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Bio-Resources as the Object of Natural Resource Management of Lakes in the Kurgan Region

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***Abstract*—In the conditions of the market system the attitude towards the natural resources and their use in the economics has changed. It is necessary to reconsider and reform the mechanism of their management with the aim of the improvement of the natural resource management efficiency (in this case, of lakes). At the same time, not only the economic interest and ecological factor should be taken into account, but also the consequences of the bio-resources irrational use. That is why audit of lakes of the Kurgan region has been undertaken, which allowed studying the conditions of the formation and the development of the natural objects. Based on the received data, the prognosis of their further use has been calculated. It can become the basis for the development of the projects of rational nature use and environmental management. Also, the received results will allow enlarging the directions of the regional natural use and making regional administration and entrepreneurship take an interest in investing.**

Keywords—natural resource management, lakes' natural resource management, bio-resources, fishing, brines, bottom deposits, recreation potential.

I. INTRODUCTION

The problems of the lake natural resource management are among understudied ones in the domestic school of geography. This is due to the fact that natural resource use was developed as an economic direction (environmental economics) and the specialization of the researches was carried out according to the kinds of "sectoral" natural resource use. That is the reason why lake natural resource use was ignored and was not considered in scientific works.

Our research was based on the works of domestic authors in the field of geography (V.S. Preobrazhenskiy, A.M. Trofimov, A.I. Chistobaev, M.D. Sharygin and others), in the field of ecology (N.M.Kozlova, A.P.Kuzmin and others), in the field of environmental protection and natural resource use (N.M. Ratner, N.F. Reymers, Ya.Ya. Yandyganov).

The basis of our article is such notions as "natural resource use", "rational natural resource use", "economic efficiency of natural resource use".

Ya.Ya. Yandyganov, V.F. Protasov, A.V. Molchanov, S.A. Surkova and others considered the notions "natural resource use", "rational natural resource use" and "environmental protection" in their works. These notions are synonymic because of the synthetic character of the science of natural resource use, presupposing ecological knowledge.

Having studied the questions of the natural resource use status of N.F. Reymers, Ya.Ya. Yandyganov, V.A. Osipov, O.G. Zavyalova, our own notion of the lake natural resource use has been proposed. It has been seen as the targeted use of lake resources to meet the society needs through intensive reproduction of lake resources.

Due to the appearance of a new direction "environmental economics" V.F. Protasov, S.N. Bobylev, A.Sh. Khodzhaev and others developed new methods of definition of the natural resource use efficiency. One of them was used while writing the article. It is the cost-effectiveness from the economic activity in the lakes of the region.

In the conditions the market economy and regional management organization each constituent entity of the Russian Federation is interested in the maximum development of the regional management, so the lake natural use has turned out to be in demand in practical terms for the Kurgan region, which is not rich in natural resources.

II. RESEARCH METHODS

The object of the research is the lake bio-resources of Zauralie. The description of the peculiarities of the lake natural resource use has been carried out on the basis of hydrological, landscape, economic and ecological researches of the Kurgan region.

The materials of the State environmental protection committee of the Kurgan region, the Committee of natural resources of the Kurgan region, open society "Kurganrybkhoz", the laboratories of geo-informational researches and technologies of the Kurgan state university served as the data basis while writing the article.

The methods of the research are general scientific: economic-mathematical, statistical, cartographic, systematic and comparative analysis [1].

The undertaken inventory control of the lakes of the Kurgan region has allowed studying the conditions of the formation and development of the natural objects. Based on the received results, the prognosis of their further use has been calculated, it could become the basis for the project elaboration of the rational natural resource use and environmental management.

III. RESULTS

In the lakes of Zauralie three types of resources have been examined: fish, bio-fodders and therapeutic muds. In lake objects 27 species of fish exist, among them the widespread ones are: golden and crucian carp, pelyad, roach, perch, ide, lake minnow, pike, ruff and acclimatized bream [2]. The

region has 5.5 thousand lakes, among which 374 fishing industry grounds with an area of 114.5 thousand hectares are assigned to fishing enterprises (data date 31 December 2018 from the report on the natural resources and environmental protection of the Kurgan region in 2017).

The dynamics of the production of fishery and bio-fodders in the region since 2014 to 2017 is presented in table 1. It is clearly seen from the given data that for 4 years there has been a general increase of the fish and bio-fodder catch by 60% in common, which is connected with their rising demand [3].

In addition to fish resources from the lakes of the region biological fodders such as artemia, daphnia, koretra, bloodworms are extracted. But the greatest practical interest is the lake sandhopper gammarus, the production of which is an auxiliary direction in the lake nature management. At cost this biological product is low and its market value is high, which gives a good economic profit. The production of gammarus comprises 70% of the total catch of bio-fodders. Its cultivation and realization is an economically profitable branch of the agriculture of our region area [2]. Using the systematic analysis of the methods, applied for the management of aquatic ecosystems [1], there is a possiblity to increase fishing by 1.5-2 times in comparison to the current level and the subsequent stabilization of the use of this biological resource.

