Studies of aquaculture safety indicators for fisheries management in the Chuy region of Kyrgyzstan

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Abstract. The article discusses the problems of the state of aquaculture quality for fisheries - trout farming in the Chuy region of Kyrgyzstan. The quality of food products is directly related to the conditions of aquaculture cultivation and the state of microbiological indicators. The features and conditions of the creation and functioning of fisheries in the zones of location and water use are shown. The conducted studies on the quality of water and fish raw materials confirm the risks associated with food safety. As a result of monitoring of fisheries, factors have been identified that directly affect threats to food safety, due to exceeding established and acceptable standards for certain indicators of chemical nature and microbiology. During the monitoring, recommendations were given to farmers of fish farms to improve the management of the fish business from farm to fork, in compliance with traceability requirements, regular monitoring of water and fish quality, use and storage of fish feeds, installation of sanitary and quarantine pools in cases of diseases.

1 Introduction

Kyrgyzstan is one of the Central Asian states that fully meets its water needs. Currently, fisheries, namely trout farming, is a dynamically developing industry in the republic. The number of active economic entities of the fishery is increasing annually (Fig. 1). According to the National Statistics Committee the total number of operating business entities in the republic is 320 farms [1].

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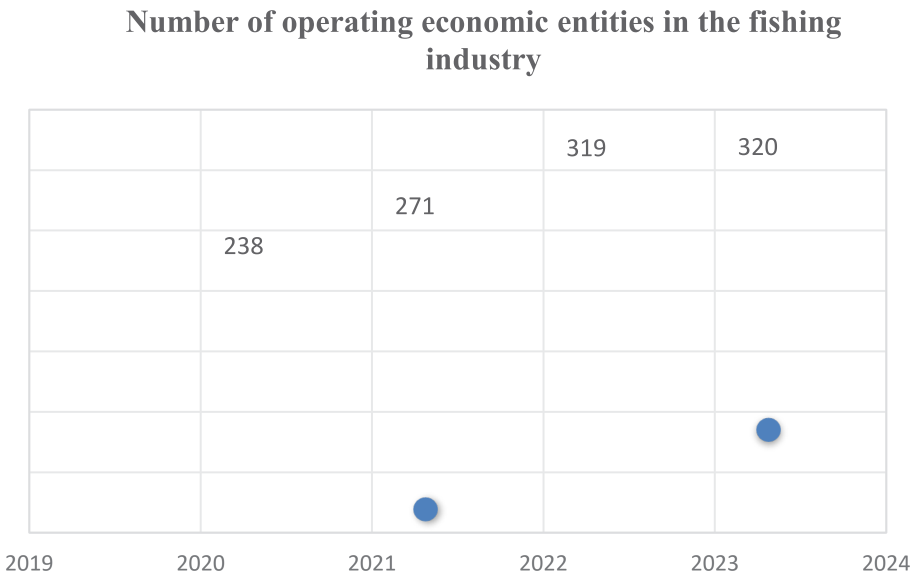

Fig.1. The number of active economic fishery entities.

It is worth noting that 281 farms are registered with the Department of Fisheries [2]. If we look at the cross-section by regions, the most fish farms are located in the Chuy - 204 farms, and the smallest number is registered in the Osh region -4 farms.

- ✓ Chuy region – 204 farms;
- ✓ Issyk-Kul region – 37 farms;
- ✓ Jalal-Abad region – 17 farms;
- ✓ Talas region – 9 farms;
- ✓ Naryn region -9 farms;
- ✓ Osh region – 4 farms.

Interest in fish farming is high among agricultural producers, so fisheries are increasing fish production from year to year. According to the data of the Department of Fisheries of the Kyrgyz Republic for Fish Farming and Aquaculture [3], the minimum amount of fish was produced in 2021 (10344.2 tons), in 2023 commercial fish was produced by 33600 tons, which significantly exceeds the volumes received in 2022 (Table 1).

Table. 1. Production volumes of commercial fish in Kyrgyzstan.

Years	Production of commercial fish, tons
2020	5139.7
2021	10344.2
2022	21000
2023	33600

According to the Department of Fisheries of the Kyrgyz Republic for Fish Farming and Aquaculture, fish exports increased in 2023 and reached 5,556.4 tons [2]. The main batches of fish are exported to Russia. But the volume of imports of fish and fish products to Kyrgyzstan also increased 1.5 times (Fig. 2) [4]. More than 50% of the products come from Russia, marine, oceanic, and canned fish are supplied here [5].

