AQUACULTURE PRODUCTION AND ITS IMPACT OF THE ENVIRONMENT IN REPUBLIC OF MACEDONIA

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Abstract: Fishery as a commercial activity in the Republic of Macedonia has a long tradition, especially characteristic for fish hunting of the three natural lakes (Ohrid, Prespa and Dojran Lake). Since the beginning of the 1960's and the construction of warm water aquaculture in Bitola, Bukri and Bel Kamen, as well as cold water fishponds in Gostivar, Vrutok and Banjica, begins the era of aquaculture production of cyprinid and salmonid fish species in Macedonia. The last 10-15 years of the 21th century are characteristic of the accelerated pace of the development of aquaculture production and construction of trout fish farms and cage farms on artificial reservoirs. Such construction at an accelerated pace and spontaneously, without greater control and prescribed standards for environmental protection will result in disruption of the ecological balance in the water ecosystems. Attention in the future should be directed towards the protection of the environment, as well as, proper and controlled development of aquaculture production.
New scientific experiences shown that with the intensification of fish production, significant changes in the biophysical and chemical characteristics of the aquatic environment are possible.
The trout production for its development requires natural sources, clean and clear waters, with constant temperature, proper biophysical and chemical characteristics of the aquatic environment in which production is achieved.
Warm water fish species require quality agricultural areas and quality water that is less available.
The limited production conditions in terms of quality water and arable agricultural land will force to introduce modern technical and biotechnical solutions for increasing the fish production in the existing built capacities, i.e. its intensification.
Restrictions and stricter norms for new fish farms of existing watercourses where fish farms are built will result in intensification of aquaculture production in existing farms, from which it is quite normal to expect better productive effects, economic effects, but also significantly greater impact on the ecological environment - water ecosystems in Macedonia.
Keywords: aquaculture, environment

1. INTRODUCTION

Nowadays, aquaculture production in the Republic of Macedonia represents fish farms – warm water aquaculture producing cyprinid fish species and classical cold water fishponds, in which rainbow trout is mainly produced, as well as smaller quantities of brown trout, brook trout and autochthonous Ohrid trout. From the beginning of the twenty-first century there has been considerable progress in the construction of cages farms intended primarily for growing carp in artificial reservoirs, as well as cage farms for growing rainbow trout.

The natural resources of healthy and clean water in our country are limited, and the demand for fish on the market is higher, due to which fish producers will be forced to turn to intensification of production and finding solutions for utilization of unused water ecosystems such as natural lakes and artificial reservoirs through the introduction of modern systems for production of cage systems.

The classic way of production in warm water aquaculture in our country is realized in total of 625 ha area, with production of about 850 - 1200 kg/ha. The cage production of warm water fish species achieves production of about 25kg/m^3/cage area. The trout production is realized at about 4.5 ha area, with an average production of 25 - 50 kg/m^2 and 250.000 - 500.000 kg/ha.

Limited natural resources will inevitably lead to intensification of fish production in order to meet the growing market needs for fish, thereby increasing the effect of emission of a larger amount of organic matter in the aquatic environment.

2. INFLUENCE OF AQUACULTURE ON THE WATER QUALITY

Many scientific studies point to the dangers of water eutrophication as a "biological" consequence of the enrichment of water with organic matter, which will be manifested in the change of aquatic biomass, as well as the structure of the animal communities. Such harmful effects on the aquatic environment as a result of the intensification of aquacultural production can be prevented and minimized by applying:

- Good manufacturing practice;

- Successful management;
- Application of new technical - technological solutions in fish farming.

Such measures should contribute to reducing the emissions of organic waste into the aquatic environment which will contribute to maintaining the quality of the aquatic environment in the fish farm itself and the water quality of the free watercourses or aquatic ecosystems in which the waters are released or the fish are grown. In addition to such technical - technological solutions in aquaculture production, it is necessary to establish full monitoring on whose data there will be appropriate legal solutions for regulating the emission of the maximum permitted fish breeding grounds and their harmful effects on the environment.

