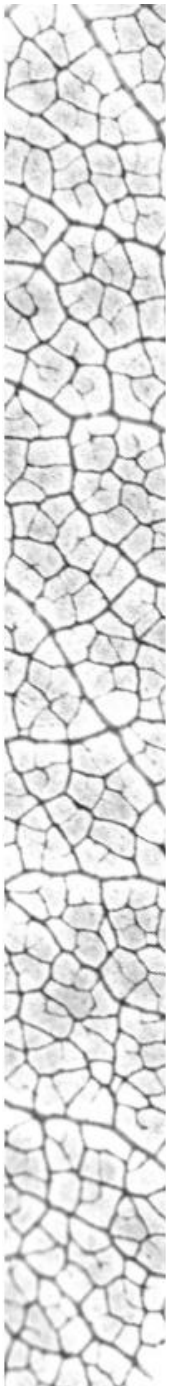

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Evaluation of the habitat state of the Zhaiyk River Ichthyofauna in modern conditions and its influence on the impacts of anthropogenic factors

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Abstract
The article presents data from a comprehensive study of the current state of the habitat and its impact on hydrobionts and fish populations in the area within the Atyrau city, where an environmental disaster occurred in December 2018, which led to the mass mortality of partial and sturgeon fish in the Zhaiyk river. In the course of research in the summer-autumn period of 2019, the hydrological regime, hydrochemical and hydrophysical parameters, the content of heavy metals, phenols, pesticides and petroleum products in water, hydrobionts and fish were studied. The state of the fish food supply (phytoplankton, zooplankton, zoobenthos), and the quality of the habitat for indicator species were assessed. The analysis of the composition and state of the ichthyofauna and the conditions of natural reproduction of fish were carried out. Pathological changes in fish organisms, the presence of parasites, viral pathogens, and the state of fish internal organs were studied. The state of the ichthyofauna and the habitat of hydrobionts were analyzed, and scientific recommendations were made to reduce the negative impact of anthropogenic factors on ichthyocenosis.

Keywords: hydrology, hydrochemistry, toxicology, food supply, ichthyofauna, histology, pathology, parasitology, virus, fish stocks, fisheries, anthropogenic factor

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INTRODUCTION

The objects of research are water, bottom deposits, hydrobionts and ichthyocenoses of the Zhaiyk river and the pre-estuary space.

The aim of the research is to assess the state of the habitat and its impact on hydrobionts and fish populations by conducting comprehensive studies and developing recommendations to reduce the negative impact of anthropogenic factors on the ichthyofauna of the Zhaiyk river.

Research area: Zhaiyk river from the tonal section of the Bugorka downstream to the pre-estuary area of the Zhaiyk river and the coastal part of the Caspian Sea.

The Zhaiyk river is a cross-border watercourse and is intensively used by industrial and agricultural complexes of the Russian Federation and the Republic of Kazakhstan along its entire length. On the territory of the Russian Federation, two reservoirs are equipped to supply the Magnitogorsk metallurgical plant in the upper reaches of the river. The main sources of pollution of water basins are large industrial enterprises: OJSC “South Ural Nickel plant”, OJSC “Ural Steel” (former Orsko-Khalilovsky metallurgical plant), oil-refining enterprise JSC “Orsknefteorgsintez”, Magnitogorsk and Chelyabinsk metallurgical plants, JSC “Novotroitsk plant of chrome compounds”, LLC “Mednogorsk copper-sulfur plant”. As a result of the activities of industrial

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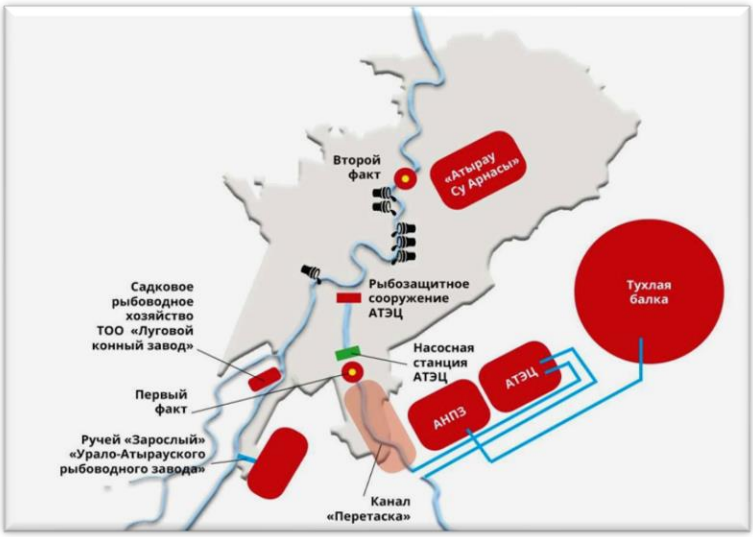

