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Bacterial Disease Management in Aquaculture: Exploring Therapeutic Solutions

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Abstract

In recent times aquaculture is one of the fastest growing animal foods producing throughout world which can reduce or eliminate the goal of WHO zero hunger via cheaper nutritional foods to rising population of the globe. However, due to the intensification in culture systems leads outbreaks of diseases and most common in aquaculture are bacterial infections. As per the review of literature, bacterial disease is more frequently more common in tropical as well as subtropical countries. To control the bacterial infection in aquaculture system, many farmers are in the globe using therapeutics, disinfectant, antibiotics, probiotic etc. are reduce the mortality and increase the survival rate. Recent advancements in the biotechnological fields leads new scientific discoveries such RNAI, DNA or RNA based vaccines, gene therapy, Nano particles, Cas9 and AMP are having potential against the pathogenic microorganism to prevent entry into the culture systems. Field level genetically modified organism, specific pathogen free, specific pathogen resistance and specific pathogen tolerance are widely used. Antibiotics are widely used by the farmers because of immediate action and reduction in mortalities. But indiscriminate use of antibiotics or therapeutants causes the AMR or toxicological effects on the ecosystems.

KEYWORDS

Fish, Disease, Bacterial, Therapeutants, Control measures.

INTRODUCTION

Due to the rising population of world leads scarcity of nutritional foods in the world and subsequently cause of nutritional related problems on the people. To achieve goal of zero hunger set up by WHO in 20230s, aquaculture can produce cheaper animals' nationals' diet to provide developing nation which directly eliminate nutritional related deficiencies in each individual (WHO, 2015). To tackle the nutritional scarcity, aquaculture plays a huge role in elimination of hunger and malnutrition throughout the world by providing cheaper nutritional diets. Aquaculture farming ranges from extensive to intensive involving high stocking density, optimum water quality and high production.

However, intensification in culture system, numbers of stress related parameters has been to the animals as well as on the environment which will lead the outbreak of the disease. One of the most challenging health problems to manage is bacterial fish disease which is highly prevalent in aquaculture system. Typically, these bacteria are saprophytic; there is physiological imbalance, nutritional deficiencies or presences of the stress like water qaulity parameters in the environments facilitates the outbreaks of the disease in the aquaculture (Sandeep *et al.,* 2016) Currently, numbers of farmers worldwide use wide spectrum antibiotics to combat bacterial infection in the culture systems. Generally, antibiotics derived from natural or synthetic processes which have static activities against the pathogenic bacteria (Serrano, 2005). There are number of authors reported that the use of therapeutics in fish production more frequently and unappreciated by farmers. Therapeutants are chemicals that can be utilized in aquaculture or fish farming operations to maintain the health of aquatic animals (fish and shell fish. The country's aquaculture sector suffered serious setbacks as a result outbreaks of diseases, which will promote the usage of therapeutic agents in both the freshwater carp and prawn industries (Pathak *et al.,* 2000).

However, mortalities in aquaculture directly cause the economic loss to farmers as well as in terms of fish production which affects the nutritional requirements of the developing nations. Moreover, the cost of fish mortality caused by disease not bears by small and marginal farmers, so they unscientifically use the therapeutants which is concern about the human health and AMR. In the US-FDA and EPA are the agencies which strictly regulate use of drugs and chemicals in aquaculture industry and give certification of compounds are usable in this industry. All most each and every chemicals and antibiotics or VMP required FDA approval to use in aquaculture or veterinary practice.

IMPORTANT BACTERIAL DISEASES IN AQUACULTURE

The aquaculture industry is being impacted by a number of major pathogens, including viruses, fungus, bacteria, and parasites. All the life stage of the fish can be affected by the bacterial disease that resulted in the high mortality (Ahameda, and Sisira, 2005). So far, there are 13 bacterial genera are pathogenic to aquatic animals, including *Aeromonas*, *Edwardsiella*, *Francisella*, *Photobacterium* etc. (Klesius and Pridgeon, 2011). As per the report, more than $6 billion USD per year loss caused by the numerous diseases in aquaculture industry throughout globe (Vijayan *et al.,* 2017), but total revenue generated by aquaculture was $105.3 billion in 2009 (Subasinghe, 2005). Characteristic and pathological sign of some of bacterium which is reported from the fish mention below:

1. **Columnaris disease**- aetiological agent- *Flavobacterium columnare*

Flavobacterium columnare cause the disease in fishes and known as 'saddle back disease'. The characteristic of this is grey discoloration near base of fins. Important clinical symptoms include such as necrotic or sluggish body surface, deeper ulceration yellow or orange, gills become black of infected fish, and colonization or pigmentation of each bacterial cells.

