ENVIRONMENT IMPACT ON AQUACULTURE PRODUCTION

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Contents

1. Introduction

The hydrosphere of the Earth plays a key role in the human life. As the civilization develops the importance of different types of water bodies increases. At the same time, humans exert greater and greater influence upon the water cover of the planet. For optimization of the wild life management (ecosystem exploitation) and the environment protection it is necessary to recognize scales of this impact on the animated Nature. For its own safety, humanity should be careful when using the water ecosystems so that to make the most of their resources with minimum of damage. The question is creation of the culturally developed water areas at the water bodies by analogy with the same in the agricultural production.

Among factors, essentially affecting quality of the water environment, contamination of hydrobionts by products of different origins and infestation of organisms have a significant place. As a result of human activities, the land water bodies are polluted withy (by) different types of waste. Among these, pollution by toxic compounds is the major one both by the scale of the spreading and by the degree of its impact. By their very long consequences the toxic pollution is dangerous also for the man who uses for food the aquatic organisms containing increased concentrations of heavy metals, pesticides, radioactive and other admixtures.

Sources of the toxic water pollution are rather different. The water bodies accumulate toxic substances those initially exist on the land and on the air. In consequence of this, the toxicity of a water reservoir should be considered as a result of general (total) pollution of the planet surface.

Pollutant impacts on the hydrobionts are rather different too. Besides acute poisoning, the toxicants, even in their concentrations, cause a number of feeding and growth disturbances in the invertebrates and fishes, the disorders of their behavior and migrations, reduction of tolerance for deceases. The permanent pollution of water and bottom sediments by the persistent toxicants leads to their accumulation in an organism that results in the pathologic changing in the internals, gills, and reproductive system.

Many toxic substances have a genotoxic effect in relation to the hydrobionts and cause in them dangerous biological consequences. From data on medical genetics, for the last decades occurrence of hereditary pathologies, caused by the mutagenes of external environment, drastically increased; this is a real threat for genofonds of human-beings, fauna, and flora.

Tremendous diversity of species, related to not only different classes but also to various types of fauna, is integrated by the same biotic feature that is parasites, i.e. such living organisms who uses other living organisms, in the given case hydrobionts, as habitat and source of nutrition, and, under certain conditions, they harm them and even cause their death. It is known that, up to the present, not more than 25% of actually existing parasites are described. Especially, the marine organisms are poorly studied. In this connection, studying of the parasite fauna, revealing of particularly dangerous species of parasites, estimating (assessment) of their pathogenecity, elucidating of the basic ways of formation of the natural locuses, the parasite biological characteristics and life cycles, choosing of the main ecological factors controlling their numbers (numerosity) present the theoretical basis for solution of actual applied problems.

The present review contains information on the most dangerous and widely distributed toxic substances, infestation of fishes and other aquaculture products, as well as on the place and role of artificial reproduction of the hydrobionts at the current stage of the civilization development.

2. Heavy metal pollution of fishes and invertebrates

The water bodies always contain small quantities of heavy metals (zinc, copper, mercury, cadmium, cobalt, chrome, iron, manganese, and arsenic). On the average, the metal concentrations are higher in the river water than that in the sea water because in the sea the metals are adsorbed by colloids, organic substances as the sea water is more rich with metals.

The natural source of the metal ingress (income) into the water environment are rocks. Presently, the levels of metal ingress from the anthropogenic and natural sources are comparable. For example, in the global scale, the annual increment of the lead concentration makes up value of the order of $6.7 \cdot 10^{-7}$ mg/l. Such rate of growth does not make a serious threat for the World ocean ecosystem. The real threat is brought by local pollutions. Comparison of the metal concentrations in waters of a number of water bodies and the biologically efficient concentrations shows that the particular metals are already contained in natural water reservoirs in the concentrations capable to cause one or another biological effect. This is noticed in the water bodies that receive the wastes of big cities and industrial centers, pulp and papers mills, and metallurgical works. Thus, for example, in muscles of the bream (*Abramis*) from the river Severnay Dvina, i.e. in the zone affected by the wastes of the Arkhangelsk pulp and paper mill (PPM) the mercury concentration exceeds the allowable norm.