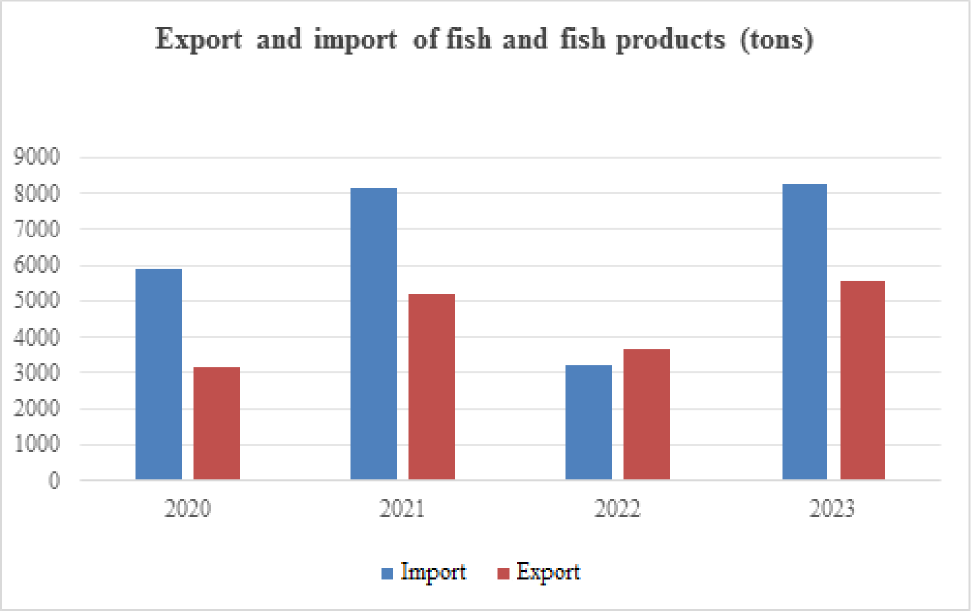

Fig. 2. Export and import of fish and fish products.

The problems of fisheries management in Kyrgyzstan are the lack of constant control over the quality of incoming mountain surface water to fisheries farms, as well as water flowing into common sources of water use after use on fisheries. The next problem is the analysis of feed quality, storage conditions, as well as the quality of farmed fish.

Currently, aquaculture in Kyrgyzstan is a promising area of the republic's economy. An increasing number of consumers of fish products prefer aquaculture of local origin.

But the main problem of the present time consists of the actual results of non-compliance of physical and chemical indicators of water quality with the NTD requirements. In fish products exported to the CIS countries, violations of non-compliance with the requirements of the Technical Regulations of the Customs Union (TR CU 021/2011) [6]

The main reasons for these negative food safety values are: the use of substandard feed in fish feeding, uncontrolled use of antibiotics [7]. Russia and Kyrgyzstan are looking for a compromise on the issue of trout supply), lack of proper control (traceability) on the part of the state for the production of safe food products, including fish during its cultivation, methods and conditions of processing. This state is associated with insufficiently competent actions of farmers, violations of the conditions for growing and caring for fish, as well as quality control of water that enters fisheries farms from their own water supply sources. This will help maintain water quality at an optimal level and affect fish productivity, prevent mass death of fish due to various diseases and natural factors.

Fishery farms in Kyrgyzstan often use natural open sources of water supply, through which water is supplied to farms. The choice of such sources of water supply is often determined by the principle of financial investment minimalism, and, as a rule, studies of the quality of water used for fish cultivation are not always carried out.

A proper fishery reservoir is one in which water provides an opportunity for fish to eat well, reproduce and not become infected with pathogenic microorganisms, without accumulating carcinogenic substances, pesticides, and herbicides.

The basis for conducting scientific research on the study of water quality for fishery purposes was the fact that for a number of years the assessment of water quality as an aquaculture habitat, as well as the quality of fish, has not been carried out. The source of water supply for all fish farms is water flowing through riverbeds from melting glaciers from the Tien Shan Mountains, as well as groundwater.

Research objectives: monitoring the quality of water and fish on fishery farms and determining the source that negatively affects the food safety of fish products.

Tasks: sampling of water from water supply sources of fisheries farms for the purpose of conducting an examination in an accredited laboratory of the Department of State Sanitary and Epidemiological Supervision. Sampling of fresh fish to study safety indicators in the laboratory of the Center for Veterinary Diagnostics and Expertise. Conducting an analysis of the results with the preparation of recommendations to reduce the risks of food safety of fish products.