Control: The use of H_2O_2 100 ppm for 30 min every day through bath treatment for 10 days increase the survival of fish (Cipriano and Holt, 2005). $KMnO_4$ dip bath 1-2 ppm for 20 min reduced the bacterial load (Avdesh *et al.,* 2021). Oxolinic acid dip treatment at 1 ppm is enough to destroy the bacteria within 24 h. Streptomycin 25mg/kg reduced the growth of bacterium (Avdesh *et el.,* 2021).

2. **Vibriosis**- causative agent- *Vibrio anguillarum*, *V. alginolyticus* and *V. vulnificus*

Vibrio spp. can cause number of diseases in shellfish and finfish and major bacterial infection in aquaculture. It includes clinical pathology such anorexia, darkening and sudden death, swollen dark skin lesions, ulcers on body surface etc. liquefaction of kidney and spleen are major internally affected organs.

Control: The compound's used against bacterium is sulphonamide 8-12 mg/kg feed (Avdesh *et al.,* 2021), copper sulphate@ 1:2000 for 3-4 days (Hetrick *et al.,* 1979)

3. **Bacterial gill disease**- aetiological agent- *Flavobacterium branchiophilum*

The pathological alteration caused by bacterium includes attachment and proliferation of the filamentous bacteria on the gill. Infected fish exhibit gasping, slower swimming are more common. In case of severe infection cotton wool-like mats of pathogen are extend to opercula. Gills section of affected fish found with fusion, lamellar proliferation and hyperplasia in histology.

Control: Hydrogen peroxide (H_2O_2) dosage of 50-100 ppm 60 minutes increase the protection against the pathogen (Cipriano and Holt, 2005). Sodium chloride given via bath treatment @ 0.5 % (5000 ppm) for 30 min or 1 % (10000 ppm) for 6-10 minutes to small fry.

4. **Furunculosis**- causative agent- *Aeromonas salmonicida*

The bacterium was reported in 1894 (McCraw, 1952) from Germany and name after salmonicida which infected the trout and salmon, cause "great red plague".

Clinical pathology: Clinical manifestation includes furunculosis is characterized by formation furuncle or boil-like lesions, blood of affected severely on the fish, discoloration of skin coloration, anorexia, hemorrhages on the fins etc. are frequently observed in infected fish with furunculosis.

Control: Bacteria can be treated with povidone iodine @ 50 or 100 (mg/L) (Bjarnheidur Bryndis, 2000). The dose of 50-80 $mgKg^{-1}$day chloramphenicols is proteive against *A. salmonicida A. hydrophila* and *A. liquifaciens* (Avdesh *et al.,* 2021). Sulfonamide @ 50 mg/kg fish for 10 days can reduce the mortality. The dose of oxytetracyclin 50-80 $mgKg^{-1}$ of fish for 7 days increase survival rate of fish (Avdesh *et al.,* 2021).

5. **Tuberculosis**- causative agent- *Mycobactrium marinum*

The bacterium can induce pathological changes such as ulceration on the body surface and fin rot. Some of other clinical manifestation loss of appetite, loss body weight, loss of scale, etc. are sings of the bacterial outbreaks.

Control: Dosage of 5-8 ppm copper sulphate for 5 min is recommended by Durborow *et al.,* (1998) for continuous 3-4 days. As per Vaerewijck *et al.,* (2005) studied, 200 mg/L sodium hypochlorite can also enhance the survival rate of fish against the *Mycobactrium piscium*.

6. **Dropsy**- causative agent- *Pseudomonas punctate* and *A. hydrophilla*

Aeromonas hydrophila is one of the major bacterial pathogen in aquaculture and cause huge mortalities in the aquaculture. Commonly known as Aeromonasis in fish. Infected fish with *A. hydrophila* observed with swollen body, scales loss, bulging of eyes, sometimes spinal curve bend, red anus, hemorrhages at the base of fins and swollen etc. Histopathological alteration in the vital tissue of fish such as liver, kidney, spleen and gills are having peculiar characteristic.

Control: *A. hydrophila* can be treated in fish culture system using following compounds. The dosage of formalin @ 5 ppm for consecutive 10 days via bath with $KmNO_4$ dose @ 5 ppm for 2 min for 10 days via bath and dosage of oxytetracyclin 80 mg/kg for 10 days (Avdesh *et al.,* 2021).

7. **Edwardsiellosis**- causative agent- *Edwardsiella tarda* and *E. Ictaluri*

Edwardsiella is gram negative bacteria which can infect the fish and leads the high mortalities in aquaculture system. The loss of pigments, increased kidneys, distension of abdomen, swollen anus etc. are the characteristic of Edwardsiella infection.

The bacterium can be control by treated with Sodium chloride (1%) is effective disinfectants, formalin (250 mg/L). Dosage of Povidone iodine @50-100 ppm and sodium chloride (1%) reduced or eliminated presence of bacteria after contact with compounds within 1 minutes. Dosage of formalin 250 ppm can destroy the bacterium within 1 hr (Mainous *et al.,* 2010). Use tetracycline or Sulphonamide 8-12 mg/kg gives protection against the Edwarsiellosis (Avdesh *et el.,* 2021).

