanding the scope of fish farming (Raju and Varma, 2017) [25], providing employment opportunities for tens of millions of people and affecting the livelihoods of hundreds of millions of people (Emerenciano *et al*., 2017) [7]. Moving aquaculture to the open sea can benefit the fish welfare and the ecosystem through better water exchange and dispersal of waste over a larger area (Cardia and Lovatelli, 2015) [2].

Cage culture is basically a system of raising the fish inside an enclosure which is having different shape such as circular, rectangular and square shape which might be suspended or floating in the water or fixed to the bottom near the sore in littoral zone. Cage/pen culture in open waters offers vast potential for inland aquaculture in the country. The production potential from sustainable cage culture for table fish production is about 50 kg m3 with enormous possibility for further expansion and intensification. Reservoirs, which are largely untapped in India, have great potential for development of fisheries. By promoting technologies like cage culture, the productivity of the reservoirs can be enhanced manifold. Due to large initial investment, this technology has so far not been successfully implemented in India (DADF, 2017) [5].

The cage permits water exchange and waste removal into the surrounding aquatic environment. The selection of site is one of the important factors for cage culture it should be free from weed and it should be located at some distance away from the shore of sea but in place where excessive turbulence is present in the sea. Site should be located in place where there is a proper circulation of water as its helps in adding oxygen and reduced the probability of installing aerators. Ideally, the site should be selected by means of a thorough site reconnaissance and site selection process. Because cages are immersed in the ambient environment, favorable physical, environmental and water quality conditions are imperative for success. However, it is important to remember that there may be several different locations involved with the overall system. Obviously, the conditions at the cage location are critical but the conditions involving a hatchery's water systems may be even more critical, due to the greater sensitivity of younger life forms. The hatchery, if there is one, may be co-located in immediate proximity to the cage site, but this is very unlikely. In addition, there will be a shore site near the cages to provide directlogistical support, servicing and maintenance to the cages and possibly a fourth location for administration, processing, and vehicle storage/maintenance. The different site location mainly includes the meteorological factors such as wind, air temperature, relative humidity and light, Locational factors such as watershed characteristics, groundwater supply, tides, waves and costal currents, Soil factors such as soil profile, percolation rate, particle size and shape, fertility and microbiological population and biological environment such as primary productivity, local ecology, wild population of desired species, presence and concentration of predators, endemic disease, parasite and toxic algal blooms.

Water with a slow current of 1.0-9.0 m/minis considered ideal for cage installation (ICAR handbook, 2017) [13]. The species which is to be selected for cage culture should have some special characteristics such as fast growth rate, it should have ability to handle stress under crowded condition, have high feed conversion rates, resistant to disease and have good market demand. The species should not breed in cages as it will disturb the stocking density of the cages. The species which satisfy the above criteria Under Indian condition include major carps such as Rohu *(L. rohita)*, Catla *(Catla catla)*, Mrigal *(C. mrigala)*, Common carps *(Cyprinus carpio)*, Mangur *(Clarious batrachus)* and Tilapias *(Oreochromis niloticus)*. In contrast, the development of brackish water aquaculture has been confined to a very few species, although India offers immense potential for the development of mariculture. Cultivable aquatic organisms in India are *Penaeus monodon* (tiger shrimp), *Penaeus vannamei* (white shrimp), *Macrobrachium rosenbergii* (freshwater prawn), *Lates calcarifer* (sea bass fish), and Catfish (Jana and Jana 2003) [17]. Species selection should also be decided on the basis of local demands and availability of the quality seeds, feeds and other inputs which are required by the aquaculture industry.

