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Fish Fauna and Assessment of Fish Safety in the Reservoirs of Akmola Region of Northern Kazakhstan

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ABSTRACT

The main direction of increasing the fish capacity of inland freshwater reservoirs is the transition from the simple exploitation of fish stock to the creation of the highly efficient regulated fishery in lakes and reservoirs. By their potential capacity, small and medium-sized lakes can produce significantly more fish with better quality if regulated and properly managed intensive-type lake farms are created.

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GA and ZA conceived and planned the study. AI and TD conducted lab work and drafted the manuscript. GA did statistical analysis of data. AI and GA revised the manuscript.

Key words
Fish, Pond, Lake, Bioproductivity, Trophicity of the lake, Quality assessment.

INTRODUCTION

Today, in the territory of Northern and Central Kazakhstan there are lots of inland reservoirs, the use of which is largely irrational. In this regard, an issue arises that concerns the need for mass study of fish availability in Kazakhstan's reservoirs for the needs of the fishing industry. First of all, this concerns lakes located near large industrial cities, the supply of population of which with high-quality fish products should be a special concern of the country. Therefore, the study of issues of bioproductivity, fishery value of reservoirs and the safety of fish products, in general, is very relevant.

One of the factors that have a great influence on the biocenosis of reservoirs is the anthropogenic impact. Thus, as a result of human activity, many pollutants of various degrees of toxicity can enter the reservoirs, which in their turn can significantly affect the hydrochemical composition of reservoirs, and have a negative effect on zooplankton and fish fauna. These factors include the widespread use of various means of protection in agriculture, inadequate wastewater treatment of industrial and municipal enterprises, removal of radioisotopes from the uranium mining enterprises into the environment, which leads to increasing pollution of reservoirs with compounds toxic for aquatic organisms (Brzoska and Moniuszko-Jakoniuk, 2001; Atchison, 1987; Culotta and Gitlin, 1999; Anderson, 1974, 1990). Meanwhile, it is known that fish in the early stages of development are most sensitive to the effects of toxic environmental factors, they are more susceptible to mass death from infections and invasions when exposed to pollutants (Corbel, 1975; Virbickas and Vaseline, 2000; Muhammad *et al*., 2017; Bedritskaya, 2000). In the past two decades, numerous studies of reservoirs of various types by Russian scientists (Perevoznikov and Bogdanova, 1999; Popov, 2002) have been conducted in this direction.

Kazakhstan has a significant fund of various types of inland reservoirs. Most of them are favourable for the life of fish and forage organisms. However, the scale of pollution of rivers and lakes in Kazakhstan is becoming critical. Environmentalists of the Ministry of Environmental Protection (MEP) in the latest issue of the departmental bulletin noted: of the 69 rivers of Kazakhstan, only 9 are recognised as clean. The remaining 60 are polluted. At this stage, the question arises of the need to study the safety of fish for the needs of the fishing industry in the waters of Kazakhstan in general.

The goal was set to study the degree of fish contamination in the reservoirs of the Akmola Region with toxic elements and radionuclides, as well as to establish its infection with helminthiases and bacterioses.

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MATERIALS AND METHODS

According to the information on the development of quotas for fish and other animals in the reservoirs of the Akmola Region, fixed and reserve reservoirs of 17 districts of the Akmola Region were studied for research work. Having studied the data on reserve reservoirs of these areas, the following lakes were selected for scientific research: Lake Shnet (Tselinograd district), Shelkar (Arshalinsk district), Uyaly-Shalkar (Korgalzhinsk district) and Maydan Dam (Arshalinsk district). Documents for obtaining permits for fauna use were generated and submitted to the Department of Natural Resources and Environmental Management of the Akmola Region; in addition, permits for research fishing were obtained (KZ49VEP00036014, KZ46VEP00036068, KZ73VEP00036067, KZ03VEP00036066).

Research work was carried out on the basis of the Fishery Research Centre at the Department of Game and Fishing Management, the laboratory of the Department of Veterinary Sanitation of S.Seifullin KATU JSC, and Republican Veterinary Laboratory RNE.