8. **Enteric red mouth (ERM)**- causative agent- *Yersinia ruckeri*

The disease found in rainbow trout but it can infect wide variety of fishes. *Yersinia ruckeri* is a Gram-negative with shape of rod and penetrate via gill, spreads in vital tissue of fish and blood. The clinical manifestation induce by bacterium in fish includes darkening of body surface, abdominal petechial, congestion of blood vessels, ulceration, haemorrhage on the fins lesion are found on the fish.

Control: Dosage of oxolinic acid @ 20 mg Kg^{-1}(Avdesh *et al.,* 2021) for 10 days consecutively give protection to fish.

9. **Bacterial haemorrhagic septicaemia**- aetiological agent- *Aeromonas hydrophila* & *Pseudomanas fluorescens*

The bacterial septicemia can be caused by the two types of bacteria which gram negative and causes huge economic loss in aquaculture. They lead secondary infection for other pathogenic microorganism.

Clinical signs: the affected fish exhibiting discoloration of body, hemorrhages near base of pectoral fins, ulcer on body, sluggish epithelial layer of muscle, and necrotic surface and so on found on the fish.

Control: Bacteria can be treated with bath treatment copper sulfate dosage of 100- 200g/100 litre water reduced the fish mortality. Application of Potassium permanganate 1- 2kg /ha increase the survival of fish (Avdesh *et al.,* 2021).

10. **Bacterial kidney disease**- causative agent -*Renibacterium salmonarium*

Renibacterium salmoninarum is caused bacterial kidney disease (BKD) particularly in salmon fish which cause serious economic loss to salmon fisheries.

Clinical manifestation by bacterium: the infected fishes usually darken in color with occasionally exophthalmos and small hemorrhages at the base of pectoral fins, lesions are found in the kidney, heart, spleen and liver, sometimes large caseous nodular granulomata, swollen and gray-white kidney, spleen redder and enlarged.

Control: Bacteria can treat with erythromycin phosphate 1 mg / kg for 15 days treatment. Dose of erythromycin @ 2 ppm can reduce the mortality of fish against the PKD (Avdesh *et al.,* 2021).

11. **Mycobacteriosis**- causative agents- *Mycobacterium fortuitum, M. marinum* and *M. chelonei*

Mycobacteriosis in fishes was first described in carp which gram-positive, acid-fast, aerobic isolated from contaminated water. Mycobacteria, comprising the genus Mycobacterium are non-motile and pleomorphic in nature.

Clinical signs: Clinical signs of infected fish exhibited by mycobacteriosis are include scale loss, ulceration, ascites etc. The fishes exhibited large spleen or kidney and characteristic white nodules in vital organs of fish.

Control: Generally, sodium hypochlorite @ 200 ppm for 60 min can reduced the numbers of viable bacteria in aquaculture (Vaerewijck *et al.,* 2005).

12. **Fin rot and tail rot**- causative agent- *Aeromonas* and *Pseudomonas*

Aeromonas and *Pseudomonas* can induce the pathogenesis in fish and cause the mass mortality. Infected fish observed symptoms of anorexic, lethargic, grayish fins, hemorrhages on the surface, fin rot and so on. Mortality rate of 80% may be observed within a few days. Fin rot like appearance on the fish body found within 48 h of post infection.

Control: The concentration of sodium chloride at 1% for 6-10 minutes is recommended by many authors. In aquaculture farms, dose of hypochlorite @ 20-30 mg/L is used for pond disinfection. Use long bath in acriflavine 10gm/100-liter water to control of Aeromonas and Pseudomonas bacteria (Avdesh *et al.,* 2021).

CONCLUSION

Exploring therapeutic treatments is essential for sustainable and efficient production in bacterial disease management in aquaculture. An inappropriate use of antimicrobials agents or antibiotics has been leads development of antimicrobial resistance (AMR), which has detrimental effects on the health of both fish and humans. Hence, researchers are investigating alternate approaches, such as phage therapy, which has demonstrated encouraging outcomes in mitigating bacterial infections in aquatic organisms like fish and shellfish. Phage treatment is the utilization of bacteriophages, the viruses specifically infect and eliminate bacteria, for the purpose of managing bacterial illnesses in aquaculture. Implementing these measures can effectively mitigate stress in cultured aquatic species, bolster their inherent immune defences, and avert the occurrence of disease outbreaks. Exploring treatment solutions such as phage therapy and enhancing overall management practices are crucial for achieving sustainable

and efficient bacterial disease management in aquaculture. Additional study is required to enhance these tactics and guarantee their efficacy and safety in aquaculture applications.

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