2 Materials and methods of research

Water from the sources of four fish farms in the Chuy region of Kyrgyzstan; regulatory documents, comparative analysis of data from the examination of the laboratory of the DSSES and TR KR "On the safety of drinking water", devices and equipment for determining water quality indicators for fishery purposes. Microbiological standards, parasitological safety indicators in fresh fish according to the TR CU "On the safety of fish and fish products".

3 Research results

The main indicators recommended for trout cultivation are given in the Veterinary and sanitary standards and Requirements for the organization and management of aquaculture [8].

The norms of the TR of the Kyrgyz Republic "On the safety of drinking water" are applied in the republic on 04/21.11 [9].

When growing fish, it is necessary to observe and comply with the following requirements for the safety indicators of fishery reservoirs:

- meet the biological characteristics of farmed fish species;
- ensure marketable qualities of farmed fish;
- prevent the accumulation of toxic substances in fish;
- carry out examinations to prevent the content of substances that spoil the taste or give the fish an unpleasant smell;
- the reservoir should not be a source of fish diseases.

Water suitable for fish farming must meet the following indicators:

- Oxygen saturation above 80%
- pH 6.5 – 8.2 (7.5 is optimal)
- BOD5 not more than 2 mg/l
- permanganate oxidation up to 10 mg/l

Water suitable for trout farming should have the following characteristics:

- iron content up to 0.5 mg/l
- ammonia content up to 0.01 mg/l
- carbon dioxide content up to 10 mg/l
- nitrites up to 0.05 mg/l
- nitrates up to 2 mg/l

To analyze the real state of the water quality used for fisheries, water samples were studied at four fish farms engaged in the cultivation of rainbow trout.

Water sampling was carried out in the autumn season, there was no precipitation during the sampling period. Three farms have their own wells, and one receives water from surface mountain rivers (Fig. 3).

Fig. 3. Reservoirs of fish farms.

The depth of the artesian springs is located in the Chuy Valley at various depths: from 50 to 150 meters (Table 2). The studied objects are located in Bishkek, Alamedin and Issyk-Ata districts of the Chuy region (Fig.4).

It should be considered that all farm fisheries are located in different zones: one farm is practically the center of Bishkek - DF, two are the lower suburban part and another farm is the foothill zone.

Table 2. Conditions of the water source and the farm location.

Farm	Location	Water supply source	Description of farm location
DF KSAU	Bishkek	Artesian well	In the city center, the territory of KSAU, well depth - 154 m
Farm 1	Mayevka village	Artesian well	Outskirts of the village, well depth - 153 m
Farm 2	Prigorodnoye village	Artesian well	Private farmstead, well depth - 47 m
Farm 3	Gidrostroitel village	Surface mountain water	Outside the settlement, in the foothill zone

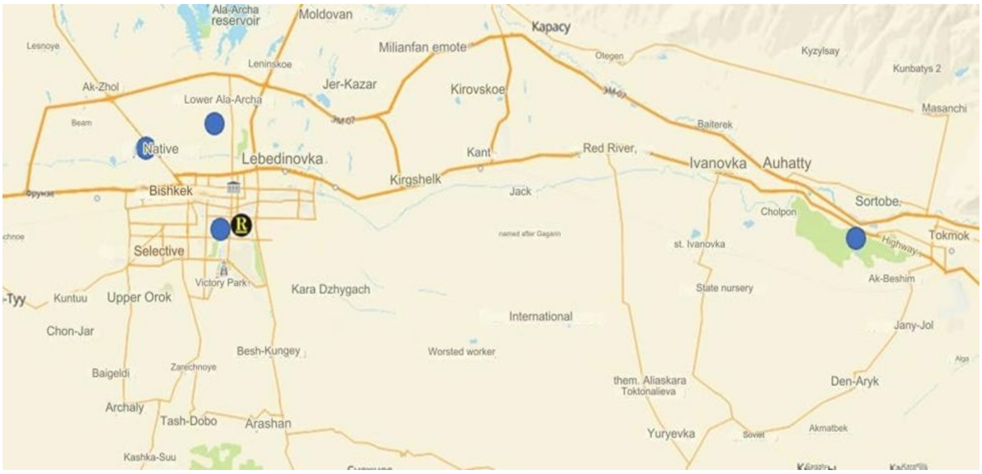

Fig. 4. Location of fish farms.

The results of laboratory studies and a comparative analysis of water quality indicators are shown in Table 3.

Samples were taken from water supply sources that supply pools with water. The physical, chemical, and bacteriological properties of water were studied.

