Fish Health in Sustainable Development of Agriculture

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Abstract: Aquaculture is a fast-growing food production sector. The gradually increase of this production of fish resulted in serious pathological problems in all countries where intensive aquaculture is practiced. Sustainable development of aquaculture relies on disease prevention. With an intensification of operations, the risk of disease occurence and spread of infectious increases. In aquaculture prevention is a key issue more than in other animal productions in health management. The risk of the diseases increases with the intensification of the production and can be controlled mainly trough the implementation of sanitary or medical prophylactic programs. Sanitation relates to hygienic rules, cleaning and disenfection procedures, water treatment, but also good feeding and rearing practies. Good husbandry and vaccination programs should be applied. Diseases maps and certificaitons programs and regulations must be established. The aim of this paper is to present general overview of important applications for sanitation in sustainable aquaculture.

Keywords: Fish, aquaculture, prevention, sanitation, disinfection

1. Introduction

The intensification of aquaculture and globalization of the seafood trade have led to remarkable developments in the aquaculture industry. The industry has been plagued with disease problems caused by viral, bacterial, fungal and parasitic pathogens. In recent years, disease outbreaks are becoming more frequent in the aquaculture industry and the associated mortality and morbidity have caused substantial economic losses. Health problems have two fiscal consequences on the industry: loss of productivity due to animal mortality and morbidity, and loss of trade due to food safety issues. Thus, disease is undoubtedly one of the major constraints to production, profitability and sustainability of the aquaculture industry.

Infectious diseases have always been limiting factors for aquaculture. High population density, adverse environmental conditions and poorly designed culture systems frequently cause to stress consequenlty reduce to immunity of fish to pathogens. Bacteria, viruses, parasites and fungi can cause outbreaks and high level mortality. All viral, many parasites and some of the bacterial diseases can not be treated with the chemicals successfully. It is reality that the treatment of a diseases is expensive and more difficult than prevention (Ahne and Winton, 1986). The ways of prevention and contingently of medical treatment of fish are very specific and often different from those in warm-blooded animals. They require a thorough knowledge of the environment of fish. Preventive arrangements are consisting of complicated set of treatments elaborated on the base of a good knowledge of the aetiology of disease and a host (fish) biology. It concerns the elimination or restriction of infection (invasion) sources and the possibilities of its further expansion likewise the enhancement of condition of fish organism in the way to be able to withstand the infection (invasion). The prevention is of basic importance in diseases elimination. No specific therapeutics were developed for a number of diseases up to now and the result of the application of effective, experimentally verified medicaments, is often reversely affected by the operational conditions and/or the technology of rearing. The medical treatment becames economically unrenumerative in this way.

In addition, some treatments cannot be performed in certain periods, e.g. in growing season, during the wintering, or in some fish culture units (e.g. large ponds). That is why it is much more important to prevent from the diseases than to recover them. The effective preventive treatments are to be applied above all in specialized fish culture units with closed warm water system, in early fish fry rearing, hatcheries, trout farms, wintering ponds, net cages rearing and storage reservoirs.

2. Preventive Measures in Fish Health

2.1. Providing Water Sources Free of Pathogens

Underground waters are the most suitable water sources free of pathogens. These sources are limited both for trout farms and hatcheries and for other special fish culture units at present. All surface water may contain species of wild fish which can act as reservoirs of infectious diseases (Roberts, 1989). The surface water from rivers and channels is used as the source of inflow water in most cases. In these situations, suitable filters can partially reduce the numbers of invasion stages of parasites in inflow water, above all when supplying smaller reservoirs with intensive culture. Bars are usually placed before these filters to separate rough particles. Sand filters are consisted of a set of sedimentation divisions terminated by filter with fibre and sand. These type of filters catch above all the heavier parasite stages unable to move actively (e.g. spores). Lower efficiency is registered in elimination of moving parasites like e.g. infusorians (Tesarčík & Svobodová, 1991). The water from the pond with fish stock is quite unsuitable for these purposes (esp. as the source of inflow water for trout farms, hatcheries and units for early fish fry stages).