The vast majority of past experience has involved the monoculture of fish, although shrimp and even turtles have been kept in cages. Even in underdeveloped countries, the culture organisms have tended to be high value fish species for human consumption. Small cage culturing industries are diverse and wide spread. These include grouper in Southeast Asia, catfish in the US and elsewhere (only a small fraction of total US catfish production is from cages), tilapia and milkfish in Asia, salmonids just about everywhere with suitable water temperatures, and carp in various places. The high tonnage production cage culturing industries tend to be marine and in temperate climates and include yellowtail (*Seriola quinqueradiata*) and sea bream (*Sparus aurata*) in Japan, and salmon/trout worldwide (Huguenin, 1997) [15].

Main component and devices in cage culture system

The cage culture requires various components for its proper functioning such as cage bag, Service system, Mooring system, Anchor system and floating system are major components of cage culture. Cage bag is one the important part of the cage culture system as it is the actual place where the fish has to spend their life. It also protects the fish from the external wild fishes especially carnivorous fishes. The material of cage should be durable and strong, but light in weight which allows complete exchange of water volume from every 30 to 60 seconds by minimum of 13-mm square mesh size that allows free passage fish waste but not stress or injuries fish and should be resistant to fouling. It should be inexpensive and readily available. The cage bag net is normally flexible and made of synthetic netting of nylon or polythene fibers reinforced with polythene ropes, although recently new stronger material like spectra or dynema have appeared. The cage unit operation and servicing includes these following activities such as stocking of organisms, counting organisms, measuring/weighing organisms, grading organisms, feed preparation and/or storage, feeding of organisms, prophylactic treatment of organisms, monitoring water quality, monitoring and control of status and health of organisms, harvesting and processing of organisms, cleaning of system (bio-fouling control and good hygiene), logistical support for organisms and personnel (trucks. boats. etc.), mechanical maintenance (connections, moorings, equipment), support facilities and services for personnel (including shelter) and storage facilities for equipment and supplies. As the environmental loads on nets account for more than 85% of total loads on a conventional fish cage (Cheng, 2017) [4].