Fig. 1. Diagram of the location of the main enterprises of Atyrau with indication of places of detection of dormant fish

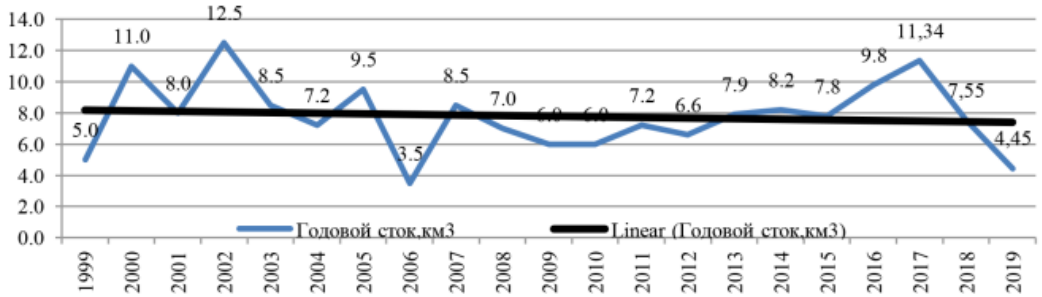

Fig. 2. Dynamics of long-term annual flow of the Zhaiyk river within the Atyrau city

enterprises, the ecosystem of the Zhaiyk river is polluted by a wide range of toxic substances. The imbalance between the anthropogenic load on water bodies and their ability to self-clean and restore led to environmental problems in water ecosystems, including the Zhaiyk river (Amirgaliev 2008, Social and environmental problems of our time and sustainable development).

On the territory of the Republic of Kazakhstan, reservoirs are located on tributaries of the Zhaiyk river: on the Ilek river (Aktobe – 245 million m^3) and on the Karagaly river (Karagaly – 280 million m^3). A significant contribution to pollution in the Zhaiyk river is made by the Ilek river, which receives industrial effluents in the Aktobe region. The main source of pollution is JSC “Aktobe plant of chrome compounds.”

In Atyrau, four enterprises officially discharge into the Zhaiyk river: JSC “Atyrau CHP”, PSE “Atyrau Su Arnasy” and two fish farms (**Fig. 1**) (Fish kill in Atyrau: main versions and hypotheses).

The first detection of dormant fish occurred on December 2, 2018 in the Lower Peretaska channel, which is accessible by the oil-refining (AORP) plant and ACHP. According to official information, AORP does not discharge water into the Peretaska, all waste from production is sent to the “Tukhlaya balka” evaporation fields (Fish kill in Atyrau: main versions and hypotheses).

The second detection of dead fish was recorded on December 3, 2018 in the area of water treatment facilities of PSE “Atyrau Su Arnasy”. At the same time, fish were killed at two sturgeon plants located downstream of the river (Fish kill in Atyrau: main versions and hypotheses).

According to the results of laboratory analyses of water in the area of fish death, an increased content of chlorides was found (Fish kill in Atyrau: main versions and hypotheses).

The dynamics of the annual water flow of the Zhaiyk river showed a trend of its decline over the last 21 years of observations, which affected the state of fish stocks. A particularly sharp decline in the annual flow of the Zhaiyk river has been noted in recent years. Thus, if in 2017 it was 11.34 km^3 (**Fig. 2**), then by the next two years, the flow decreased by 1.5-2.5 times, which could affect the oxygen regime and other environmental factors.