Chemical treatment of inflow water is an emergency arrangement with often undesirable parallel affects. Disinfection of the water entering fish culture units by UV radiation is an usual way can be considered as the simple method how to destroy viruses, bacteria and moulds germs. Since the inflow water from rivers and channels is slightly turbid and contents a number of suspended solids and dissolved compounds, the disinfective efficiency of UV radiation is markedly reduced in these situations (Liltved et al., 1995; Maisse et al., 1981; Kimura et al., 1976).

It is very profitable to supply the individual ponds and/or reservoirs independently, not throughflowly. The water from each pond or reservoir should be drained separately and should not flow into any other. Especially quarantine ponds and other reservoirs can be separated by this way.

2.2. Protection From the Transfer of Pathogens

This principle means above all the transfer of pathogens by uncontrolled transport of fish and spawns. The transport of fish with unknown health condition is to be avoided in principle. All transported fish are to be accompanied by veterinary certificate confirming that fish were examined before transporting them, they are healthy and originate from the environment in which no important transfer diseases appear. Some viral and bacterial diseases can be transfered also by spawns. Their transport must be completed by the same veterinary certificate like fish transport from this reason (FAO, 1988).

Eggs can act as an important vehicle for transmission of diseases from parent to offspring and between hatcheries because opportunistic pathogens may be present in epiflore of fish eggs. The surface disinfection of eggs reduces the probabilityof development of pathogens (Planas & Cunha, 1999). Disinfection of eyed rainbow trout eggs is important to reduce egg and fry mortalities by the reason of Flavobacterium psychrophilum (Rangdale et al., 1979). Egg can be disinfected by polyvinyl pyrolidone iodine or hydrogen peroxide. Both can be used 100 ppm for 10 minutes bath. However shouldbe neutralised with sodium thiosulphate if iodine used (Bruno, 1995).

Fish introduced from other territories must be subjected to quarantine for one year regardless if native or extraneous species. The duration of quarantine can be prolongated e.g. in the case of fish imported from abroad until the period of 3 years. Prolongated period of quarantine is of special importance especially in spawners predestined for further reproduction of imported species (Rosenthal, 1988).

The selfsustaining in stock production in individual farms and similar organizations is a significant way of prevention from dissemination of fish diseases. Only fish previously examined, free of diseases and relevantly treated by medicinal baths are to be stocked into ponds and fish culture units. The stocking of fry originating from semi-artificial and artificial spawning not contacted with fish of higher age categories also minimizes the danger of infection.

The prevention from introduction of coarse fish into ponds and fish culture units is the other important arrangement protecting the stock against transfer of pathogens. These fish are above all the source of ectoparasites, dangerous especially in the period of decreased resistence of fish. Except of this they can transfer also some other pathogens which can result in heavy losses in important fish species. Adequate bars and filters can serve for prevention from coarse fish penetration.

The protection of piscivorous birds to step into fish culture units (esp. trout farms) is the prevention limiting the expansion of some fish diseases as IPN (Wolf, 1988). Protective nets are used to prevent the birds from running in. The numbers of piscivorous birds are regulated in localities where overpopulated. Preventive control of snails (Lymnaea sp.) as intermediate hosts of some fish parasites can be performed by biological (introduction of black carp, Myelopharyngodon piceus or 3-years-old tench, Tinca tinca), mechanical (placing nets in the inflow), physical (drying and freezing of the bottom) and chemical (application of molluscocides) ways.

Safe and harmless removing of dead fish is a significant way how to prevent from further transfer of fish pathogens. Fresh or slightly decayed dead fish are decontaminated in the nearest veterinary facility. Lower masses of dead fish are to be burnt or burried into deep pits (aprox. 2 m) in distance of at least 20 m from the pond bank. The bottom of this pit and dead fish must be covered by burnt or chlorinated lime. The layer of at least 60 – 80 cm of the soil must cover the content of a pit (Tesarčík & Svobodová, 1991).