Field expedition work on the collection of materials for scientific research was carried out in three stages. The first trip was from May 19 to May 28, 2018, the second trip was from July 16 to July 25, 2018, the third trip was from September 17 to September 26, 2018.

Ichthyological data collection was conducted to assess the species, age composition of fish populations, their mass and size, the presence of valuable commercial/rare species.

In the studied reservoirs, only stationary nets with mesh sizes from 20 to 80 mm were used. At each station, the nets were stationed overnight, the fishing time was approximately 12 hours. When fishing time increased or decreased due to weather or other reasons, the catch amount was recalculated per unit of time (net/day).

Processing of catch with stationary (gill) nets included the (i) species identification; (ii) calculation of the total number and weight of each species in the catch of each net; (iii) mass measurements (measurement of the fishing length) of the entire catch; (iv) a selection of the most widespread species was conducted, for which biological analysis was performed. The sample size was determined at the rate of 10 specimens of each analysed species for every centimetre of the length of fish of this species.

The biological analysis included (i) the measurement of the total body length of the fish (L); (ii) measurement of the body length of the fish without a tail fin (ℓ); (iii) measurement of total body mass (Q); (iv) determination of fatness; and (v) selection of material to determine the age.

Material collected to determine the age of fish is stored in scale books. Fish samples prepared for laboratory analysis were fixed with 10% formalin solution.

Assessment of the number and biomass of fish, the determination of the maximum allowable amount of extraction was carried out according to the method for passive fishing gear (Kushnarenko and Lugareva, 1989). According to this method, the assessment of the number and biomass of fish was conducted using the formula:

$$N=QS/CKP$$

where N is the number or biomass, thousand pieces/ton; Q is the average number or biomass according to the catch, units; S is the area of the reservoir for the study period, ha; C is the area of fishing operations (ha), which is determined taking into account the total number of the used net to account for commercial stocks; K is the factor of power of nets used and is 0.5; P is the probability of fish entering the net due to the angle of attack.

When determining the number and biomass of fish, it is necessary to take into account the proportion of the reservoir area occupied by each species. Extraction rates will be determined in accordance with the age at which females of the population enter maturity.

Evaluation of the number and biomass of fish, the determination of the maximum allowable amount of extraction was performed according to the method for passive fishing gear (Kushnarenko and Lugarev, 1989; Mukhachev, 1989; Pravdin, 1966).

Determination of the degree of fish contamination with toxic elements and radionuclides was performed on the basis of the Republican Veterinary Laboratory RSE REM of the Committee for Veterinary Control and Supervision (CVCS) of the Ministry of Agriculture of the Republic of Kazakhstan in the accredited Food Safety Analysis Laboratory (international standard ISO/IEC17025). For research, samples of fish of various species (crucian carp, bream, roach, perch, carp, and pike) were sampled directly from reservoirs of the certain districts of the Akmola Region.

The determination of the content of toxic elements (lead, mercury, cadmium and arsenic) was performed on a TA-Lab voltammetric analyser. Radioactive contamination has been established according to the amount of caesium-137 and strontium-90 radionuclides determined using the beta-gamma spectrometric complex Progress (manufactured by Russian company Tomanalit).

For the analysis of contamination by toxic elements, fish from three reservoirs, namely Lake Shnet (Tselinograd district), Maydan Dam (Arshalinsk district), Lake Uyaly-Shalkar (Korgalzhinsk district) were selected; in addition, samples of fish directly from the food markets were selected; in general, 50 samples were tested.

The determination of the infection of fish with

helminthiases was performed by the method of a complete helminthological study, which includes the study of mucus, scales, gills, eyes, internal organs and muscles by the visual and compressor method. In a clinical study forbacterioses, the skin and fins were carefully examined at first; special attention was paid to the quantity and quality of mucus, discolouration, the presence of swelling, haemorrhages, ulcers, scars, cysts, raised scales, etc. Gill covers were lifted and gills were examined. The sick fish were recorded in absolute and percentage values (incidence).