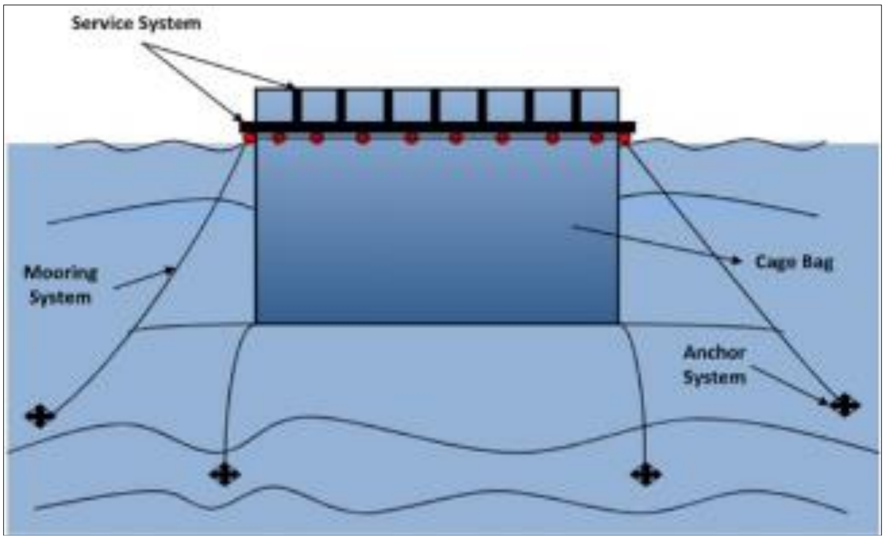

Fig 1: Showing the main component of the cage culture system

Floating system provides buoyancy and holds the system at a suitable level on the surface of water and in some cases it also play important role for maintaining the shape of cage. The most common floatation materials include metal or plastic drums, high density polythene (HDPE) pipes, rubber tires and metal drums coated with tar or fibre glass. Styrofoam blocks, covered with polyethylene sheets provide good buoyancy and may last for as long as five years under tropical conditions. The different materials are attached with main assembly of the system by connectors, stitching or tying. The mooring system hold the cage in suitable position according to the direction and depth decided in the design, and sometimes helps in maintain the shape of the cage. The mooring joins the cage at anchor system and it must be powerful enough to resist the worst possible combination of the forces of currents, wind waves without moving or breaking up. The materials used in mooring system are sea steel lines, chains, reinforced plastic ropes and mechanical connectors. The mooring force capacity depends on both the material and size, and can be adjusted to the requirements. Attachment to the system is by metallic connectors and ties. The Anchor system holds the cage and all the components in a particular site in seabed and is connected to the cage by the mooring system. There are basically three types, pit anchors, dead weight anchors and anchors that get their strength by engaging with the seabed. Pile anchors buried in the seabed re effective, especially for system where a small space is necessary, but they are expensive to buy and install. Dead weight anchors are usually concrete blocks. Hard sand, rock or gravel is no different from the concrete blocks as they can resist their own weight in water and in soft seabed conditions.

Besides these main component as discussed above the modern cage culture system employed various other equipment which is based on the very advanced and recent technologies generally employed throughout the world however in some developing and poor country like India these modern equipments are less employed as compared to the developed nation and if employed then it is generally limited up to laboratory and research purposes and with respect of open sea cage monitoring is done through the variety of water quality sensors, buoy submersible mark technologies and robot technologies are mainly used to realize all-round three-dimensional monitoring of aquaculture environments. These modern equipment generally includes automatic feeding equipment, water quality monitoring equipment, fish movement tracker and net cleaning equipment. However, existing online water quality sensor monitoring systems have some problems, such as field wiring and short data transmission distance. Because of the difficulty in data extraction and the immovable sampling of water quality, buoy submarine-marking technology fails to realize three-dimensional real-time monitoring of the water quality of aquaculture water. Underwater robot technology realizes three-dimensional monitoring of aquaculture water quality, but its application in aquaculture is limited by its own energy supply and navigation routes. Using machine vision and sonar technologies, fish behaviour can be monitored. Due to the unknown seabed environment and the limitations of machine vision technology (light and clarity of seawater are required), machine vision is still in the exploration stage in aquaculture activities. Although sonar technology overcomes some limitations of machine vision technology, it is expensive and difficult to be popularized in aquaculture (Wei *et al*., 2020) [31]. Future development of open sea cage monitoring will move towards an all-round, three-dimensional and intelligent direction to realize the integration of water quality monitoring and fish behaviour monitoring. Combined with existing online monitoring technology, sensor technology, buoy technology and the developing underwater robot and unmanned aerial vehicle technologies (UAV), a multi-space unmanned water quality monitoring system can realize the integration of water quality and sea, land and air quality monitoring. Fish behaviour monitoring will be based on the water quality monitoring system, combining machine vision, sonar technology and fish biological models to establish a reliable and multi-functional environment-fish behaviour monitoring system that will provide data support for culture management accurate feeding and movement of cultural species.

The automatic feeding control system utilizes modern means such as machine vision, acoustics and sensors, combined with the environment and water quality parameters of the cage culture area, and refers to the fish behavior, so that the automatic feeding system can determine the feeding time in real time according to the fish growth demand. The number of times, in order to achieve intelligent feeding, to improve the utilization of feeding, reduce the pollution of residual bait on the water body, save farming costs and improve the quality of fish. Open sea cage culture has increased feeding difficulty because the culture area is in the sea far from the shore. The automatic feeding control system can be used to feed the cage far from the coast and promote the development of open sea cage culture. In large-scale cage culture, automatic feeding equipment is used to optimize feeding methods to solve the problems of high labour intensity, low efficiency, high cost, low accuracy and low reliability of manual feeding (He, 2006) [16].