2.3. Responsible Movement of Live Aquatic Animals

Increased trade of live aquatic animals and the introduction of new species for farming, without proper quarantine and risk analysis in place, result in the further spread of diseases. A scientific process should be undertaken to assist decision making regarding the risks versus the benefits for the species intended to be imported. Such an import risk analysis includes hazard identification, risk assessment, risk management and risk communication (Rosenthal, 1988, Bondad-Reantaso et al., 2005).

2.4. Disinfection of Ponds, Fish Culture Units And Equipment

Disinfection is of a big importance in prevention and elimination of fish diseases. Preventive disinfection protects the fish stocks against pathogens. Hygiene of environmental conditions for fish is improved by this way. Focal disinfection is performed for control of the focus of dangerous fish disease.

Natural physical phenomena are fully used for disinfection in intensive fish culture due to their ecomical convenience. It concerns the drying and freezing of the pond bottom. The most of pathogens die after perfect drying of the pond bottom when its relative moisture had dropped on 10–15 %. The perfect freezing of the wet places and sun radiation (above all by its UV rays) have a very favourable effect in ponds. The influence of these natural physical phenomena is exploited by summer drying and winter freezing of water reservoirs (Tesarčík & Svobodová, 1991).

Chemical disinfection is an effective way of prevention from fish diseases. Usually accessible disinfective preparations are used in fish culture (e.g. burnt lime, chlorinated lime, nitrogen lime, natrium hydroxide, potassium permanganate, formaldehyde, chloramine, chlorseptol etc.). Burnt lime is mostly employed for disinfection of the bottom of ponds and reservoirs in the dose of 2.5–3 $t.ha^{-1}$, or chlorinated lime in the dose of 0.5 – 0.6 $t.ha^{-1}$. In case of myxosporoses, nitrogen lime (5 $t.ha^{-1}$, or 0.5 $kg.m^{-2}$) is to be applied. Immediately after fishing out the pond, the disinfection of fishing pit, pond ditches and muddy wet places is performed on large ponds where the whole-surface bottom disinfection is not possible. 5% water solution of formaldehyde, chlorinated lime (200 – 400 $mg.1^{-1}$), 0.5 % water solution of natrium hydroxide, Chloramine and chlorseptol (30 $g.1^{-1}$) or other disinfectants can be used for treatment of concrete channels, troughs and other arrangements employed for fish culture. The same disinfectants and concentrations are to be used for the treatment of the equipment. Potassium permanganate (5 g.l^{-1}) and other disinfectants can be also employed for these purposes (Bruno, 1995, De Kinkelin et al., 1985, Le Breton, 2003b).

2.5. Optimalization of Environmental Conditions

The optimalization of natural environmental conditions is the main pre-condition how to ensure the good health condition of stock during the rearing period. The following principles must be ensured. Optimal water quality without stressing physico-chemical effects. Keeping the oxygen concentration on optimal level and protection against water pollution are of special importance,(Tesarčík and Svobodová, 1991).

2.6. Good Husbandry Practices

Choosing the optimal fish density is important. Depending on the fish species and water quality conditions (especially the oxygen saturation of the water, there is a certain fish density that should not be exceeded. A common mistake is to increase the stocking density to compensate for a decrease in survival rate. This is a source of stress for the fish that can lead to skin injuries, low performance and a higher susceptibility to disease. In contrast, stocking fish optimally will allow fish to grow to their best potential and decrease the risk of disease outbreaks (Tan et al., 2006).