Studies on the most common helminthiasis were conducted; namely those studies included the examination for trienophoresis, ligulosis, diplopstomiasis, postdiplopstomiasis, filometrociasis, tapeworms and roundworm larvae, for the presence of spores, crustaceans and fungi (not dangerous for humans, but significantly reducing the quality of fish), as well as for opisthorchiasis, metagonimiasis, diphyllobothriasis (dangerous to humans). The study was conducted on six species of fish (crucian carp, bream, roach, perch, carp, and pike), a total of 290 specimens of fish were examined.

The statistical processing of the material was carried out using the Microsoft Excel software package. The difference in mean values was estimated by Student's test and probability P, which was recognised as statistically significant at $P \geq 0.95$, by (Plokhinskiy, 1961; Vassilyeva, 2004) algorithms.

RESULTS AND DISCUSSION

The size-age and species composition of fish in reservoirs of the Akmola Region weredetermined. Thus, rich species composition of fish fauna is noted in LakeUyaly-Shalkar, and it is represented by 9 species, namely *Carassius auratus gibelio* B*, Rutilus rutilus lacustris, Abramis brama, Percaf luviatilis* L*., Leucis cusidu sidus, Esox lucius* L*., Sander lucioperca, Gymnocephalus cernua, Cyprinus carpio*. Of these, bream and pike-perch are introduced species. In Lake Shnet, the species composition is represented by 4 species, namely *Carassius sauratus, Carassius carassius, Rutilus rutilu slacustris*, *Cyprinus carpio*. In this case, all species are native ones. In the Maydan Dam, the species composition is represented by 3 fish fauna species, namely *Rutilus rutilu slacustris, Perca fluviatilis* L*., Esox lucius*. In Lake Shelkar, during the control setting of nets, no representatives of the fish fauna were found. The absence of fish fauna in this lake is explained by the fact that the reservoir was almost dry three years ago. Water collection was observed only in the last two years.

When determining the size-age composition, the following results were obtained. Indicators of the fish population size in Lake Uyaly-Shalkar are presented in Table I.

Prussian carp was found in size classes from 14 to 42%. Most of them are recorded in size classes 16, 18, and 20. The least occurrence was in size classes 26, 30, and 38. This species is the most encountered in net catches in the studied reservoir. Of the total catch, 81.25% is found in the nets with a 40 mm mesh. Pike is represented mainly in the larger size classes (26-42%).

At Lake Shnet, the greatest number of crucian carp was in size classes from 8 to 24%, while the Prussian carp was mostly caught in stationary nets with mesh sizes from 40 to 50 mm. Carp and roach were found in size classes of 10-12%. A small number of crucian carp was found in nets with 20 and 30 mm meshes. More than 52.5% of the catch of crucian carp was from the nets with a mesh size of 20 mm (according to the results of the spring expedition). With regards to the Prussian carp, 60.3% of it is caught by the nets with a mesh size of 50 mm.

The study on the Maydan Dam showed the roach in the catches was mainly in the 14-26% size classes. There was no catch in the remaining lines of nets. Only one specimen of the pike was caught in nets with a mesh size of 30 mm. Perch in the dam is noted in all age classes. Its highest occurrence is in the 14% age class, the smallest in the larger 34-38% classes.

When determining the age composition of reservoirs, the following results were obtained. Thus, the age structure population of Prussian carp on Lake Uyaly-Shalkar is represented by the older age group (65% of the total catch). According to the catch in net lines, roach, perch, pike, and ide in the lake are presented in all age groups. Carp and ruff were noted only in younger age groups, 100% of the total catch.

In Lake Shnet, carp and roach in the age composition were noted only in the younger age groups. The main catch in the lake was represented by Prussian and crucian carp. According to the catch in net lines data, the population of these species of fish is represented by all age groups (95% of the total catch).