Due to the lack of feedback information from the farming environment in an actual fishery process, the problem of feed waste has not been well solved (Li *et al*., 2017) [20]. On the other hand, the residual feed from blind feeding may lead to eutrophication of the water, aggravate the aquatic environment, and damage the water quality of culture areas, and this approach is not conducive to the healthy growth of fish. With the development of computer, automation and electromechanical integration technology and aquaculture technology, an important development direction of open sea culture is to use underwater cameras to conduct real-time monitoring of fish growth and the underwater environment in the cage and accurately control feeding by computers to realize precision aquaculture for open sea cages (Yan *et al*., 2018) [32].

Classification of cages

The cages can be classified on the various types based on their types and design, but its main classification is in terms of operation and on this basis cages can be classified into four groups that is fixed, floating, submersible, and submerged. Fixed cages consist of a net supported by posts driven into the bottom of a lake or river, they are comparatively inexpensive and simple to build, but their use is restricted to sheltered shallow sites with suitable substrates. Floating cages have a buoyant frame or collar that supports the bag they are less limited than most other types of cages in terms of site requirements and can be made in great variety of designs and these types of cages are most widely used ones. Submersible cages rely on a frame the advantage of submersible over other types is there position in water column can be changed to take advantage of prevailing environmental conditions generally it is kept on surface during the calm weather. There are a number of ways to classify types of cages. Cages have been and are used from full strength seawater to freshwater. Most have their tops at or slightly above the surface (to keep fish from jumping out). Some with mesh over the top operate submerged, often for only short periods of time such as during major storms. In this type they can be raised to the surface for servicing and can be lowered again. They are submersible rather than submerged cages. The advantages of being below the surface are avoidance of most wave forces, independence from boat traffic and floating objects, better thermal stability, reduced bio-fouling and some security from the different human activity above the water surface. The disadvantages are greater system complexity if submersible and major increased problems in servicing and operating the system underwater. However its classification can also be done on the basis of where it is operated (marine, freshwater, brackish water) means of support - fixed to bottom or floating, types of structure – rigid or floating, access for servicing- catwalk and no catwalk, Environmental severity- sheltered, exposed and open water.

When there is a strong wind or storm, artificial water or air and other methods can be used to adjust a cage in the water layer so that the cage sinks to a certain depth of water to avoid the attack of typhoon waves. After the strong wind or storm passes, the cage can float to the surface. Semi-submersible cages have the advantages of convenient daily operation and management of the floating cages, as well as the advantages of avoiding wind and waves. However, the floating operation of this type of cage increases the complexity of cage operation, increases the difficulty of design and processing, and requires more supporting equipment (Guo and Wu, 2004) [12].

Advantage and disadvantage of cage culture

Cage culture helps in reducing the pressure on land resources especially country like India where due to population pressure and demand for protein is increasing day by day and it also increases the possibility of making maximum use with the greatest economy of all the available water resources and combining several types of culture within one water-body. Movement of cage and its relocation can be done with very easily. With this cultural system we can easily control competitor and predators and also daily observation and management becomes easy with this system. Determining the optimum scale for the overall system is a major decision. This decision can be time dependent, with both initial and future values. Greater size can result in substantial economies of scale in bulk purchases of seed stocks, feed, equipment, supplies and services. In addition, larger system scale allows for the economic benefits and increased management control inherent in vertical integration. Control over required inputs can also substantially reduce risks. There are minimum scale thresholds where owning and operating your own becomes economically attractive for such things as processing plants, hatcheries, marketing structure, and feed mills. This also reduces the risks of sudden unavailability of critical services. Due to inefficiencies inherent in small-scale operations, many small operators find that much of the potential profit is made by processing plants and marketers, who shoulder little of the risks or efforts involved with culturing. However, many of these advantages of larger scale do not require co-location. A number of similar small cage sites acting together to get the benefits of greater scale can be called as big system and such cooperative arrangements among a number of small farms is very common worldwide. The minimum size for a given location is then determined by labor availability, logistical considerations and the size of individual cages. The economic benefits of open sea cage culture are related to many factors, such as stocking density (Viera *et al*, 2016) [30], feeding frequency (Fan *et al*, 2018) [8], water quality environment in aquaculture areas, disease prevention, routine maintenance and labor costs (Reshma and Kumar, 2016) [26] and other factors will affect the economic benefits of farmers. In order to improve the economic efficiency of farmers, these factors need to be closely monitored using the open sea cage culture intelligent monitoring and control technologies. Moniruzzaman *et al*. (2015) [22] proved that the appropriate stocking density is conducive to the growth of production objects and achieve the highest economic return. Automation of the feeding activity using a drone technology can assure regular feeding. This also ensures that feed is distributed uniformly in the cages so that all production objects are equally fed and also minimal loss of feed, thereby reducing routine maintenance and labor costs, and increasing farmers' income (Reshma and Kumar, 2016) [26].