Among the water bodies of Karelia, the Lakes Onega and Ladoga, and Vychozero, and the Toma and Yanis-Ioki rivers are exposed to the greatest pollution from PPM. As a result of this, the catches of valuable fish species have been drastically decreased.

In the Azov-Black Sea basin, the regular active sources of heavy metal pollution of the sea aquatories are sites where the ground excavated at deepening of the bottom is discharged. This results in silting of the spawning grounds (breeding bottom); exceeding of the MACs (maximum allowable concentrations) of heavy metals and other pollutants by tens and hundreds of times is observed in the water.

On the average, the high yearly levels of concentration of the heavy metals and other toxicants are observed in the lower course of the river Don; sometimes, this results in the mass death of fishes, especially in periods when the water temperature rises.

In the river Volga delta (mouth), pollution of the bottom sediments, water, and fishes by the toxic substances results in the development of oncologic diseases in fishes.

In the river Moskva, within the city boundaries and downstream, the metal content levels (zinc, lead, cadmium) exceed the sanitary standards by factor two or three. A great number of anomalies and deformities in the fishes is reported; and this number increases downstream. Disturbances in structures of cranium, organs of sight, gills (fins) as well as disorders of internals (especially, of liver) occur the most frequently.

By the example of the Kuibyshevskii water reservoir, the irregularity of the metal accumulation both by different organs of the same fish species and by individuals of different species belonging to different levels of the trophic chain: sabrefish (plankton-feeder) (*Pelecus cultratus*), bream (*Abramis*), and roach (benthos-feeder) (*Rutilus rutilus*), perch (mixed feeding) (*Perca fluviatilis*), zander (*Stizostedion lucioperca*), and pike (predators) (*Esox lucius*), is shown. Minimum quantity of manganese is contained in muscles and gills of the sabrefish and roach, that of copper is contained in the bream muscles. The skins of bream and pike contain a minimum amount of zinc, and a minimum quantity of lead is contained in muscles of sabrefish, roach, and bream, and in the bream liver.

Analysis of fishes from the river Oka basin has revealed irregularity of the metal distribution in the fish organs. In all species, except the bream and white-eyed bream (*Abramis sapa*), copper was absent in the muscles while in the liver of silver bream (*Blicca bjorkna*) its content exceeded allowable amount by 1.3 times, and in the livers of bream, sabrefish, and white-eyed bream its level exceeded by a factor of 3.1, 5.5,and 17.8, respectively. Spawn of silver bream and white-eyed bream contained the significant amount of copper.

Unlike the organic substances which in time are utilized in the water body, the metal compounds conserve toxicity practically for infinite time since during their transformation a basic component of the compound, i.e. metal, does not change.

The metal toxicity is determined by many factors: concentration and duration of action, ambient temperature, oxygen content in water, pH, hardness of the water, presence of complex of formers, etc. Rise of the water temperature, deficit of oxygen, decrease of pH, and the hardness usually enhance the metal toxicity for hydrobionts. Simultaneous presence of organic compounds or metal in water does different effect on the metal toxicity.

Coefficients of the metal accumulation by hydrobionts, calculated in relation to levels of their concentration in the water, are highly different for organisms of different taxonomic status, for different organs and metals. Basically, the values vary within a range from few tens to tens of thousands.

The metals get into the hydrobiont organisms mainly together with food. In fishes, the metals can come by a way of mechanical capture of suspended particles of hydroxides in gills, by a way of hemosorption of ions on the mucous membrane.

With respect to decreasing of toxicity for the hydrobionts, the metals are arranged in the following order: Hg>Cd=Cu>Zn>Pb>Co>Cr>Mn=Fe>Sn.

Criteria of the water quality for the heavy metals are not the same in different countries. Thus, the limiting concentration of copper makes up o.002-0.004 mg/l in Canada, 0.0003-0.005 mg/l in Sweden, 0/006-0/021 mg/l in the USA, and 0/001-0/005 mg/l in Russia. The tendency to increasing of the metal average concentrations in fishes from inland seas as compared with the ocean species is noticed. The average mercury concentrations in muscles of fishes from the Baltic, Black, and Caspian seas are higher in 2-4 times than in the oceanic piscifauna. We noted similar differences for lead and cadmium, though those were smaller in values.