There are two species of fish in the Maydan Dam, namely Siberian roach and perch, which are represented in all age groups, whereas pike in this lake was only in the third-age structure of the population.

Thus, the following species composition of fish fauna was determined: 9 species in Lake Uyaly-Shalkar, 4 species in Lake Shnet, 3 species of fish fauna in the Maydan Dam, and no fish fauna in Lake Shelkar.

Table I.- Size structure of the population of Lake Uyaly-Shalkar.

Size classes. %												Average length. cm
14	16	18	20	22	24	26	28	30	34	38	42	
***Carassius auratus gibelio* B**												
5.2	25.2	26.1	25.6	5.2	3.9	2.6	3.5	1.3	-	0.9	0.5	20.1
Rutilus rutilu slacustris												
50	18.6	11.5	7.8	6.2	2.0	2.7	1.2	-	-	-	-	18.1
***Perca fluviatilis* L.**												
-	43.2	8.2	13.5	10.4	12.3	10.4	-	2.0	-	-	-	17.5
***Esox lucius* L.**												
-	-	-	-	-	-	41.6	8.3	8.5	8.3	16.7	16.6	30.4
Abramis brama												
22.9	-	-	5.7	11.5	14.3	22.8	8.5	8.6	2.8	2.9	-	25.7
Leuciscus idosidus												
21.4	7.1	7.2	-	-	7.2	-	14.2	28.5	7.2	7.2	-	19.8
Sander lucioperca												
-	12.5	25	-	12.5	-	-	-	-	37.5	-	12.5	30.3
***Gymnocephalus cernua* L.**												
83.4	16.6	-	-	-	-	-	-	-	-	-	-	-

By age composition, Prussian carp and bream in Lake Uyaly-Shalkar are presented in all size classes; in Lake Shnet, the crucian carp is found mainly in the younger age groups, and the Prussian carp is mainly found in the older age groups. The frequency of occurrence of Siberian roach and perch in the Maydan Dam was noted for the entire size composition, which suggests the population is in good conditions of existence.

By the species structure, the population of roach, perch, pike and ide was found in Lake Uyaly-Shalkar; Prussian and crucian carp were found in Lake Shnet, and Siberian roach and perch were found in the Maydan Dam.

The determination of residual amounts of toxic elements in fish meat was carried out in the context of the fish species and reservoirs from different districts of the Akmola Region; the following data was obtained and presented in Table II. It shows that the residual amounts are found in almost all samples, however, excess of the maximum permissible concentrations is not observed.

In terms of cadmium content, the greatest accumulation is observed in roach meat (0.0102 ± 0.0002 mg/kg), followed by carp (0.0052 ± 0.0000 mg/kg), perch (0.0041 ± 0.0001 mg/kg), bream (0.0037 ± 0.0001 mg/kg), pike (0.0032 ± 0.0000 mg/kg) and the lowest content was in crucian carp meat (0.0016 ± 0.0000 mg/kg).

In terms of lead content, the greatest accumulation is observed in carp meat (0.420 ± 0.002), followed by crucian carp (0.305 ± 0.002 mg/kg), perch (0.268 ± 0.012 mg/kg), roach (0.126 ± 0.002 mg/kg) and the lowest content was in pike (0.108 ± 0.001). The amount of mercury in the largest amount was noted in bream meat (0.028 ± 0.0002), followed by carp meat (0.024 ± 0.0001 mg/kg), roach (0.019 ± 0.0001 mg/kg), perch (0.013 ± 0.0002), and the lowest content was in pike and carp (0.009 ± 0.0002 mg/kg). The arsenic content was observed, respectively, in crucian carp (0.055 ± 0.001 mg/kg), perch (0.052 ± 0.002 mg/kg), carp (0.044 ± 0.003 mg/kg), pike (0.037 ± 0.001 mg/kg), roach (0.033 ± 0.001 mg/kg) and the lowest content was in bream meat (0.029 ± 0.001 mg/kg).

