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MAINTAINING OF GOOD WATER QUALITY – A PREREQUISITE FOR HEALTHY FARMED FISH

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Abstract. Water quality is one of the key factors in maintenance of fish health. The current article revises the effects of various water quality parameters on fish health, methods of quality analysis and diagnosis of fish health, as well as methods for improving the water quality in fish ponds, aiming to reduce the fish health risks. The synthesis is a joint work of an international consortium formed from scientists of the Institute of Zoology and Ion Ionescu de la Brad Iasi University of Life Sciences, which allows a broader view on the fish health issue for identification of sustainable solutions for fish farmers from the Republic of Moldova and Romania.

Introduction

Maintaining of a good water quality is an important prerequisite for successful aquaculture. A range of water parameters such as water temperature, oxygen saturation, pH, carbon dioxide, ammonium nitrogen, specific pollutants (e.g. pesticides, herbicides, heavy metals, chlorine derivatives, petroleum products etc.) can harm fish in various ways – from physical damage of skin (erosion), gills and internal organs to functional alterations, such as the lower metabolism and ventilation rates, change in circulatory parameters, influence on immune system, which increase their susceptibility to diseases. In addition, some farm management practices, such as improper feed quality and quantities, excessive fertilization or stock density and inappropriate stocking time can also contribute to worsening of the water quality and fish health. For example, feeding fish on high lipid content commercial feed may lead to accumulation of fat in their bodies and, consequently, to bioaccumulation of many toxic pollutants, e.g. PCBs [4, 5].

Thus, periodic investigation of water quality parameters and also of the health status of fish may prevent significant production losses in fish ponds. Measurements of the hydrobiological and hydrochemical conditions along with the fish health status at different production stages or when major fish health issues are encountered are extremely important. The current article made a synthesis of methods for water quality analysis and diagnosis of fish health, various quality parameters affecting fish health, as well as fish pond management measures for ensuring a good water quality for an adequate fish health.

Materials and methods

The diagnosis of fish health status is a rather difficult task, since the fish and water are not sampled during the same period of time when the pollution occurred. Hence, it is necessary to use all the available farm information and relevant field and laboratory analysis to detect the cause of the harm to fish and, where appropriate, to aquatic invertebrates, which provide fish food resources but, also, contribute to the maintenance of the fish ponds. The field investigations shall involve firstly an assessment of previous records of factors, which might have produced the changes at ecosystem level, and recent main factors, responsible for impoverishment of water quality and fish health status. The next steps are to perform the necessary physico-chemical and hydrobiological analyses of the water. If necessary, the bottom sediments, periphyton and then the fish themselves should be examined. Compared to other animal species examined when necessary, fish require little visible contact with the examiner. Thus, specific fishing techniques are required for direct examination of catches, from which fish with an apparent phenotypic pathology or lethargic fish are selected. The examination is based on a detailed history, direct clinical examination, necropsy examination and laboratory examination.

For assessment of the water quality, samples shall be collected for hydrochemical analysis (some measurements are carried out *in situ*, e.g. O2, temperature, pH, transparency, conductivity etc). To have a complete picture, the status of the zooplankton, phytoplankton and benthic communities shall also be assessed.

Besides chemical and hydrobiological analysis, it is important to obtain information from the fish farmers. In order to establish a dialogue, an appropriate simple language shall be used, without the use of scientific or technical terms. The clinical interrogation does not have to be an indictment aimed at discovering the guilt of fish farmer or pond owner. Collateral questions can be used to discover errors in technological exploitation, because there is a tendency to overlook these mistakes. It is important to get information on the used feed supplements (such as vitamins, antiseptics), other substances added to water (lime-based preparations, drugs etc.).

Field examination includes direct observation (inspection) of fish in the water body, in the net or on the shore. Biometric and weight measurements data shall be collected. Fish movements need to be observed as well, in order to register if there are any exaggerated or apathetic swimming movements. Under some stressful conditions, fish may even jump out of the water or swim in a circle or in a spiral. The intense decrease of dissolved oxygen or the diseases accompanied by respiratory disorders, most often associated with gill injuries, will cause prolonged swimming at the water surface or swimming with open mouth. Some disorders may cause swimming in a lateral direction. The examination of the body shape and dimensions, tone and vigour of the movements, appearance of the body surface, fins, scales, gills and eyes can be examined in the field, but also examined more thoroughly in the laboratory, where the presence of wounds, macroscopic parasites, pigmented spots, tumours, edema need can be evaluated. Hand magnifiers may also be used for inspection.