2.7. Good Feed Management

Fish should be fed with a balanced diet as nutritional deficiency can have an adverse impact on immunity and disease resistance. Dry pelleted feed adapted to each farmed species is preferred over trash fish as it gives a consistent supply of nutrients free from pathogens. Some international feed companies have invested a considerable amount of resources in the development and supply of nutritionally-balanced pelleted feed for marine and freshwater fish. A wider usage of pelleted diet should contribute to an increase of the overall health status of the fish, thereby reducing nutrition deficiencies and the risk of disease. At the farm, dry feed should be appropriately stored in a cool and ventilated environment to avoid moulding that could lead to mycotoxicity problems (Tan et al., 2006).

Live food as *Artemia*, Rotifer and algae are used to feed marine fish larvae. Improvement in live food culture trough the introduction of new techniques or products has also represented a major step. Bacteriostatic coumponds in *Artemia* culture enrichments represent a major help in controlling the level of hygiene and the development of bacterial flora in both live food culture and larval tanks. Bacterisid treatment such as formaldehyde can also be applied and eventually combined with probiotics to re-equilibrate the flora (Gatesoupe, 2002a). Trash fish bivalve mollusc, octopus, krill are used for feeding marine fish broodstock and some times for trout. It has been reported that IPN virus isolated from rotifer (Comps et al., 1990) and some bacteria have isolated from artemia. Ichthyophoniasis have reported by eating contaminated trash fish in rainbow trout (Holiman, 1993), cod, herring and sea bass (Bodatilla & Pellittero, 1990).

2.8. Regular Control of Health Condition And Preventive Treatment of Fish

Preventive control of health condition is to be carried out in hatcheries and early fry rearing units twice a week, and in highly productive intensificated ponds, trout farms and fish culture units with recycling water weekly. Other stocks (esp. in usual pond culture) are investigated monthly.

Health condition of fish is always to be controlled before fishing out, transporting fish and stocking. Preventive treatment can be suggested on the base of investigational results. This treatment is performed above all by the application of medicaments into the water environment and feeding by medicated feeds. During the past years, the use of immunostimulants in marine species production has increased (Sakai, 1999, Efthimiou, 1996) especially on larval and juvenil stages (Valdstein, 1997). Their indications in non-specific prevention are multiple: before handlng or stressful situation, to reduce the risk of mortality after transfer, for broodstock during the maturation period and to prepare fish for vaccination and increas their immun respponse.

2.9. Selection of Hatchery-Raised Fingerlings

The overall health status of fry and fingerlings is a critical factor for a successful production cycle. When choosing a species to be farmed, preference should be given to species that are already available from hatcheries. The attention given to fish in the hatchery, and the availability of specific larval diets required to obtain strong juveniles, will allow for a constant supply of good quality fingerlings (Tan et al., 2006).

2.10. To Minimize Stress

Stress can be defined as any stimulus (physical, chemical or environmental) which tends to disrupt homeostasis in an animal. Under stressful conditions, fish must expend more energy to maintain homeostasis and less energy to combat disease (Edmondson, 1991). Aquatic organisms are fundamentally different from terrestrial animals: they are immersed in their environment and can not go somewhere else. Some disease agents are almost always present in the water (Muroga et al., 1986). These opportunistic pathogens will invade fish when they become stressed.

Some good practices to reduce stress include:

a) Starvation before handling of fish: handling is a source of stress as it puts fish under extreme conditions (overcrowding, manipulation outside the water, etc.). Starving the fish for 24-48 hours prior to handling will reduce stress and will avoid the deterioration of water quality when fish are overcrowded.

b) Sedation during handling and transportation: in situations such as handling or transportation, fish are overcrowded. Therefore, there is a higher risk of skin injuries. To avoid such damage, sedation using approved fish anaesthetics/sedatives is recommended as it decreases the level of stress and possible skin injuries.

c) Grading of fish to give a homogeneous population: when size variation increases in a cage, it often creates competition between the larger and the smaller fish. This can result in stress, especially for the smaller fish. In addition, when feeding, the bigger fish are stronger and get more feed. As a consequence, the smaller fish get weaker and more susceptible to disease. As they get sick, they will also become a source of infection for bigger fish as size variation is also a source of cannibalism (leading to horizontal disease transmission).

d) To maintain good water quality: water quality should be monitored on a regular basis and be maintained at optimal conditions.

e) To avoid over-feeding: over-feeding can induce stress and unconsumed feed will pollute the water (Tesarčík & Svobodová, 1991).