Harmful effects on aquatic recipients stems are from direct consequence of:

1. Fish production in fish farms

Fish breeders, limited by spatial possibilities, will endeavor to increase the fish production in existing spaces by applying novelties in the production technology, i.e. applying new intensive methods in breeding such as:

- biological – genetic methods;
- application of new technical - technological solutions in order to achieve maximum production effects per unit production area.

This way of intensification in aquaculture production will result in increased fish production per unit area for several times of the current production, and such increased production will require intensive fish nutrition, so it is normal to expect increased emissions of organic matter in water, whereby the presence of N and P, as well as CO_2 in the water in which the fish are grown, but also in the direct water recipients in which the outflows of the salmonid fishponds or direct emissions from cage system production.

Most recent studies show that great amount of the organic C in aerobic conditions, about 50% of organic biomass is incorporated into the bacterial flora and the rest in CO_2. With a high concentration of oxygen, the decomposition of organic matter can be very effective, so mineralized nutrients rapidly entering the trophic chain.

Organic N is an incentive for the nitrification process as a result of the action of heterotrophic bacteria that increase the ammonia intake, whose presence in the water is the result of breeding activities in the aquaculture. The joint influence of N and P in the aquatic environment is manifested by the eutrophication of the ecosystem.

Water is the primary carrier of oxygen, food and metabolic waste. The concentration of oxygen in the water depends primarily on the water temperature, the altitude, the amount of fish and the amount of organic matter in the water. Depending on the manner of fish breeding and the organization of production (traditionally or intensively), the emission of waste organic matter from fish farms in the aquatic environment is the result of non-consumed food and fish waste (feces), as well as, extinct phyto and zoo plankton, died fish etc., especially in warm water aquaculture.

If the water transparency in these fish farms is reduced, it leads to a higher concentration of ammonia, which in conditions of high temperatures and increased pH appears in the toxic form. The water environment, unlike the atmosphere, is far poorer with oxygen. The oxygen content of the water is about one hundred thousand times smaller than the oxygen content of the air. The oxygen content in the water is 10 g/t water, while the oxygen content in the air is 200 kg/t air.

The increased amount of organic matter in the water largely poses a danger to the level of oxygen in a given aquatic ecosystem in which fish are grown, but also a significant problem for the environment in which fish and other aquatic organisms live freely.

The bacterial activity of heterotrophic bacteria results in the production of inorganic nitrogen and phosphorus compounds, as well as, CO2.

Under aerobic conditions with the help of the self-trophic nitrifying bacteria, the ammonia is transformed into nitrites, then in nitrate form and together with the carbon is involved in the complex food chain and the assimilation process.

Fish, crabs and shells are heterotrophic organisms that satisfy their nutritional needs and energy for life and growth by feeding with quality foods.

The nutritional needs for optimal growth consist of balanced nutrient requirements (proteins, fats, carbohydrates, minerals and vitamins). Fish compared to terrestrial animals have specific nutritional characteristics and energy needs to satisfy life functions. The fish are poikilothermic organisms, so their energy needs are ten times smaller than the energy needs of mammals (homoeothermic). They have to maintain the body temperature at a constant high level. This characteristic is an advantage in the protection of the environment for the simple reason that with lower food consumption obtains a kilogram fish meat growth.

Food and nutritional requirements depend on age and individual weight. For example: for 1000 numbers of five grams trout, the energy needs for growth are twice bigger than the energy needs of five individuals with weight of one kg.

The incorporation of one part of digestible units into muscle tissue is accompanied by an increase in total biomass (anabolism) while the rest is transformed into heat and secretions (catabolism). A number of scientific studies have suggested that only a small proportion (about 20%) of the food introduced N and P are implanted in tissue, so that a significant portion ends up in the water.

During the fish breeding, the following waste materials prevail:
- non eaten food, as a result of bad zoo- technical procedures, disease or bad environmental conditions;
- not digested food that ends in the feces, and is a result of a more nutritious diet that is much larger than the metabolic needs of the fish, especially in salmonid production and the application of nutrition ad libidum, often ends with overeating and accelerated peristalsis of the digestive tract, producing organically rich feces as a result of undigested food in it.

Fish excretory products distinguish in the aquatic environment through the gills and kidneys, and these are often toxic compounds such as NH_3 and CO_2, while the organic matter for its demineralization mainly requires oxygen, reducing its level in water, which also lead to reducing the amount of oxygen required for fish and other aquatic organisms.