Within the framework of the on-going project 2 SOFT/1.2/47 Team up for healthy fish in aquaculture systems in the Prut River basin - HealthyFish (Joint Operational Program Ro-

mania-Republic of Moldova 2014-2020, funded by the European Union), a joint expedition was carried out with the participation of researchers from the Institute of Zoology and the Ion Ionescu de la Brad Iasi University of Life Sciences. The expedition was focused on fish farm Rompescaris SRL (Podu-Iloaiei, Iaşi county) and S.C. Piscicola S.A. - Drăcşani fish farm (Botoşani county) (Figure1).

Figure 1. a) Joint field trip carried out by the team members of the Institute of Zoology and- "Ion Ionescu de la Brad" Iasi University of Life Sciences at fish farms in Romania, on 25 of May, 2021; b) knowledge sharing between researchers and farmers regarding fish infestation

Researchers and farmers discussed in detail the problems faced by fish farmers and ways to solve them. Hydrochemical, hydrobiological, ichthyological and ichthyoparasitological samples were collected. Some investigations were performed *in situ*, for example, pH, Eh, O2, N-NH4+, N-NO2-, N-NO3-, mineral phosphorus, conductivity, etc. Fish health was also analysed primarily under field conditions.

Results and discussions

Water temperature and its oxygen saturation are among the monitored parameters of water quality in fish growth. These factors, along with the synergistic effect of other coexisting stressful conditions lead to various problems such as discomfort to the fish, disease prevalence and in the worst case – to mass deaths. For example, the change of water temperature can lead to intensification of the metabolic rate of fish, as fish requires more energy to cope with the increased water temperature. Temperature increase also intensifies organic pollution of water, which, in turn, leads to a decrease in the content of dissolved oxygen and, as a consequence, creates a favourable environment for the growth of pathogenic bacteria and parasite invasions [2, 3]. Favourable thermal water conditions for carp vary from 0-1° C to 25° C. Above this value fish usually dies, this being also determined by the lack of oxygen, which correlates with the water temperature. Sharp changes with 10-15° C cause shock to large fish, loss of balance, inactivity, stopping of movement of the gills and finally – suffocation. Young fish are more tolerant, but larvae or juveniles, on the contrary, are more sensitive, as only a small difference of 1-2° C can lead to significant physiological changes or even perishment of larvae.

Oxygen saturation of water is a major factor in fish health. Carp can tolerate low concen-

trations of oxygen in the water, but such species as perch as pike, vice versa, are sensitive to oxygen deficiency. The lowest critical oxygen level in carp ponds is approximately of 3-4 mg/L. Some signs of severe oxygen deficiency are the death of fish with open mouths and gills, enlargement and redness of the lower lip. In addition, if the pH is too low or too high, damages may also occur, with haemorrhages of the gills and on the lower part of the body. Also research showed that low pH levels can facilitate the metal release from rocks and sediments, which can affect the metabolism of fish and its ability to take up water through the gills [2, 5, 7].

A consequence of the decrease in the amount of dissolved oxygen is the excessive development of cyanophyta algae caused by excess of nutrients. Algal bloom is one of the main causes of the mass perishing of such species as carp, silver carp, bighead carp, grass carp, pikeperch, catfish, crucian carp. Some fish species are even able to accumulate their toxins throughout life through bioaccumulation, thus posing a risk to consumers [2, 7]. Fish death is also often caused by the rapid decay of aquatic vegetation, which contributes to oxygen deficiency and the formation of hydrogen sulphide (H2S), which becomes dangerous at a concentration of 1-10 mg/L. Presence of toxic substances in water may cause poisoning and considerable losses to farmed fish. In spite of the protection ensured by the tough epithelium, scales and secreted mucus, some toxic substances can cause lesions to the tegument, the fins and also damage the ability to secrete mucus and control internal osmotic pressure [2, 5]. Such toxic compounds as heavy metals, chlorine derivatives, pesticides, petroleum products may damage not only the skin, but also internal organs, e.g. liver, thus increasing the susceptibility of fish to disease. Contamination with heavy metals with bioaccumulation properties (accumulation in food chains), such as mercury, even at low concentrations can often cause various diseases not only to fish, but also to consumers of fish products, including humans. Intensive feeding on lipid rich feed will accelerate this process, as fish body fat will accumulate toxins [5]. Also phenol and pesticides, along with chlorine derivatives, even at small concentrations can cause disorders of the nervous system of fish and liver degeneration. Among the most harmful compounds, which are used as insecticides in agriculture, are those containing mercury or gamma-hexachlorocyclohexane (gamma-HCH), as they may accumulate in the muscles of fish, becoming in this way highly toxic to humans.Various components of agricultural waste, as well as organic waste resulting from animal husbandry can cause toxicity in fish and increase the incidence of various diseases. Excessive organic fertilizers can lead to direct damage to fish epithelium. Lime used in water disinfection increases the pH of the water and can influence /damage to the respiratory epithelium of fish.Free ammonia (NH3) and ammonium ions (NH4+) are among the most common toxic substances, the source of which is the breakdown of protein substances and urine or their penetration into sewage from fertilized agricultural lands. Ammonia usually causes problems for intensive farming systems, especially recirculatory ones [1, 5]. Fish may tolerate concentrations of up to 5-10 mg/L of total ammonia in neutral water (pH 7), but in alkaline waters (pH>7) already an amount of 0.2-0.5 mg/L causes convulsions in fish and bleeding of gills. The first signs of ammonia toxicity in fish include a slight restlessness and increased rate of respiration. Fish usually congregate close to the water surface. In later stages, with intensification of