2.11. Record Keeping And Disease Monitoring

Record keeping is crucial in understanding the epidemiology of diseases and can also allow us to identify critical management points in the production cycle. The collection of this historical data will help us take early action in the case of disease outbreaks. Often, in small scale operations, recording of farming parameters such as daily mortality, feed consumption, growth rate and water quality parameters is not standard (Tan et al., 2006).

2.12. Proper Disease Diagnosis – a Prerequisite for Effective Health Management

As aquatic animal health management is about implementation of control measures to prevent the incidence of diseases, it is a prerequisite to have a good understanding of diseases that might occur in a particular fish species. Therefore, adequate attention should be given to disease diagnosis and epidemiology studies. As an example, a disease investigation and epidemiology study over the last past 5 years in Asian seabass have allowed us to identify the most critical pathogens in this species (Grisez et al., 2005; Komar et al., 2005; Labrie et al., 2005a).

2.13. Vaccination, a Powerful Tool That Complements Other Health Management Practices

In Europe as in others countries such as North America, The legislative framework is being developed for the marketing of veterinary products, limiting the number of licensed products available for treatment in aquaculture. The increasing request of the consumers for quality products, the implementation of quality schemes and enviromental issues are pressuring the procuders to reduce the use of antibiotic in their production. For these main reasons, fish vaccinlogy is becoming a major issue and an alternative in Aquaculture Health Management (Le Breton, 2003a).

There are many problems associated with the use of antibiotics. In addition to developing antibiotic resistance, sick fish often do not eat and the efficiency of delivering antibiotics orally is often questionable (MacMillan, 2001; Smith et al., 1994). Two key technical comments should be made regarding antibiotics: 1) by nature they are active mainly against bacterial pathogens and have no direct effect against viral and other pathogens and 2) antibiotics work only as long as they are present in the appropriate concentration in the target organ. Whereas the use of antibiotics is a curative measure to treat an existing infection, in contrast, vaccination is a preventative measure, dependent on the immune system of the animal.

Vaccines can act against bacterial, viral and, at least experimentally, parasitic infections and they will usually act only against the targeted pathogens. The duration of protection obtained with vaccines normally largely exceeds that of antibiotics.

Vaccines are various preparations of antigens derived from specific pathogenic organisms that are rendered non-pathogenic. They stimulate the immune system and increase the resistance to disease from subsequent infection by the specific pathogen(s). Vaccination can be compared with an insurance policy - it is worth paying a basic fee for a policy that would later cover the costs of a more expensive disease that may occur. Similarly, vaccination is a preventive measure that protects fish against a future disease and the associated costs due to morbidity, mortality and therapeutic treatment (Ellis, 1988). However, just as an insurance policy will cover the costs of an accident only if this fits the clauses of the insurance contract, a vaccine (generally) only protects against specific diseases. For example, a vaccine against S. iniae infection will protect the vaccinated fish against this specific species of Streptococcus but not against another streptococcal species such as S. Agalactiae (Tan et al., 2006).

Specific, very effective way of prevention from diseases is the vaccination of fish. Vaccines against following relevant viral and bacterial diseases are recently tested with different success: CCV, IPN, SVC, VHS, IHN, furunculosis, ERM, and vibriosis (Le Breton, 2003). Individual vaccines are applied intraperitoneally, perorally or in the form of bath. Peroral application or bath are most suitable ways from the point of view of fish culture practice. Also vaccines against some other fish diseases including parasitoses are currently developed (Li and Woo, 1995).