The changes in the quality properties of water as a result of the organic substances in it are manifested by decreasing the concentration of oxygen in the water, which are especially emphasized in the reduced water change, poor flow in the flowing fishponds, which will cause problems in the fish breeding and will be manifested by poor metabolism, poor growth, weekness or in the worst case, fish mortality as a result of oxygen deficiency. Aquatic organisms that live freely in the aquatic ecosystem leave the such poor oxygen-rich waters and are settled in areas suitable for their survival.

Waste in an extensive way of fish breeding generally does not pose a threat to the environment or water ecosystems. Wastes from the extensive way of fish breeding are mainly biological components (proteins, fats and carbohydrates). With the mineralization of these organic compounds sedimentation particles are formed which are mainly dispersed through the water column and directly enter the fishery feeding chain (fish, bacteria, benthic organisms).

2. Organic waste and their impact on the environment

Fish breeding facilities (fishponds, cage farms) produce organic waste containing organic matter, derived from residues of unoccupied foods, feces, metabolic products, death fish, etc., which have a significant impact on the environment. The level of environmental changes is different from minimal to significantly depending on:

• The size of the farm;
• The density of planting.
• Biophysical conditions of location.
• Quality and digestibility of food.
• Water temperature.
• Photo - synthetic capacity of the eco system.
• Other anthropogenic impacts on the environment.

Negative impacts in salmonid fishponds are more pronounced if the amount of water that fishery farms provide is minimal, as well as, with small flows and minimal water changes. In such cases often it can lead to reduced oxygen concentrations in the outgoing water leaving the fish farm and to larger contents of nitrogenous, phosphoric and hydrocarbon compounds that will affect the physical and chemical characteristics of the water in the open ecosystem.

The fish breeding in strictly controlled conditions and the application of modern technical and technological solutions in the breeding has almost no harmful consequences on their populations in open waters, but has seen positive impacts on its natural development. There is an undivided positive view that fish farms traditionally have a positive impact on the ichthyo-population in open waters. It is assumed that in oligotrophic waters where conditions of low natural production prevail, the cage system of fish breeding positively influences the development of the natural ichthyofauna (Machias et al. 2005), manifesting itself with greater success at the coastal fishing, increased development of phyto and zoo plankton, food for natural ichthyofauna etc.

The increased development of phyto-plankton significantly affects the reduction of the amount of P in the water because it is incorporated into phytoplankton organisms (Yucel-Gier et al. 2008).

Although there are positive impacts on natural ichthyofauna, however, it should be extremely careful about the impact of ecosystems from fish breeding. Biological water treatment and the possibilities for its regeneration from such influences should always be considered.

Depending on the impact of aquaculture production, the full equipage of the given ecosystem is established within a few months to a few years from the cessation of the functioning of the fish breeding facility, depending on the size of the fish farm and its production, or the technology of operation. In any case, attention to environmental protection should always be at a satisfactory height to avoid the harmful consequences.

There are a number of scientific and expert assessments related to the impacts of aquaculture and their reduction in the environment. Recommendations aimed at protecting the environment from the impact of aquaculture production are directed towards the fishponds and cage systems, in undertaking specific measures, which are:

- Biological measures;
- Zootechnical measures;
- Good management practice;
- Innovative technical and technological measures.

Biological measures consist of selection of fish species that have a faster growth and better food conversion. The zootechnical measures are aimed at the correct selection and proper regulation of the daily fish feeding, which will enable the smallest breakage of feed and will not allow overeating of the fish.

Proper and good management practice consists in the coordination and full harmonization of the previous two measures and of course the tehnical and technological solutions with the only goal of good and economical production and full protection of the ecosystem in which the fish are grown.

The technical and technological solutions are focused on the selection of the location and harmonization of the production capacity with the characteristics of the aquatic recipient, its possibilities for biological self-purification of water and the modern zoo technical characteristics of fish farming, integrated poly cultural fish breeding with different nutritional needs is a prerequisite for reducing the risk of water eutrophication.