ammonia toxicity, fish gasp for air, their restlessness increases with rapid movements and respiration becomes irregular, then a stage of intense activity follows. In the worst cases, the fish can lose their balance, leap out of the water, affected fish lie on their side and spasmodically open widely their mouths and gill opercula [2, 5, 7]. Intensive feeding with a high nitrogen diet may lead to ammonia poisoning, which in combination with other additional stresses, e.g. an abrupt oxygen deficit, or sudden changes in water temperature, may also worsen the fish health status.Along with pollution, poor maintenance of fish pond such as periodic disinfection for algal control, low water level, too high stocking density of reared fish, poor quality or excessive feeding are common causes, which lead to a decrease in water quality, but also in the health status of fish. Some feed supplements, e.g. excess quantity of molasses, feed covered with mold and remnants of fermented agricultural waste may have a negative impact on fish health due to formation of toxic compounds (amines and peroxides), which alter the intestinal bacterial flora. Overcrowding of fry and fingerlings coupled with low oxygen level can lead to quick spread of parasitic diseases, while improper temperatures, nutritional imbalances, chronic exposure to toxic substances, including PCBs, or to high content of suspended solids (200-300 mg/L) can lead to development of the spring viremia and tail rot infections [1-2].This, an optimization of water quality conditions along proper control of feeding of fish are important prerequisites for ensuring a healthy state of fish stock. Also stocking the ponds with the right number of fish and at the right time in the spring are other important preventive measures.Combating the algal blooms is sometimes difficult, because some resistant forms of cyanobacteria, once propagated in the fish ponds, are able to survive for many years in the bottom sediments. Treatment with slaked lime or chlorination of sediments of the fish pond in question (after removing the fish from it), in which a significant amount of cyanobacteria has developed, is very important, even if it is known that many useful organisms will also be destroyed as well. The extent of the phenomenon depends directly on the amount of nutrients in the water and the thermal regime of the fish pond, therefore, in order to prevent or reduce the intensity of algal bloom, it is important to reduce the amount of nutrients that fall into it. The natural food, made up of detritus, bacterial colonies, aquatic plants, plankton, benthos, insects and their larvae, is extremely important, as a source of protein in the diet of fish, which would otherwise be provided exclusively by fishmeal, more expensive or by a number of components of animal or vegetable origin, often incomplete in relation to the fish requirements.In the larval or brood stage, micro-algae are used as food, especially the green ones, and often the aquatic crustacean *Artemia salina*. This species lives in saline watersheds and feeds on diatoms and green algae. The production of natural nutrients in ponds can be maintained by applying various mineral and organic fertilizers (including organic and agricultural animal waste). These products increase the primary phytoplankton production and the production of bacteria, which represent an important food source for invertebrates. Some species of bacteria and most invertebrates are the main source of protein in the nutrition of high-energy pond fish to maintain optimal growth. Thus, the natural basis of fish feed is an important factor in the efficient feeding of fish. During the summer growing season, the full value of the ration is obtained by increasing the amount of natural food in the pond. Formulas

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for calculation of quantitative indicators of the natural feed base for different fish farming areas are available [8-11]. Based on the available quantitative indicators of the natural food base in reservoirs, the trophic potential or food base of the water body is calculated. For example, it has been shown that for breeders and remontants of carp, natural feed should form 75-80% of the total feed, for two-year-old fish - 40-50%, and for one-year-old fingerlings - 25-30% [4-7].

For increasing in the resistance and tolerance of the nutritive basis of fish, the trace elements can be used [6]. The permanent monitoring of the hydrochemical regime, particularly of the water temperature, oxygen and nutrient level, as well as of phytoplankton, zooplankton and zoobenthos communities will allow taking appropriate measures in the right time to avoid fish production losses.

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