It is necessary to find compromises between different sectors of the economy regarding the use of water, as

Table 1. Content of hydrochemical indicators of the Zhaiyk river, spring 2019

Research stations	pH	CO_2 mg/dm³	Dissolved oxygen, mg/dm³	Biogenic compounds, mg/dm³			Permanganate oxidability, mg/dm³	Total mineralization, mg/dm³
				NH_4	NO_2	NO_3		
Bugorka	8.5	not detected	5.9	0.039	0.068	7.9	1.62	732
Kurilkinsk pond	8.2	not detected	5.6	0.1	0.003	4.1	1.52	756
Peretaska flow	8.4	not detected	5.4	0.09	0.002	4.4	1.52	670
Lower Damba	8.4	not detected	5.8	0.031	0.077	7.3	2.0	810
Average over river	8.4	0	5.7	0.065	0.037	5.92	1.66	742
12 square (pre-estuary)	8.2	0	8.5	0.41	0.005	2.43	5.0	6100

well as to address issues of joint use of water resources of Ural within the framework of the existing Kazakh-Russian commissions on water resources. The agreed measures will lead to a decrease in the amplitude of inter-annual fluctuations in water content, in which only the abiotic (fluctuations in natural water content) component will remain. Only then the conditions for natural reproduction of fish in the Zhaiyk river (Ural) can be assessed as satisfactory in the medium term.

The results of hydrochemical studies have shown that there is a significant transformation of the chemical composition of water from the Zhaiyk river to the pre-estuary, which is due to both natural and anthropogenic factors. It is manifested in a number of changes in hydrochemical characteristics: in permanganate oxidability and increase in water mineralization. The content of nutrients in the Zhaiyk river in the summer and autumn of 2019 was within natural fluctuations. No excess of the maximum allowable concentrations of nutrients was observed. It should be noted that in recent years there has been a gradual decrease in the content of dissolved oxygen in the winter period.

The values of the dissolved oxygen content of 6 mg/dm^3 in the subglacial period satisfy the vital functions of most fish species. However, for sturgeon fish, the oxygen content in winter was within the physiological norm, but below the optimal one. Sturgeon fish are highly sensitive to lack of oxygen. For normal life, the oxygen concentration should be 7-11 mg/dm^3 (**Table 1**).

Toxicological studies of the Zhaiyk river ecosystem were also conducted. The main pollutants of the Zhaiyk river – heavy metals, pesticides, oil products, phenols, etc. - were determined in the habitat and hydrobionts.

Among the heavy metals in the aquatic environment, zinc dominates. The most polluted areas are the estuary (st. 12 square) and the area of st. Atyrau su Arnasy (autumn). According to the approved standards, MPC was not exceeded. In 2019, the concentration of zinc increased by 3.3 times, nickel by 1.5 times, and the content of copper and cadmium decreased by 2.0-2.5 times, and lead by 5 times compared to 2015.

The content of bivalent and trivalent iron in water almost everywhere exceeds acceptable levels. The maximum values are typical for the estuary section of the river. In the seasonal dynamics, there is a tendency to decrease iron by the autumn in the upper sections, but closer to the Caspian Sea remains at the same level and even higher.

Oil products exceed the fishery MPC in the summer at the estuary of the river (3.4 MPC), in the autumn - in Kurilkinsk cage (2 MPC). The content of phenols in almost the entire research area is 2-10 times higher than the acceptable level. A decrease in phenols is observed at the estuary, the maximum concentrations are found on the st. Bugorka.

The main pollutant of bottom deposits is lead. On the total content of more polluted soils of the upper plot (st. Bugorka). Compared to 2015, the lead content increased 5 times, and the number of other metals decreased. The distribution of oil products in the river soils is characterized by high variability - 18.0-129.0 mg/kg in summer, 23.0-465.0 mg/dm^3 in autumn. The maximum concentration observed in areas of the Kurilkinsk cage, Peretaska, Atyrau Su Arnasy and 12 square.

Mercury, arsenic, and organochlorine pesticides were not found in the habitat (Kurmashin et al. 2014).

In the studied invertebrates, lead is the leader in accumulation. The trace element composition of zooplankton and nekton-benthic is almost identical. Mollusks have a long life cycle and their storage capacity is higher. Concentrations of lead and cadmium in shellfish exceed those of planktonic and nekton-benthic organisms by 2.4 and 1.3-2.0 times, respectively. Mercury (0.003 mg/kg), arsenic (0.0001 mg/kg), and the residual amount of HCCH pesticides (0.01 mg/kg) were also found in mollusks. There are no significant changes in invertebrate bioaccumulation in the inter-annual dynamics.