This agrees with general process of increasing of the level of the sea domain pollution when moving from the open ocean to the neritic zone and inland seas. However, one cannot exclude also a possibility of increasing of the heavy metal concentrations in the water, fishes of the inland seas, and in coastal waters due to natural processes, mainly, terrigenous runoff (river water influx, abrasion of shores, a.o.).

Increase of the lead concentration in marine and catadromous fishes as compared with the oceanic species is always certain while for the cadmium such dependence is not always observed.

The mercury accumulation in large oceanic predatory fishes (tuna (*Thunnus*), shark, swordfish (*Xiphias*), and mammals) is by the order and more higher than in other representatives of the piscifauna. In this case, the irreversible accumulation of natural mercury in the predatory fishes takes place through the food chain.

The lead and cadmium are the most accumulated in the coating and bone structures of fishes.

The mercury is more concentrated in muscles and livers that is connected with the mercury property to create the strong complexes with the functional groups of proteins. This results in creation of stable mercury-organic complexes with high capability of the bioaccumulation. These compounds are slowly removed from the animal organisms. Cases of mass poisoning of people and animals are known in Japan, Iraq, Pakistan, and Guatemala (Minimata's disease).

The mercury content in the sea invertebrates is usually smaller than that in fishes. For example, the average concentration of mercury in muscles of 41 species of commercial (food) fishes in the North Atlantic shelf amounted to 0.154 mg/l while in the soft tissues of mollusks and invertebrates this did not exceed 0.1 mg/l. Similar data are typical fro the Northern and Baltic seas and bays of Australia.

With respect to changing in the species sensitivity by the example of mercury, the hydrobionts are arranged in the following order: bacteria, crustacea, algae, fishes, mollusks, insect larvae. For the first time, the information on the high mercury content in fishes, i.e. up to 7 mg/l of raw mass, was obtained in the USA in the middle of 1970s when studying the water bodies in the South Carolina state. Increase of the mercury content in fishes was revealed both in the Finnish water bodies and in those of North America. By the late 1980s, in Sweden the toxicant concentrations in fishes higher the standards were found in ten thousand lakes. One of causes of this is decreasing of the water pH that increases biological accessibility of mercury.

Under the metal effect, a sensitive indicator is fecundity and productivity of hydrobionts.

The water hardness plays a key role in manifestation of the metal toxicity. For the most of fish species, increased water hardness reduces the metal toxicity.

The metal toxicity depends also on a degree of the compound dissociations. Ions of the metals are toxic as well.

It is very actual and important to take into account in practice the synergetic and antagonistic effects of metals on the hydrobionts. Combinations of the heavy metals, such as copper and zinc, copper and cadmium, nickel and zinc, are synergetic. The compounds of metals with cyanides create the metal cyanide complexes whose toxicities are significantly lower than tyhose of the cuanides and salts of heavy metals apart.

The heavy metals have a high degree of accumulation. Many of them are accumulated through the food chain with the subsequent increasing. All this can intensify the metal effect both directly on the hydrobionts and on the man eating the sea products. The most various combinations of metals between themselves and also with the other ions and substances in the domestic and industrial wastes present a real and potential hazard for the water ecosystems. This problem needs to be thoroughly analyzed and studied.

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Biographical Sketches

Bagrov Alexei M., born in 1946, is a well-known pisciculturist of Russia, DrSc in biology, corresponding member of Russian Academy of Agriculture. He is leading specialist on the fish breeding and growing (rearing). For about 40 years, he deals with investigation of biology of objects of aquaculture and breeding of ecologically specialized fish species. Now he is the Director General of All-Russian Research Institute of Freshwater Fish Culture.

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Shesterin S.I. was graduated in biological-pedospheric faculty of the Lomonosov Moscow State University in 1968 receiving the speciality "aquatic toxicology and sanitary hydrobiology". In 1972, he had finished the post-graduated course and defended the thesis devoted to inter-relation of plankton at the metabolite level. Since 1972, he is a head of Laboratory of ecological toxicology in the All-Russian Research Institute of Freshwater Fish Culture. His scientific field covers investigation of the toxicant influence on fishes and development of methods of improvement of toxic resistance of the aquaculture objects under condition of pollution. Recently he is at the head of works for ecological monitoring of fish-culture water basins in Central and North-West regions of the Russian Federation.