Thus, it was found that there is no excess of residual amounts of toxic elements in fish meat from reservoirs of the Akmola Region, while their accumulation in the meat of different fish species is not even; in most part, the residuals accumulate in the meat of fish such as carp, crucian carp, roach, and pike, which is the least harmless one.

When determining the content of toxic elements in the meat of fish from reservoirs located in different areas of the Akmola Region, the following data was obtained (Table III). It shows that the residual amounts of toxic elements are found in almost all samples, but they do not exceed the maximum permissible concentrations.

Table II.- Determination of the degree of contamination by toxic elements of various fish species in reservoirs of the Akmola Region.

Kind of fish	n	Toxic elements (mg / kg)			
		Cadmium	Pb	Hg	As
Crucian. n=13	13	0.0016±0.0000	0.305±0.002	0.009±0.0001	0.055±0.001
Perch. n=11	11	0.0041±0.0001	0.268±0.012	0.013±0.0002	0.052±0.002
Roach. n=9	9	0.0102±0.0002	0.126±0.002	0.019±0.0001	0.033±0.001
Bream. n=6	6	0.0037±0.0001	0.185±0.001	0.028±0.0002	0.029±0.001
Carp. n=6	6	0.0052±0.0000	0.420±0.002	0.024±0.0001	0.044±0.003
Pike. n=5	5	0.0032±0.0000	0.108±0.001	0.009±0.0002	0.037±0.001
Permissible concentration		0.2 mg / kg	1.0 mg / kg	0.6 mg / kg	1.0 mg / kg

Table III.- Toxic elementcontamination of fish (mg/kg) sampled from various reservoirs of the Akmola Region and markets of Astana.

Toxic element	Permissible concentration	Lake Shnet (n=15)	Maidan Dam (n=15)	Lake Uyaly-Shalkar (n=10)	Markets Astana city (n=10)
Cadmium	0.2	0.002±0.000	0.002±0.000	0.007±0.002	0.004±0.000
Pb	1.0	0.280±0.041	0.147±0.001	0.422±0.061	0.281±0.003
Hg	0.6	0.009±0.001	0.015±0.001	0.017±0.001	0.015±0.001
As	1.0	0.058±0.002	0.053±0.002	0.034±0.002	0.046±0.002

Table IV.- Radionuclide contamination of fish (Bq/kg) from the reservoirs of the Akmola Region.

Radionuclides	Permissible concentration	Lake Shnet n=15	Maidan Dam n=15	Lake Uyaly-Shalkar n=10	Markets Astana city n=10
Cesium 137	130	60.0 (in 1 sample)	32.10 (in 1 sample)	32.50±0.6 (4 samples)	12.75±0.2 (3 samples)
Strontium 90	100	26.1±0.4 (8 samples)	14.57±0.2 (8 samples)	17.76±0.2 (4 samples)	22.075±0.6 (5 samples)

Thus, in terms of cadmium content, the greatest accumulation is observed in the meat of fish from Lake Uyaly-Shalkar (Korgalzhinsk district), where its amount was 0.007 mg/kg, which is 3.5 times higher than in the meat of fish from Lake Shnet (Tselinograd district) and MaydanDam (Arshalinsk district), where its content was respectively 0.002 mg/kg; in fish samples taken from markets, its content was 0.004 mg/kg (1.75 times). In terms of lead content, the greatest accumulation is also observed in the meat of fish from Lake Uyaly-Shalkar and amounted to 0.422 mg/kg; 0.280 mg/kgin fish from Lake Shnet, 0.147 mg/kg in fish from the Maydan dam, and 0.281 mg/kg in fish from markets. The mercury content in fish samples from Lake Uyaly-Shalkar was 0.017 mg/kg, which is almost two times higher than in fish from Lake Shnet, 0.009 mg/kg. In fish samples from the Maydan dam and from the markets, its amount was 0.015 mg/kg.

The highest content of arsenic is found in fish from Lake Shnetand amounts to 0.058 mg/kg, 0.053 mg/kg in fish from the Maydan dam, the smallest amount 0.034 mg/kg in fish from Lake Uyaly-Shalkar and0.046 mg/kgin fish from markets.