According to the level of bioaccumulation, fish species can be arranged in the order of decreasing the content of trace elements as follows: crucian > bream > asp > pikeperch > carp. Lead and cadmium accumulate in all tissues and internal organs. Arsenic and mercury accumulate in the reproductive organs. Hexachlorocyclohexane (HCCH) was detected in the liver of adult carp, asp and crucian carp. The dependence of the accumulation level of pollutants on the age of fish is specific for each species. The total content of toxicants is higher in young-aged individuals of carp, pikeperch and bream. Among individuals of asp and crucian, older ones are the leaders in accumulation. In the inter-annual dynamics, there is a decrease in the content of trace elements in the fish muscles: lead by 3-8 times, cadmium - 2-16 times compared to the results of 2015. The concentrations of toxicants in the fish of the Zhaiyk river do not exceed acceptable levels. According

to toxicological indicators, the fish of the Zhaiyk river meets the requirements of food safety and can be used in human nutrition without restrictions. However, the presence of representatives of the ichthyofauna in the component composition of the Zhaiyk river of highly toxic elements and pesticides determines the need for monitoring toxicological studies of the habitat and hydrobionts, taking into account the composition and specific properties of pollutants coming from industrial and agricultural wastewater.

Based on the results of toxicological studies, recommendations are made to reduce the negative impact of anthropogenic factors on the ecosystem of the Zhaiyk river.

One of the directions is to determine the real sources of pollution along the entire length of the river, creating a data bank on toxicants coming from industrial and agricultural runoff. With the help of complex studies, develop maps with mapping of sources of pollution, identify and highlight areas within the river with very high, high, medium, low levels of toxic substances from the point of view of fisheries regulations.

It is recommended to organize a comprehensive monitoring to assess the impact of anthropogenic factors on aquatic organisms, establish the reaction of hydrobionts to pollutants, indicator species and various index criteria. Based on the results of scientific research, make proposals to enterprises (sources of pollution) to clarify the requirements for environmental protection and take measures to implement them, as well as appropriate changes and additions to the technical documentation on the regulation of the main components of pollution of a particular enterprise.

We recommend developing regional fisheries regulations for bivalent and trivalent iron. To determine the background content of iron ions in the Zhaiyk river, additional studies should be conducted covering all seasons for 2-3 years.

We recommend that when calculating the maximum permissible discharges (MPD), take into account the combined effect of toxicants - synergy (for example, copper and zinc, copper and cadmium, nickel and zinc), which significantly increases the toxic effect when interacting together. In the technological process, switch to the use of reagents, although more expensive, but effective and of a low hazard class.

The use of modern pesticides in agriculture needs to be regulated and scientifically justified concentration limits developed for a wide range of organochlorine and organophosphate compounds. And it is also necessary to replace pesticides with less toxic and completely harmless biological means of protection.

Currently, it is important to develop and adopt a national standard for the regulation of harmful substances in terms of their toxic effects on hydrobionts.

An important component of monitoring the state of natural waters is hydrobiological methods, which are relatively simple and quick to obtain results compared to other methods for determining water quality.

A representative number of samples were selected for all the study issues set out in the work program within the planned time frame at the installed stations, which were analyzed after in-house processing.

In the spring and summer of 2019, 79 taxa from 7 taxonomic groups of microalgae were identified in the phytoplankton of the Zhaiyk river. Among them, 37 species were recorded in the summer and 61 in the autumn. Blue-green algae form the basis of phytoplankton abundance throughout the water area. The biomass of the reservoir is produced mainly by larger-sized diatoms and green algae.

35 saprobity indicator species were recorded in the phytoplankton of the studied section of the river. Most of the observed species were from the β-mesosaprobe zone (Kitayev 2007). The obtained material indicates medium polluted water level in the Zhaiyk river with organic substances. Also, in the warmest period of the year, in summer, the poor species composition of phytoplankton (37 species and forms) indicates limiting environmental factors for the development of heat-loving microalgae species. By the autumn, the mass development of almost all representatives of algae groups (61) indicates the restoration of environmental conditions in the Zhaiyk river.