The water obtained from underground sources at different depths does not differ greatly in quality indicators, with the exception of some. The excess values of the dry residue of water were revealed, among the biogenic components ammonia and nitrates are also present in the water. A high concentration of the above indicators is observed in all fishery farms.

Table 3. Comparative analysis of water quality indicators.

Indicator	Measurement unit	Indicators					Compliance with the NTD norm
		Recommended according to Veterinary and sanitary standards and requirements for the organization and management of aquaculture	Farm 1	Farm 2	DF KSAU	Farm 3	
Ammonia	mg/dm^3	Second decimal places	<0.1	<0.1	0.05	0.241±0.07	Excess according to the standards in 3 farms,

							except DF
Nitrites	mg/dm^3	up to 0.05	0.003	0.003	0.003	<0.003	below the recommended standards
Nitrates	mg/dm^3	up to 2	28.5±2.0	55.1±8.2	26.5±3.9	10.8±2.75	Exceeding the standards
Dry residue	mg/dm^3	110.0±11.0	321.0±32.1	389.0±38.9	285.0±28.5	550.0±55.0	Exceeding the standards
Rigidity	^{0}J	3-7	4.0±0.6	5.0±0.7	4.6±0.7	5.18±0.77	Within the normal range
Phosphates	mg/dm^3	up to 0.5	<0.015	<0.015	<0.05		Within the normal range
Iron	mg/dm^3	up to 0.5	<0.1	<0.1	<0.1	0.129±0.03	Within the normal range
Permanganate oxidizability	mgO_2/dm^3	Up to 10	<0.25	<0.025	<0.025	3.80±1.14	Within the normal range

Comparative characteristics of water quality indicators for fishery purposes performed in the farms of the Krasnodar Territory and the results of water indicators in Kyrgyzstan fisheries established differences in regulatory documents on permissible limits of nitrate and phosphate content [10].

Common colimorphic bacteria and thermotolerant bacteria belong to the indicator group, which determine the water pollution level. Thermo-tolerant coliform and common colimorphic bacteria were found in water samples from farm 3 (Table 4). Since farm 3 contains poultry near the reservoir, which is probably a source of pollution. An additional source of pollution may be the proximity of settlements through which river water flows to the reservoir in farm 3.

Table 4. Comparative analysis of microbiological indicators of water quality of reservoirs for trout cultivation.

Indicator	Meas .unit	Norms of indicators of the Resolution of the Government of the Kyrgyz Republic No. 813 dated 12/15/2017 (for fishery needs)	At the time of monitoring			
			Farm 1	Farm 2	DF KSAU	Farm 3
TMC	cm^3	Up to 1	0	0	0	Was not determined
Thermo-tolerant coliform bacteria (TCB)	cm^3	Not standardized	Not found	Not found	Was not determ ined	Detected
CCB (common colimorphic bacteria) (CCB),	cm^3	Not standardized	Not found	Not found	Was not determ ined	Detected
CB number in 1.0	cm^3	Absent	Was not determin ed	Was not determin ed	If index is less than 3	Was not determined
Salmonella	cm^3	Not standardized	Was not determin ed	Was not determin ed	Was not determ ined	Not found

Kyrgyzstan has been a member of the Customs Union since 2017 and safety regulations, which include TR CU 040/2016 "On the safety of fish and fish products" and TR CU 021/2011 "On Food Safety", which specify the maximum permissible levels of pollutants are of equal importance for the Commonwealth countries.

Fish raw materials – trout samples from 3 farms to assess quality indicators were examined in the laboratory of parasitology and the Department of Chemical Toxicology and Veterinary and Sanitary Expertise of the Center for Veterinary Diagnostics and Expertise (Protocols No. 273 dated 04/08/2024; No. 367 dated 04/3/2024; No. 426, No. 427 dated 04/17/24). Research results (Table5) confirm the safety of fish raw materials. Microbiological indicators do not exceed the standard values. There are no antibiotics and pathogens of parasitic diseases in raw materials.

Table 5. Comparative analysis of fish raw material quality indicators.

Indicator	Farm 1	Farm 2	Farm 3	MPC
Presence of antibiotics	Not found	Not found	Not found	Not allowed
QMAFAnM, CFU/g	1.2×10^2	2.3×10^2	2.0×10^2	No more than 5×10^2
Listeria monocytogenes	Not found in 25.0 g	Not found in 25.0 g	Not found in 25.0 g	Not allowed in the product mass 25.0
Pathogens of protozoa, arachnosis, helminthiasis	No pathogens have been detected	No pathogens have been detected	No pathogens have been detected	Not allowed

3 Discussion

According to the results of laboratory studies, certain conclusions follow, which are indicators of compliance with the quality of water and fish raw materials grown in these reservoirs.