However, it must be remembered that vaccination is only one of the tools for good health management and it is not sufficient on its own to guarantee high survival and profitability. All the measures mentioned previously are needed to sustain a successful aquaculture industry.

2.14. Applications of Therapeutic Substances

Fish are subjected to therapy in those cases when a disease is so developed that the life or performance of the fish is immediately endangered or expected to be endangered in the subsequent period. Therapeutic treatment should be regarded as emergency measure resorted to when prevention has failed. The therapeutic treatments may be as follows:

a. application of therapeutic substances and preparations to the aquatic environment (therapeutic baths for fish and eggs)
b. administration of therapeutic substances in feed
c. administration of therapeutic substances via a probe
d. administration of therapeutic substances by means of injections

Therapeutic substances are put into water to control ectoparasitic, fungal and bacterial diseases of the body surface and the gills. In some cases the therapeutic baths can also be used (after absorption of the active substances via the skin) for controlling the causative agents of internal diseases. According to the lenght of exposure, the therapeutic baths are subdivided as follows:

1. immersion baths (up to 5 minutes)
2. short-term baths (5 minutes to 2 hours)
3. long-term baths (2 hours to several days)

The long-term baths also include the treatment, with therapeutic substances, of whole fish culture reservoirs and ponds (Herman, 1972).

To perform the therapeutic baths effectively and to avoid losses of the fish, a number of general principles must be respected, including:

a) The state of health of the fish stock must be continuously monitored so that the most effective therapeutic bath can be promptly chosen and applied: fish in an advanced phase of a disease are exhausted and weak and can be easily killed by exposure to the drug in the bath.

b) The results of examination of the fish serve as a basis for determining the type of therapeutic bath. Most of the therapeutic preparations are toxic to the fish at higher concentrations, so the instructions have to be strictly adhered to. The substances and preparations used for the baths must be fresh, packed in original containers. The dose to be used in the bath must be accurately calculated to avoid poisoning the fish by overdosage, or to avoid a poor effect if the dose is too low.

c) Fresh and uncontaminated water must be used to prepare the solution for the bath. The physico-chemical characteristics (temperature, pH, concentration of organic substances, acid capacity etc.) of the water influence the effectiveness of the therapeutic substances and preparations and also their toxicity to the fish.

d) A tolerance test must have been conducted before any bath. The tolerance test is a bioassay on several fish to see the safety or harmfulness of the therapeutic bath for the fish stock to be treated under the existing conditions.

e) The therapeutic baths themselves are carried out in all-glass tanks, fibre-glass tubs, vats, fibre-glass plastic troughs, in concrete or earth storage basins or straight in the ponds. It is also possible to subject the fish to short-term therapeutic baths in the transport boxes during shipment if the shipment time is the same as, or shorter than, the recommended exposure time.

The fish should have been given no feed before an immersion bath or a short-term bath to avoid increased need for oxygen (for example, one to three feedings are skipped on the trout farms). Fish exposed to long-term baths, with several days' exposure times, have to be fed with supplementary feeds. Emergency scenarios must be prepared for the prevention of possible accidents: water aeration facilities must be ready for use, or precautions should be made for promptly removing the fish from the bath and putting them in fresh (preferably flowing) water, or an emergency inlet of clean and safe water must be available for fast dilution of the bath solution. The tanks or reservoirs with the therapeutic solutions should never be overstocked.

f) When the treatment is finished the fish should be removed from the bath and put into clean (preferably flowing) water. If the treatment was performed in a whole pond, the inlet source must be strong enough to allow for rapid dilution of the bath solution. All regulations and standards regarding surface water quality conservation must be respected in discharging the used therapeutic solution outside the fish culture facility. In the majority of cases the used solutions are disposed of outside the aquatic environment: for example, they are left to seep into the ground in places free of the danger of penetration into surface or underground waters.

g) The effectiveness of the therapeutic baths must be checked by macro- and microscopic examination of 5 fish at the minimum from each pond or tank after the rinsing of the treated fish in clean water. This must be done immediately after the bath, within one day of the termination of the bath at the latest.

h) It is a general principle that market fish should not be treated by therapeutic baths 14 days before shipment to the market.

i) All labour safety precautions must be taken during the treatment of fish by therapeutic baths (Tesarčík and Svobodová, 1991).