In the zooplankton composition in 2019, 54 taxa of organisms were noted, of which 19 species had an indicator value of saprobity. The maximum number of zooplankton species, as well as phytoplankton, in the Zhaiyk river was recorded in the autumn observation period, and the minimum in the spring. A distinctive feature of the river zooplankton in March 2019 is the exceptionally high number of small rotifers of synchetes, among the dominant species were *B. urceus, Keratella quadrata,* which exceeds by two orders of magnitude the April indicators of previous years. Presumably, the reason for this peak in numbers may be an increase in the amount of organic substances in the water, caused by the mass fish mortality before our research. Communities of planktonic animals achieve significant development in reservoirs during the growing season for them, from May to September. For the Zhaiyk river, the beginning of the plankton vegetation is shifted to the end of June due to high water with a strong current and turbidity of water, which negatively affect the plankton in the early summer. It is known that any pollution is considered as a change in the habitat, as a result of which some hydrobionts in new conditions begin to develop intensively, while others, on the contrary, slow down the development or even die off.

Only 23 species and forms of zoobenthos have been recorded in the bottom and benthic cenoses of the river. Species diversity among benthic aquatic organisms created insect larvae and nekton-benthonic crustaceans. But the quantitative indicators of

zoobenthos were formed here thanks to other groups of animals: worms and mollusks.

In the month of March 2019, benthic biomass is 3.0 times lower than in the previous year, 2018. This indicates a sharp decrease in the biomass of large-sized mollusks in the river this year.

Spatial analysis of the distribution of mollusks in the Zhaiyk river revealed that the highest density of their colony in 2018 was observed at the stations Institute, L. Damba and 7 Post. At that time, the total mollusk biomass indicators were very high, ranging from 91.5 to 459.1 g/m^2 from spring to autumn, however, the biomass of small and soft benthic fish feeders varied within narrower limits: 3.2 and 6.8 g/m^2. On average, relative to the material of the previous year, in 2019, the number and biomass of the community is almost 3.0 times lower compared to the quantitative development of the previous year.

Thus, observations of bottom and benthic communities revealed the following changes in the Zhaiyk river cenosis: reduction of zoobenthos biomass in 2019 relative to the spring, summer and autumn data of 2018 due to a decrease in the mass of large-sized mollusks in the bottom part of the river. At the pollution a complex change in the physical properties of water, chemical composition, micro- and macro-population of the reservoir, which led to a change in the overall structure of the bottom and benthic cenosis of the Zhaiyk river after the death of mollusks in the spring of 2019, occurs. The average value of the saprobity index corresponded to the α-mesosaprobic zone - IV class of water quality, only 5 degrees of pollution. The specified value of saprobity is characterized by a greater degree of decomposition of organic substances.

Under anthropogenic conditions, benthic communities tend to be in more unfavorable conditions than phytoplankton or zooplankton organisms, due to the accumulation of toxic pollutants in the benthic layer of water and in bottom deposits. In the Zhaiyk river, there were cases when, after a salvo discharge of waste water from the Orenburg oil refining plant in the Zhaiyk river, on a section 15 km below the discharge, practically all passively moving groups of zoobenthos sensitive to environmental conditions were dead. Then the content of some chemical elements in the river water can exceed the maximum permissible level of them from 2 to 75 times. Due to the limited lability of benthos and the relative stability of bottom biocenoses in the temporal aspect (long life span of bottom hydrobionts), they reflect pollution of a relatively long period and integral conditions, both in water and in the soil.

Thus, the poor biodiversity of hydrobionts in 2019 relative to previous years in the Zhaiyk river and the decrease in quantitative indicators of benthic hydrobionts indicate changes in the overall structure of the bottom and benthic cenosis of the Zhaiyk river after the mollusk mortality in the spring of 2019.

Applied indices for determining the degree of pollution of the reservoir (Atlas of saprobic organisms 1977) indicate the medium polluted water level in the Zhaiyk river with organic substances. The detected level of zoobenthos saprobity indicates a more polluted state of the Zhaiyk river soils relative to the surface water layer communities.

Studies of the state of the Zhaiyk river ichthyofauna and pre-estuarine areas of the sea have shown that the biological indicators of fish are within the average long-term values. The number of populations of commercial fish species is limited only by the conditions of reproduction.

The main factor determining the state of fish stocks in the Zhaiyk river is fishing. In recent years, work has been constantly carried out to improve the fishing regime and the protection of fish stocks in the river. According to official data, the amount of the allocated limit for fishing in the Zhaiyk river is not being developed. The drop in catches occurred in the early 2010s, when the start date of the spawning ban on fishing was moved from mid-May to April. The fishermen are unable to adjust to a shortened spring fishing season.

