Good Aquaculture Practices

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Aquaculture is among the fastest-growing animal food sector in the world (FAO, 2014), supplying about 50% of the fish consumed by humans. Global aquaculture production recorded 122.6 million t in 2020. Of this, 54.4 million t emanated from inland waters and 68.1 million t came from marine and coastal aquaculture (mariculture), at a total value of about USD 281.5 billion in 2020 (FAO, 2022). The Asian region contributed about 91.6% to this production. India is ranked as the world's second-largest aquaculture producer and the third-largest fish producer. Ministry of Fisheries, Animal Husbandry, and Dairying, New Delhi, states that the Indian Blue Revolution initiatives have brought measurable improvement in aquaculture in India and is now considered a sunrise sector. The aquaculture and fisheries sectors support the livelihoods of about 16 million fishers and thousands of others along the value chain. India's fish and shellfish species resources, including that of the seas, lakes, ponds and rivers, are about 10% of the world's such resources. Our extensive coastline, exclusive economic zone and vast expanse of the shallow continental shelf are home to innumerable living resources. Our fisheries and aquaculture goods being exported amount to nearly 20% of the agricultural exports. Our exports of marine products were valued at US$ 5.37 billion in 2020-21, and the United States of America is the largest importer of Indian seafood, amounting to 41.15% of their seafood imports. The growth of exports anticipated from the 2016s to 2030 is about 16%, and more and more aquaculture and mariculture ventures are expected to come up in near future. Though aquaculture brings huge befits to humanity in the form of food and nutrition, livelihoods, income and employment, the sector is equally a matter of concern worldwide due to its impacts on the environment and human/ animal health. Un-treated discharge of aquaculture wastewater, indiscriminate use of medicines like antimicrobial and growth promoters, nutrient loading from faecal matter and food leftovers, and escape of captive organisms into the wild waters have potential impacts on the local environment, biodiversity and have the potential to spread disease/ pathogens Guangjun *et al*. (2010). With the ever-increasing demand for aquaculture food and products, there is an increasing trend to adopt intensive or high-density, high-production aquaculture systems based on formulated high protein feeds, oxygen supply, and application of drugs and antibiotics. This is expected to push up the concerns on environment and human safety several folds. This concern worldwide has resulted in louder calls for urgent transformation of aqua-food systems to ensure bio and food security and safeguard ecosystems and social equity. Hence sustainable aquaculture is critical to meet the growing demands for aquatic foods (FAO, 2022).

Aquaculture systems and their impacts

Aquaculture systems are classified based on the level of human interventions, the density of organisms stocked and the energy consumption per unit volume of water used/ supplied as follows.

- Extensive,
- Semi-intensive,
- Intensive,
- Highly or super-intensive

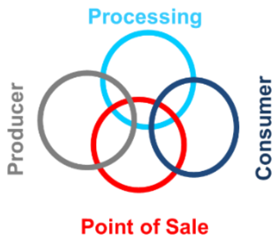
Extensive aquaculture depends on farming aquatic organisms on natural foodstuff, while semi-intensive aquaculture uses manure and fertilizers with a moderate supply of artificial feeds. Intensive aquaculture uses high densities of stocking, provides aeration, and depends only on artificial feeding and application of chemicals to prevent and treat diseases, resulting in a high unit area or unit of water used. While the super-intensive aquaculture systems rely on complete control, use extremely high stocking density, water re-circulation and very high input of food materials and chemicals, besides very high energy consumption. Depending on the system of aquaculture practised and species used for farming, the intensity of impacts varies from the lowest for extensive aquaculture systems to the highest for super-intensive aquaculture. These impacts can be visible and invisible, positive and negative (Preston *et al*. 1997; Wang *et al*. 2005). Discharge of effluents, fertilizers, chemicals, medicines, growth promoters, disinfectants, pesticides, pathogens, and particulate matter and the escape of stocked organisms to nature are among the significant effects of aquaculture. Hence, regulated and monitored aquaculture practices are needed to achieve sustainability and reduce the risk factors through a set of assessment tools laid out.

Aquaculture assessment tools

There are generic tools available for the assessment of aquaculture for promoting responsible aquaculture practices in the form of methods, guidelines and processes used for planning, development, management and decision-making (Miao *et al*., 2013). The application of these tools ranges from the farm level to the national policy level, while international agreements and instruments guide some others. Some of these, for example, are as follows (Miao *et al*., 2013).

- To assess risks in aquaculture (e.g. pathogen risk analysis, food safety risks, genetic and ecological risks)
- Risks in international trade (e.g. IRA);
- For Impact Assessment (e.g. EIA);
- For assessing governance (e.g. codes of practice)
- For management (e.g. BMPs, GAqP, certification)
- Socio-economic assessments.

The following sections shall focus briefly on Good Aquaculture Practices (GAqP), which is one among the management tools available for aquaculture assessment and monitoring.



Aquaculture food safety points of concerns

Good Aquaculture Practices (GAqP)

Good aquaculture practices (GAqP) are a set of operational standards for aquaculture production, defined in several ways. It is a management tool for optimizing aquaculture practices and improving product quality and safety, whilst contributing to environmental integrity and social equity (Miao *et al*., 2013). However, in general, GAqPs are prevention methods/ protocols developed and implemented to meet the needs of the farmed species, farming methods, humans as end users and the local environment. This is achieved through identifying areas or acts of potential risks and implementing preventive and control measures to avoid or manage the risks through a set of Hazard Analysis Critical Control Point (HACCP) principles with maximum and/or minimum levels for each component of the system. Whenever the critical limit exceeds, corrective actions are implemented for compliance with the laid-out protocol (Jahncke *et al*., 2002) through a step-by-step approach to identifying and controlling the hazards in both freshwater aquaculture and mariculture. There are seven fundamental principles in HACCP.