2.15. Using Chemicals/Antibiotics:

While under certain circumstances antibiotics can help to control some bacterial diseases, there are many problems associated with their use. Also, as sick fish do not eat, the efficiency of delivering antibiotics orally is often questionable.

Most countries have strict regulations on the use of antibiotics and chemicals. For example, malachite green, chloramphenicol and furazolidone are actually banned from use in most due to their teratogenic effects and severe measures are taken against exporters of fish and shellfish that contain residues (Alderman, 2003). Regulations on acceptable withdrawal periods must be adhered to.

Between species, differences exist in drug disposition and metabolite formation. Moreover, temperature and composition of the water (fresh/salt water, pH value, hardness, organic material content, etc.) may affect the absorption, distribution, metabolism and excretion of drugs. Per species, relevant pharmacokinetic data are often lacking. Therefore, extrapolation of data from one species to another is difficult (Intervet, 2003).

Changes in the taste of water caused by the addition of antibiotics can influence the intake of medicated feed negatively. Also, chemotherapeutics can negatively influence the immune system of fish (Grondel et al., 1987). Added to the water in recirculation systems (e.g., for eel, catfish and turbot), antibiotics may disturb the biological clearing systems and (bio)filters. Especially in aquaria, there is a risk of serious disturbance when antibiotics/biocides are not used properly. Added to the water, antibiotics can rapidly lead to induction of resistant bacterial strains. The following attention should be paid regarding the use of chemicals/antibiotics:

• Antibiotics should be used only as a last resort.

• Definite disease diagnosis, including antibiotic sensitivity, should be made before administering antibiotics.

• Observe the regulations on banned chemotherapeutants. Maximum residue limits and withdrawal periods should be considered before harvesting the fish.

• The tolerance of the species should be known. For safety reasons, always first try the chemical/antibiotic at a given dose and treatment time with a small number of fish. Fish of different species and sizes under different water conditions (salinity, alkalinity and temperature) may well react differently. In general, lower water temperature requires a longer treatment duration and vice versa.

• Follow the correct dose and treatment time. Pay close attention to concentration of the active ingredient and adjust the dose accordingly if the chemical is not pure (< 100% active).

• If using an immersion approach, add the chemical/antibiotic to a small portion of the water in a small container and make sure it is dissolved completely before use. Then pour this 'concentrate' into a tank/container to reach the desired final concentration and mix well before placing the fish into it.

• Withhold feed for 8-24 hours depending on the fish size.
• Treat during the coolest part of the day.
• Monitor water oxygen levels before, during and after treatment; if necessary, aerate as required.
• Keep a close watch on the fish during treatment and be prepared to stop treatment immediately if adverse reactions (e.g., gasping for air, strange swimming behaviour,etc.) are noted.
• In some cases, such as the occurrence of a serious disease problem, eradication should be considered. Eradication includes removal of all susceptible species followed by thorough cleaning and disinfection of the cages/nets or ponds (Herwig, 1979).

3. Conclusion

In conclusion, some of the practices recommended for the fish farming industry for disease control are :

- Protect from the transfer of pathogens
- Control live aquatic animals movements
- Select hatchery-raised fingerlings
- Quarantine incoming animals
- Use pathogen free formulated pelleted feed
- Disinfect the ponds, fish culture units and equipment
- Monitor water quality
- Optimize environmental conditions
- Good husbandry practices
- Grade fish periodically
- Control the health condition regularly
- Minimize stress
- Record disease monitoring
- Remove dead fish at least once a day
- Diagnose the diseases
- Vaccinate the fish
- Applicate therapeutic substances properly)

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