The second reason for the drop in catches was the cessation of dredging on the Zhaiyk river and fish channels from 2012 to 2018. In the spring and autumn, migration routes run along the main channel of the Ural river (the Golden arm) and simultaneously along the Yaitsky river fish channel, including the right and left Yaitsky arms. In recent years, the low water content of the Ural river has led to shallowing of the Yaitsky river's fish channel, including the right and left arms, which are fish migration routes. Fish in the spring simply cannot find their way into the river, so the capability of spawning has decreased, and spawners are forced to look for spawning grounds along the coast in desalinated areas of the sea (Mansoor et al 2018).

The moratorium declared since 2010 on commercial fishing of sturgeon species continues in order to preserve the gene pool. In the conditions of extreme insufficiency of spawners of sturgeon species of fish in the Zhaiyk river, it is necessary to take measures to quickly create their replacement-brood stocks at sturgeon plants. To do this, we recommend reconstructing existing sturgeon plants to create conditions for keeping and forming replacement-brood stocks of these fish species.

All subjects must comply with the current fishing Rules, "Restrictions and prohibitions on the use of fish resources", allocated catch limits and quotas, and fishing effort Standards.

Currently, fish stocks are low, but stable. The total commercial fish stock of the Zhaiyk river and the pre-estuary area is 21.8 thousand tons. For 2020-2021, we have set the annual maximum allowable catch at 5.1 thousand tons. The average number of offspring from 2014-2016 is expected to enter the fishery, so the state

of commercial fish stocks in the short term is estimated as low, but stable.

High risks of technogenic accidents dictate the need not to have fish farms (pond, cage) within and immediately downstream of industrial centers. Various pollutants that enter the river from industrial and domestic effluents are diluted and sedimented along the river, and their toxicity is gradually reduced. As a rule, after a few kilometers (in the worst case – tens of kilometers), the water in the river does not cause acute poisoning in fish.

Aquaculture farms should take care of the construction of treatment facilities at the water inlet, or at least ponds-sedimenters. If the water is allowed to settle for several hours before being launched into the ponds, then the toxic elements are bound by chemical reactions with other compounds in the water, sedimentation (precipitation) occurs, and their toxicity decreases. After settling, the water will flow to the rearing and stock ponds, which will reduce the risk of toxic damage to the farmed fish in the event of multiple discharges of toxicants into the river.

As a result of ichthyoparasitological studies two sections in the pre-estuary area of the Zhaiyk river “12 square” identified to species 17 parasitic organisms belonging to different taxonomic groups: 5 types of monogenetically flukes, 6 species of digenetically flukes (trematodes), tapeworms (cestodes) - 2 species, 3 species of roundworms (nematodes), 1 species of parasitic copepods.

The most pathogenic for fishing are the cestodes found by us *Khawia sinensis* and *Bothriocephallus opsariichtydis*, which can lead to a massive pest of cyprinid fish species of the Zhaiyk river at their high intensity of invasion.

Of the pathogens of zoonotic invasions, 3 species of anisakid nematodes from the family *Anisakidae* have been established, with which a human is infected when eating poorly fried, boiled or smoked fish. 5 fish species out of 7 studied were infested with anisakids. Anisakidosis has not been established in carp and crucian.

From crustacean parasites, the copepod (Copepoda) *Ergazilus sieboldi* was found. It is a polyspecific parasite of many species of freshwater and semi-aquatic fish.

Thus, can be concluded that the 17 species of parasites identified by us during ichthyoparasitological studies are an integral part of the biocenoses of the Zhaiyk river. These parasites were established in fish on the Ural river in the 30-70s by A. I. Agapova, which, like free-living organisms, react to anthropogenic changes occurring in the water and can be indicators of its state. The deterioration of the hydrobiological regime of the river changes the species diversity of invertebrate fauna, and this leads to the loss of intermediate hosts of parasites. Such conditions profoundly change the species composition of parasites, which makes it possible to use the parasitological situation in assessing the state of reservoirs and determining the level of anthropogenic impact on aquatic ecosystems.