In Finland, over the past 50 years, the quality of water bodies has been monitored on the basis of established base stations. Based on the obtained results of water samples, 20 to 40 physical, chemical and bacteriological parameters are determined annually, which then enter the national database of the Finnish Institute of the Environment (SYKE). The results of the analysis of water samples allow for environmental ranking by class and targeted rehabilitation measures and monitoring the quality of water sources [11].

Based on the experiments conducted with indicators of increased permanganate oxidizability (up to 22.3 mg/l), alkalinity (1.5-4.6 mg-eq/l) when using pre-filters, the possibility of reducing the above indicators to standard values has been proven [12].

In the research of A.V. Karpov [13], norms have been established for the successful cultivation of fish in Russian regions and from a zoohygienic point of view, it is important to consider the factor that for the normal life of fish, the content of nitrates should be within 0.5-1 mg/l, phosphates – in the form of dissolved mineral salts of phosphoric acid. Although in Kyrgyzstan, acceptable values for nitrate content in water are set to 2 mg/l.

Exceeding the indicators for ammonia and nitrates noted in the studied farms indicates fecal contamination, which really proves the inadmissibility of creating fisheries near or directly on the territory of residential settlements and agricultural farms.

In previously conducted studies and published results of the scientific article by Karimov T.Kh., et al., devoted to the assessment of environmental and sanitary safety of water supply sources in Kyrgyzstan, it was determined that 900-1150 million m^3 of various wastewater are discharged into surface water bodies annually. But only 301-635 million m^3 of wastewater are subjected to biological and physical and chemical or mechanical treatment, which is approximately 30% of the total volume of wastewater. Thus, 0.42-0.75 million tons of polluted water are discharged into open water bodies without treatment [14].

The indicators for the dry residue indicate water mineralization, exceeding these values is not a good result, as a result of which it is recommended to install reverse osmosis mechanical cleaning filters.

The main reason for the excess of certain indicators, such as dry residue, water hardness, sulfates, and the excess of E. coli bacteria, for the most part, can be explained by the fact that reservoirs are practically located in the private sector of residential development, there are agricultural farms and fields nearby where crops are grown, and fertilizers are usually used.

The main method of eliminating overestimated values of water quality indicators is the installation of filtration and disinfection systems corresponding to this type of pollution control measures.

According to the information presented in the article by A.V. Besedina [15], to grow high-quality fish that does not accumulate toxic substances, heavy metals, pesticides, and other toxins, as well as hazardous chemical compounds, strict measures should be taken to control and prevent water pollution in aquaculture farms. Constant monitoring of water quality and the use of mechanical water purification technology are necessary. After all, fish during its life cycle accumulates toxic substances from environment in its body, as well as hazardous chemicals and compounds that sometimes lead to serious human diseases.

The quality of fish raw materials directly depends on the conditions of fish keeping during the growing period, the quality of fish feeds and food additives used, as well as preventive measures to prevent fish diseases, as well as the sanitary condition of fish farms.

Based on the conducted research [16] according to the analysis of statistical data on fisheries of the Belgorod region, improved indicators for the chemical composition of raw materials of rainbow trout are noted. The use of domestically produced fish feeds is practiced in the region. Additionally, probiotics, chelated compounds of trace elements, and other biologically active additives are included in the fish diet, which qualitatively affect the results of food safety studies.

When studying foreign experience, in particular the experience of the Republic of Korea, in the development of the fishing industry, it is recommended to introduce smart aquaculture based on scientific research on the artificial breeding of fish species resistant to diseases, with high productivity, which may also include salmon [17].

4 Conclusions

For the successful development of the fish products market in Kyrgyzstan, a lot of efforts should be made to ensure that this agricultural sector is successful not only in the domestic market, but also in the international markets of the EU and EEA countries.

Of particular note is the weak control and implementation of regulatory measures by the state in the field of food safety. The most effective action can be the introduction of a traceability system for the production of a food product - fish from the receipt of fry to the release of the finished product.

When allocating a land plot for fishery activities, violations of the requirements of Veterinary and sanitary standards and requirements for the organization and management of aquaculture should be avoided.

As recommendations, it is necessary to remember about the establishment and regular replacement of filters at the water supply and during its discharge.

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