Cage culture can be established in any suitable body of water, including freshwater, marine water and brackish water with proper water quality, access and legal authority. This flexibility makes it possible to exploit underused water resources to produce fish. Cage culture has relative low initial investment as compare to the cost of pond construction and its associated different infrastructural works such as electricity, roads, and wells etc. cage culture in an existing body of water can be less expensive. At low densities (relative to pond surface acreage) cages often do not require aeration. Cage materials are not especially expensive and many kinds of cages can be constructed with little experience. Cages lend themselves to straight forward observation of the fish. The observation of fish behavior, especially feeding behavior, is critical to anticipating and avoiding problems with stress and diseases, which often occur in cage culture. Fishes in cages are usually harvested by moving them into shallow water, crowding the fish into a restricted area, and simply dipping the fish out of the cage. Or, the cage can be lifted partially out of the water so that the fish can be collected into a smaller volume, and then the fish dipped out. This makes it possible to partially harvest fish from cages as needed for local markets or personal consumption.

With so many advantages cage culture system also got various disadvantage such as it is difficult to give feed and medicine when the water surface is very rough and therefore restricting location to sheltered areas. Marine aquaculture usually has many forms, but the main way is cage aquaculture, which mainly includes traditional cage aquaculture models and open sea cage aquaculture models. Traditional cage culture technology is primitive, and the links among water environment monitoring, feeding and capturing are basically determined by farmer, which has great randomness and blindness. Compared with the traditional cage farming mode, the open sea cage farming mode has a high degree of automation, and the supporting software and hardware facilities are complete, greatly improving the cage farming efficiency (Chen *et al*., 2016) [3]. Traditional cages have low fish activity generally with small fishes and also having low production efficiency. Traditional cages usually based on manual throwing methods for feeding; it is difficult to accurately master the most suitable feeding technology to meet the needs of production objects, resulting in waste of feed. In addition, manual feeding has many problems such as high labour intensity, high economic cost, uneven feeding, inaccurate feeding, unpunctuality, and difficulty controlling feeding amounts. Traditional cage aquaculture in a limited area with high density can easily lead to various problems, such as deterioration of water quality and increases in disease, resulting in the death of a large number of cultured fish (Zhang and Su, 2001) [34]. It requires adequate water exchange through the cages to remove metabolites and maintain high dissolved oxygen levels and rapid fouling of cage walls require frequent cleaning. Species in cage depends absolutely on artificial feeding unless utilized in sewage ponds, high quality balanced rations essential, feed losses possible through the cage walls. Sometimes small natural fish may enters in the cages and this natural population can acts as a reservoir of disease or parasites and can increased risk of diseases in cultured species and can also eat our artificial feed.

The different water parameters such as water temperature, pH, dissolved oxygen, nitrite, ammonia nitrogen, chlorophyll and other water quality parameters (Devi *et al*., 2017) [6] are monitored in real time, and the changes in water quality parameters are analyzed from the data obtained in real time to solve the traditional water quality monitoring method for open sea cage culture cannot dynamically reflect the problem of water quality change, and achieve the goal of unattended operation in the open sea cage culture area, so that the fishermen can obtain the hydrological and water quality parameters of the open sea cage culture area at any time in the remote monitoring room.