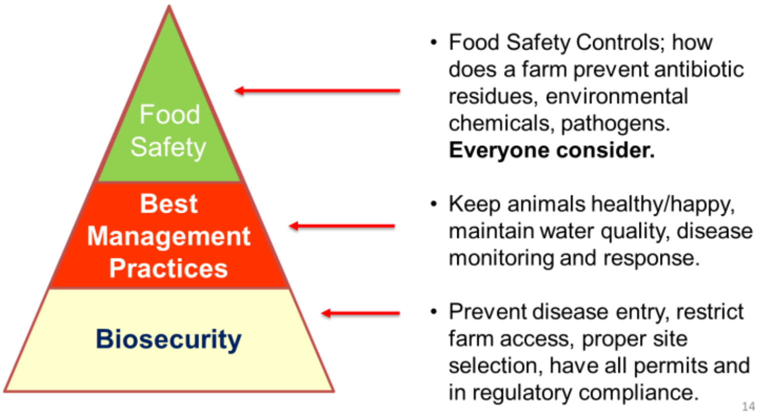
1. Hazard and Risk Analysis
2. Identify Critical Control Points
3. Establish Critical Limits
4. Establish Monitoring Procedures
5. Establish Corrective Actions
6. Establish Verification Procedures
7. Establish Record Keeping Procedures

The Hazard and Risk Analysis includes the collection and evaluation of information on potential hazards related to the product or process being considered to decide the chances of occurrence and severity of it. This can be achieved by the construction of a flow chart of all inputs to the aqua farm and identifying its potential hazard, and evaluating control for such hazards. From broodstock maturation to reproduction and through live feed production, larval rearing, grow out, and harvest and post-harvest in aquaculture, the water quality parameters, disease outbreaks and food offered are among the critical control points. These are the primary areas for potential risk analysis. Identifying the Critical Control Points with minimum and maximum levels permissible, as in the case of water quality (for example), for monitoring and taking ameliorative actions. Establishing critical limits is the setting of minimum and maximum levels for each parameter (for example) below and beyond which a physical, chemical or biological hazard is to be controlled to prevent, eliminate or reduce the impact of the occurrence of a hazard. Stocking density, food ration and the ratio of natural and artificial feed given, environmental parameters, aeration intensity, etc. (for example). Establishing Monitoring Procedures for the operation that maintains levels of a Critical Control Point and the accuracy of the monitoring procedure to take note of deviations, if any, from the set protocol levels. Failure to properly use and monitor chemotherapeutic agents may result in detectable residues in the Critical Control Points set; frequency of monitoring, methods used for monitoring, equipment used for monitoring, etc., for example. The establishment of Corrective Actions includes what and how of it to be implemented in the event of a hazard being identified; including short, medium and long-term actions. The Establishment of Verification Procedures is equally important to determine the validity of the corrective actions implemented and verify if the farm is operating as per the protocols. Record Keeping Procedures is the final step to document all previous steps from serial numbers 1 to 7 above, after their respective implementation. Records need to be maintained for all identified Critical Control Points and need to be made accessible to staff and managers in paper or electronic form. The entire operation can be guided through Standard Operating Procedures (SOP).

Example of a hazard risk analysis (Source: Stanley, 2015)

Identify Potential Hazard	Is the Hazard Significant	Justification	Preventive Measures	CCP
Seed stock	Yes	Shrimp larvae may contain detectable pathogen	SPF certification for each receipt. Quarantine procedures and test periodically (CCP)	Yes
Water source	Yes	Potential pathogens	Provide pre-treatment to ensure water supply is safe (CCP)	Yes
Feed Source	Yes	May result in and poor production	Certificate from feed supplier to ensure standard (CCP)	Yes
Stocking Density	Yes	Important to optimize production	Controlled by Standard Operating Procedure (SOP)	Yes and No
Effluent or Recirculated Water	Yes	Effluent may contain pathogens	Controlled by Standard Operating Procedure (SOP)	Yes and No
Animal and Human Vectors	Yes	May transfer contaminants and pathogens	Controlled by Standard Operating Procedure (SOP)	No
Farm Equipment and Sanitation	Yes	Equipment may become contaminated with pathogens	Controlled by Standard Operating Procedure (SOP)	No

SPF – Specific Pathogen Free; CCP – Critical Control Point; SOP – Standard Operating Procedure



Layered Preventative Controls in GAqP (source: Brett Koonse, JIFSAN)

Standard Operating Procedure (SOP)

An SOP usually is a manual prepared in an easily understandable manner for farm managers to refer to for directing their actions in each step of the HACCP. This needs to be prepared before the farming operation begins. The SOP normally includes the design of the facility, flow diagrams for actions from start to end, husbandry/ management procedures for each step in the production process, waste management, pest control, staff rules, etc. SOP can also include animal welfare, environmental protection and social responsibility as well, with information on stock, diagnostics and detection methods, disinfection and pathogen eradication, etc. The principles of HACCP provide a logical step-by-step approach to preventing contamination, entry of pathogens, and disease outbreaks, allowing farm managers to choose essential process steps and choose appropriate Critical Control Points and Measures.

GAqPs can minimize animal diseases, human disease outbreaks, exposure to drugs, antimicrobial resistance (AMR), and violations at import, improve the poor perception of aquaculture and save everyone time, money and effort. It builds a plan, identifies risks, places the controls, and documents and verifies that it works.

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