Thus, by the results of the research can be concluded that in waters exposed to multidisciplinary pollution, spread of fish helminths, in the cycle of development involving cyclops, gammarids, mollusks, tubificid depends on toxicoresistance of these invertebrates, as well as from the reduction in new environmental conditions, number of worms at the stage of eggs and free-living larvae that live in the environment.

The above indicates that the species diversity and the number of ectoparasites (infusoria, monogeneas, leeches and cancers) decreases in the reservoirs contaminated with toxicants, but the number of endoparasites, in particular nematodes, does not change.

For histological analysis, the internal organs of pike, crucian, bream, pikeperch, Volga zander, white-eye, rasorfish, asp and carp were taken. In the gills of the majority of individuals taken for research, both in the summer and in the autumn, there was a pronounced parasitic invasion by unicellular parasites that were located in the interlamellar space and led to destruction of the gill epithelium and hemorrhages. In the liver, most of the studied individuals had no pronounced pathological reactions, except for Volga zander and asp, where parasites were noted in the parenchyma of the organ, the influence of which led to necrosis of hepatocytes, inflammatory infiltrations and deposition of bile pigment. In the intestine (for the study, mainly samples were taken from the small intestine), most individuals showed destruction and desquamation of the epithelium and lymphocytic infiltration of all layers of the intestinal tube. In the muscles of most individuals, there was a dilution and lysis of muscle fibers, which is the result of hypoxia of muscle tissue, in addition, focal leukocyte infiltrations were observed in the muscles of carp and white-eye. The study of gonads showed that most individuals had ovaries and testes at the II, III, and IV stages of gonad maturity. No serious pathological abnormalities were found in the gonads, with the exception of Volga zander from the autumn harvest, who had destruction of most oocytes of unknown etiology in the ovaries. This pathology leads to a violation of the reproductive function. In all other cases, the reproductive potential is within the normal range.(Ali et al. 2015)

Thus, histopathological analysis of fish caught in the summer and autumn showed a high level of infection of fish with parasites, both unicellular in the gills and multicellular in the liver, which led to concomitant pathological reactions of the organism.

Intensive infection with parasitic invasion may be due to the ecological imbalance in the ecosystem of the Zhaiyk river, which is probably a result of the rotting

remnants of dead fish after the environmental disaster that occurred in December 2018, and abnormal temperature rise in the summer, contributing to the development of pathogenic unicellular organisms.

Histopathological analysis of the studied organs and tissues showed violations that fit into the normal response of the organism and in general, characterizes the fish habitat as satisfactory.

Ichthyological studies have shown that the species composition of fish in the study area is represented by 11 species, one of which (mullet) belongs to marine fish. In summer and autumn harvest, we once met a rasorfish and white-eye and there was no bream. The size and age composition in the summer and autumn harvest corresponded to the carp - 3-4 years, asp - 3-5 years, mostly 3, bream - 2-6, mostly 3, crucian - 2-5, mostly 3, pikeperch - 3-7, Volga zander - 4. The number of crucian, pikeperch, bream, and asp predominated in summer harvest, and in autumn – bream and asp, the number of Volga zander according to the results of our research – is low.

Morphobiological indicators in the studied fish of summer and autumn harvest correspond to a satisfactory condition. Hematological and histological analysis also revealed no serious disorders, including pathologies resulting from chlorine poisoning. Histopathological disorders associated with chlorine poisoning are specific.

During the reporting period, in the Zhaiyk river, during the feeding period, from 56 individuals of 10 species of fish from the families of cyprinids, pike, perch and mullet, 387 bioassays were collected for virological and bacteriological studies in the form of pieces of internal organs, gills, sexual products and blood.

The result of metabar-coding DNA of microbiome homogenate of the fish gills, identified 576 species of microorganisms that make up 54.57% of the total number of received reed library 16S rRNA gene of prokaryotes. The remaining 45.43 % were not identified to the species level.

The dominant representatives of the gill microflora of cyprinid fish of the Zhaiyk river were the species of bacteria present in their habitat.

Currently, fish stocks are low, but stable. The total commercial fish stock of the Zhaiyk river and the pre-estuary area is 21.8 thousand tons. For 2020-2021, we have set the annual maximum allowable catch at 5.1 thousand tons. The average number of offspring from 2014-2016 is expected to enter the fishery, so the state of commercial fish stocks in the short term is estimated as low, but stable.

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