The aquaculture industry suffers very large losses every year due to diseases caused by various pathogens. Therefore, effective disease detection and control is important to maximize productivity and ensure the quality of the final product (Ninawe *et al*., 2017) [24]. Luis *et al*. (2017) [23] proposed a method for disease control in aquaculture using nanotechnology. Nanotechnology has a broad spectrum of uses and can significantly contribute to its evolution. Applications of this technology include the sterilization of ponds, water treatment, detection and control of aquatic diseases, efficient delivery of nutrients and drugs (including hormones and vaccines) and improvement in the ability of fish to absorb these substances (Bhattacharyya *et al*., 2015) [1]. Due to the installation of the cages at a particular place for longer duration it has accumulated various types of heavy metals, as the persistent environmental pollutants, are non-degradable and toxicant in ecosystems ubiquitously, which have attracted worldwide attentions (Gao and Chen, 2012) [11]. It is also well-known that heavy metals could be readily transferred and bio-accumulated along with the aquatic food web (Hao *et al*., 2019) [14]. This way of fish farming is considered as one of the efficient ways of farming fish, aquaculture has been widely used to increase fish production around the world, aiming to meet the growing demand for human consumption and thus it is also clear that high quality and yield of aquaculture products mainly depends on the input of formulated fish feed and the application of antibiotics, pesticides and other inputs (i.e., animal and human excreta, industrial and domestic wastewater as nutrients) (Sapkota *et al*., 2008) [27]. Among which, fish feed has been generally manufactured with or composed of heavy metals such as Zn, Cu and Cr to enhance fish growth, and Cu/Pb-based antifouling paints are widely used to provide corrosion resistance (Zhang *et al*., 2012) [33].

Summary and conclusion

Thus from above discussion finally we can conclude that cage culture system plays very important and crucial role in the aquaculture industry not only in India but throughout the world especially developing country with less land based natural resources but more aquatic resources. By using these techniques of aquaculture we can utilize our aquatic resources to its full potential by producing various aquatic organisms and it can also become tool for tackling unemployment and means of livelihood for huge number of unemployed youth. Government should takes various initiatives for the development as well as promotion of these types of system especially in those areas which is having plenty of water resources such as our costal states and those villages and towns which is situated on the bank of various rivers and lakes.it would help in utilizing our underdeveloped aquatic resources.

It is clear that with the world's population growing at a rate of more than 80 million people a year and expected to reach 9 billion by 2050, with this rate of increment there is no doubt that India will be the most populated country thought the world so it is important for us to use our oceans and precious freshwater resources more efficient and productive way in terms of increased global aquaculture food production. In addition, while the need for improved efficiency and productivity will be critically important in the development of aquaculture in general and cage culture specifically, so will be other factors, particularly food safety in combination with socially acceptable and economically and environmentally sustainable food production according to agreed and certified principles, with particular attention paid to animal welfare, all of which rank increasingly high in consumer perception and acceptance of aquatic products. Cage aquaculture will play an important role in the overall process of providing enough (and acceptable) fish for all, particularly because of the opportunities for the integration of species and production systems in near shore areas as well as the possibilities for expansion with siting of cages far from the coasts.

Cluster based approach should be adopted as all the things which is required for the development and operation of the cages system should be available locally. Various other facilities should be developed such as easily availability of quality feed, Establishment of broodbank and certified hatcheries in order to ensure supply of good quality and availability of different drugs and medicine should be made locally available. More and more farmers and interested youth should be encouraged trained especially those which are having fishing as their livelihood from many generation and mostly employed traditional methods of fishing. These modern techniques should be demonstrated through different government and private training institutes. If these measures are adopted it will definitely increase the fish production potential as well as the economy of the different developing country including India.

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