Water soluble wastes (NH_4 and P) from fishponds and cage systems can be successfully reduced or completely eliminated by breeding shellfish organisms or water plants, such as practice in Asian countries. The application of a poly cultural model of production is a set of organisms with different nutritional needs and habits living in different ecological niches in the integrated ecosystem. In order to reduce the emission of harmful organic effects on the environment, it is necessary to take into account the quantity and quality of the food used. The emission of organic matter in the environment depends primarily on the composition of food and feeding. These are the main factors that influence environmental change, but they are also the main factors affecting the economy of production. The food need for a kilogram of fish (conversion) is considerably more favorable in the diet with highly concentrated fully balanced industrial prepared (extruded) food. FC ranges from 1.0 - 1.5 for most fish. By using high quality and environmentally friendly foods in the salmonid species, the conversion is within the range of about 1.0 kg or under 1.0 kg.

In the fish production process, the correct determination of the daily meal has significant influence, in order to reduce the impact of slag. The amount of food that is characterized as a slag of non-eaten food due to poor and irregular management ranges from 5 - 10%, which is primarily a significant economic loss, but also a high risk percentage of environmental pollution. The percentage of slag as a reason from overeating fish and ejection of food as an undigested part in the feces can reach a high level of 15 - 20%, as a result of poor estimation and bad zoo technical measures. All of these aspects are a sufficient indicator of the correct selection of foods for feeding fish, proper regulation of daily rations in order to use the given food to the maximum, as well as the selection of the most favorable food that will have the most favorable conversion and the smallest emission of N and P in the water. It is a prerequisite for economical production and a clean environment.

Great impact on environmental protection on the one hand and production economics on the other hand can be achieved by educating the technical staff (growers) in the direct fish production in order to optimally harmonize the fish diet with the ecological characteristics of the water and the entire biorhythm of the fish.

When raising trout, one kilogram of quality dry pelleted food can give one kilogram of fish meat growth, as well as 100 - 200 g feces (wet mass).

The feces contains a large amount of C, 60 - 70% from the introduced, 10 - 15% N and 40 - 50% P from the digestible, which largely depends on the quality of the food consumed. Today's foods intended for trout feeding are highly environmentally friendly foods that take care of the emission of nitrogen and phosphorus in the trout-producing waters.

Nitrogen (N) is a basic element for building muscle mass (tissue) in fish, while phosphorus (P) enters the formation of bone tissue. These two elements are nutrients for plants and algae in rivers and lakes, and therefore these are regarded as contaminants.

The best food conversion will have the smallest impact on the environment.The average quantity of N and P that is discharged from the fish is different and depends mainly on the quality of the food consumed, the category of fish, the quality and quantity of water that provides the fishpond, the amount of oxygen in the water, as well as the manner of feeding and the determination of the daily meal. With today's foods used for trout feeding it can be said that N retention is within the range of about 30g per kg of trout produced and about 3.5g P at a conversion of 1.0 kg food (Katavic, 2003).

Eg: Feed (Aller aqua – Denmark) intended for feeding rainbow trout with average protein content of 45% and a conversion of 1.0 kg (according to the production declaration) emits 27.5 kg N soluble in water and 4.8 kg N bound to fish feces, as well as 0.7 kg P soluble in water and 2.4 kg P bound to fish feces, at 1000 kg produced fish.

The emission of N in the environment can easily be calculated using the following formula:

$$Nw = (Hk \times Nh) – (1000 \times Nm)$$

N - content of N in aquatic environment
Hk - feed conversion
Nh - content of N in food
1000 kg produced fish
Nm - content of N in fish meat (around 3.0 %)

Danish food Aller sapphire according to the production declaration contains 7.91 % N in food. The prescribed conversion is 1.1 kg. In this case, the emission of N in the aquatic environment would be the following:

$$Nw = (1100 \times 0.0791) - (1000 \times 0.03)$$

$$Nw = 57.01 \text{ kg}$$

The calculation of the P emission is performed by the same mathematical procedure as the N emission. The content of P in fish meat and the bone skeleton is estimated at about 1.4%, while the content of P in trout feed is about 2.1%, with a conversion of 1.1 kg (according to the Danish food production specification). In this case the calculation is as follows:

$$Pw = (1100 \times 0.021) – (1000 \times 0.014) = 9.1 \text{ kg P}$$

According Neori (1991), in the metabolism of organic substances from consumed foods in cage system farming of sea fish species and 90% used of the given food meal at 10% food slag, the emission of metabolites would be: 44% C, 7.1% N and 0.8 - 1% P. About 20% of C, 25% N and about 25 - 40% P are used mostly for bone tissue, from nutrients of consumed food.