Thus, the most contaminated with toxic elements is fish from Lake Uyaly-Shalkar in Korgalzhinsk district, wherethe residual amounts of cadmium exceed 3.5 times, mercury exceeds 1.8 times and lead exceeds 1.5

and 2.8 times when compared to fish in the reservoirs of Tselinograd (Lake Shnet) and Arshalinsk (Maydan dam) districts. However, with regard to safety, the fish in the reservoirs proved to be harmless.

A radiological study was conducted to determine the presence of residual amounts of radionuclides in fish meat; the obtained results are shown in Table IV.

Excess of maximum permissible concentrations was not observed, and the residual quantities of radionuclides were not detected in all fish samples. Thus, the content of caesium-137 in fish from Lake Shnet was found only in a single sample and was 60 Bq/kg; in fish from the Maydan dam, it was also found only in one sample and amounted to 32.1 Bq/kg; in fish from Lake Uyaly-Shalkar, it was found in 4 samples and amounted to an average of 32.5 Bq/kg; in fish from the markets, it was found in three samples and amounted to 12.75 Bq/kg.

The content of strontium-90 was 26.1 Bq/kg in fish from Lake Shnet (8 samples), 14.57 Bq/kg in fish from the Maydan Dam (8 samples), 17.76 Bq/kg in fish from Lake Uyaly-Shalkar (5 samples), and 22.075 Bq/kg in fish from markets (5 samples). Thus, the presence of residual amounts of radionuclides in individual fish samples was determined, while an excess of the maximum permissible concentrations was not observed, which indicates the safety of fish in this assessment parameter.

The study of fish from reservoirs for the presence of helminthiases determined the presence of only one disease, namely opisthorchiasis, and only in one species of fish, namely roach (caught from the reservoir of Maydan Dam of Arshalinsk district). Thus, out of 29 specimens of this type of fish examined, 21 were infected, while the extensiveness of invasion was 72%, the intensity of invasion ranged from 1 to 8 metacercariae.

When studying infection of fish with infectious diseases, the clinical signs helped to determine two cases of infection of Prussian carp from Lake Shnet (Tselinograd region) with bacterial haemorrhagic septicaemia (infectious ascites of carps); no bacterioses were found in fish from other reservoirs. Thus, infection of roach with the opisthorchiasis was determined in the reservoir of the Maydan dam with a high extent of invasion amounting 72% and an intensity of invasion of 1–8 metacercariae; in addition, single cases of infection of Prussian carp from Lake Shnet with bacterial haemorrhagic septicaemia (infectious ascites of carps) in the initial stage were determined.

CONCLUSION

In the course of the study, it was found that the residual amounts of toxic elements are detected in almost all fish samples from reservoirs of the Akmola Region. At the same time, their accumulation in the meat of different fish species is not even, in the greatest amount they accumulate in the meat of such fish like carp, crucian carp, roach, and pike, which is the least harmless one. The most contaminated with toxic elements is fish from Lake Uyaly-Shalkar, Korgalzhinsk district, where the residual amounts of cadmium exceed 3.5 times, mercury exceeds 1.8 times and lead exceeds 1.5 and 2.8 times when compared to fish in the reservoirs of Tselinograd (Lake Shnet) and Arshalinsk (Maydan dam) districts. The residual amounts of caesium and strontium radionuclides are detected only in individual fish samples, and no excess of the maximum permissible concentrations is noted, which indicates the safety of the fish in this assessment parameter. Only one species of fish was infected with opisthorchiasis, namely roach from the MaydanDam reservoir in the Arshalinsk district with a high extent of invasion amounting 72% and an intensity of 1-8; in addition, single cases of infection of Prussian carp from Lake Shnet of the Tselinograd districtwith bacterial haemorrhagic septicaemia (infectious ascites of carps) in the initial stagewere detected.

Statement of conflict of Interest

Authors have declared no conflict of interest

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