Carnivorous fish species easily digest fats, but their molecules have great influence on the environment due to the C content of the metabolites and oxidation requires large amounts of oxygen.

Summed scientific knowledge of the impact of aquaculture production on the environment is assessed through the emission of N which is about 9%, while the impact assessed through the emission of P is about 3% of the total anthropogenic emissions of wastes in the aquatic environment.

3. DISCUCCION

The impact of trout production on the environment may have a certain impact on the change in the quality of the effluent as a result of the presence of organic matter (excrement) in the water leaving the fishponds. Such impact on the environment can be minimized if specific technical and technological measures are taken that should be directed to the protection of the aquatic environment. Preparation of spatial plans for the construction of fish farms on aquatic ecosystems (streams, rivers, artificial reservoirs and natural lakes), where the advantage will be given to fish production in accordance with environmental standards and water protection, on the one hand, and autochthon species in the aquatic recipient, on the other hand. All of this can be achieved and a balance of satisfactory level and unhindered economic development can be established if attention is paid to the following protective measures:

- Construction of solid waste (feces) retention tanks;
- Control of the construction of fishponds on one watercourse;
- Nutrition of fish with quality concentrated foods in which the content of nitrogen and phosphorus is at an ecological level;
- Proper diet of fish with a precisely determined amount of foods adjusted to the increase in fish and the best conversion coefficient of food;
- Release of the outgoing water in the aqueous recipient with a satisfactory oxygen concentration of 7.0 mg / l;
- Education of the labor that manipulates fish production.

In the recent history of the operation of fish farms, a number of irregularities have been noted that have led to pollution of the waters as a result of inadequate care for the environment. One such example is the production of trout in Denmark. The problem with the pollution of flowing waters in Denmark can serve as an example for us in taking measures for protection against water pollution. The regulation from the Danish government regulates the construction of fish farms according to the natural possibilities of water, and regulates the production of fish in the existing fish farms to the extent that it can be. The main limiting factor of fish production was put on the fish diet and what type of food would be used for trout feeding in line with biochemical oxygen demand for fish breeding in all Danish fish farms. It was established exactly prescribing for the quantity of food used by the fish farmers. This type of food shortage has forced both interested fish producers and food producers to seek solutions to improve food quality and the ability to reduce food demand for a kilogram of fish meat growth and a lower emission of harmful substances in the aquatic environment, without drastically reducing the production of fish in fish farms.

We have a similar situation now in our country where fish farms are built and cages are located in artificial reservoirs without greater control over the consequences of the production itself and the water ecosystems.

4. CONCLUSION

Aquaculture production in the Republic of Macedonia will have to take place under strictly controlled conditions and prescribed monitoring for the protection of the aquatic environment by the competent institutions and scientific research institutions which rules will be adhered by the fish producers, with main purpose of protection the environment and the smooth production and livelihood of producers. All this will be achieved by joint efforts and adherence to the following:

1.Proper dimensioning and construction of fish farms according to the hydrological characteristics of the watercourse and the quality properties of the water:

- Considering the distance from one to another fishpond depending on the emission of harmful elements in the water (N and P) and the possibility of self-purification of the watercourse.
- Compulsory biological minimum in the riverbed of the watercourse, for the normal survival of the autochthon species from which the water occupies.

2. Fish diet

- Precisely prescribing the highest amount of used foods by fish producers.
- Determining the composition of food and the use of food that meet environmental norms regarding the emission of N and P in the environment.

3. Construction of solid waste retention tanks;

4. Mandatory control of oxygen saturation of the exit water from the fish farm.

5. Keeping production documentation for the achieved annual fish production, as well as consumed fish food.

6. Submitting reports to the competent institutions for the fish production and consumed food.

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