In the past two years 25 users of various forms of the ownership have participated in the fishery of bio-fodders. The fishing was going on in 59 lakes of Vargashinskiy, Dalmatovskiy, Ketovskiy, Kurtamyshskiy, Lebyazhievskiy, Makushinskiy, Mishkinskiy, Petukhovskiy, Polovinskiy, Safakulevskiy, Tselinnyiy, Chastoozerskiy, Shumikhinskiy and Schuchanskiy areas of the Kurgan region [4]. The data in table I show that from 2014 to 2017 the production of bio-fodders decreased by almost 2.8 times but the catch of fish increased by 3 times. Of these, the catch of pelayd increased by 2017 and amounted to 57 % of the total production of fish resources and crucian carp – to about 30% [3]. However, the Kurgan region is potentially able to increase the production of the fish and bio-fodders by 3-5 times.

TABLE I. THE EXTRACTION OF LAKE RESOURCES IN THE KURGAN REGION FOR PEROD 2014 – 2017 (TONS)

Bioresource	**2014**	**2015**	**2016**	**2017**
Crucian carp	510.72	715.5	847.05	960.7
Bloodworm	13.33	12.94	33.2	28.7
Verkhovka	-	-	2.0	0.25
Pelyad	368.6	1200.0	606.1	1553.6
Minnow	1.07	1.82	4.7	1.65
Perch	13.45	14.007	44.7	22.2
Sazan	0.1	0.145	15.375	24.6
Pike	2.8	4.8	14.9	9.7
Bream	2.1	1.5	3.95	0.7
Pike-perch	1.4	-	2.55	0.7
Ruff	0.02	-	-	-
Roach	1.38	0.7	1.9	8.0
Rhotane	28.5	27.3	47.98	44.1
Ide	0.165	-	0.45	-
Carp	-	26.4	131.5	31.0
Freshwater catfish	-	8.5	-	-
Burbot	-	-	0.16	-
IN TOTAL	**943.7**	**2013.62**	**1756.5**	**2685.9**
Gammurus	703.4	688.7	693.92	332.5
Artemia	309.7	52.1	210.76	167.3
IN TOTAL	**1023.1**	**740.8**	**904.68**	**499.8**
IN ALL	**1956.8**	**2754.42**	**2661.18**	**3185.7**

Many lakes of the Kurgan region have the most valuable medicinal properties. Zauralie's lakes have different composition of brines and bottom sediments of different types (peloids, sapropels, silt mud). According to the composition of the water, the following lakes are distinguished: chloride (chloride-sulfate) sodium, chloride-sulfate-bicarbonate-sodium and bicarbonate (bicarbonate-chloride) sodium or soda (table II).

In the southern part of the region the lakes have highly mineralized water (up to 10-59 g/l). Here the evaporation is several times higher than precipitation. A special role is played by medium-mineralized lakes with sulfide sapropels, combining the properties of sulfide mineralized mud and freshwater sapropels. Such lakes are unique and are found only in the Kurgan region. Among the most famous lakes of this type are lake Gorkoe of the Zverinogolovskiy area (sanatorium "Pine Grove"), Setovskie lakes in the Tselinnyiy area, a unique lake Gorkoe (Uzkovo) of the Kurtamyshskiy area, where soda comprises 95% in the brine.

Increased concentrations of trace elements of bromine, iodine, molybdenum play an important role in the life of the body despite their small amount in water. The presence of these trace elements, especially in drinking mineral waters, often determines their balneological and therapeutic value [5].

TABLE II. LAKES OF THE KURGAN REGION WITH THE PRESENCE OF BALNEOLOGICAL RESOURCES IN THEM

Area	**Name of lake**	**S*(sq km)***	**Mineralization *g/l***	**Water chemical quality**	**Type of mud**	**Mud chemocal quality**	**Mud stock *(thousand cub.m)***	**Layer thickness *(m)***
Vargashinskiy	Vargashi-	1.546			Clay		1200	
Zverinogolovskiy	**Gorkoe**	**8.8**	**12...60**	**Ch -B- Na**	**Transition type**		**825**	**0.15-1.6**
Ketovskiy	Krutaly	19.53			Clay saprop.		482	0.15-0.20
Kurtamyshskiy	Gorkoe	4.6	9...13	B- Na	Transition type		500	1.4
	(Uzkovo)			(soda)	saproplel			
	Sukhanov-	0.6	15...100	Ch -S- Na	Transition type		150	
	Isakovskoe	0.96	45...	Ch - Na	Silt	Miner.	250	
Lebyazhievskiy	Gorkoe	6.8			Silt	Hydrogen sulphide	1600	
	Kamyshnoe	0.4			Clayed silt		800	
	Kisloe	5.5			Transition type		250	
	Kolmatskoe	21.01			Silt	Hydrogen sulphide	1500	
	Lebyazhie	9.4			Clayed silt		500	
	Priezzhie	6.4			Clayed silt		400	

	Balakul	13.1			Transition type		1000	
	Suerskoe	21.5			Transition type		1000	
Makushinskiy	Gorkoe	3.5	47…63	Ch -S- Na	Silt	Sulphide	300	
	Baskoe	8.8			Silt		3000	
	Elanach	20.5			Silt		1240	
	Sazykul	61.7			Clayed silt		5000	
	Semiskul	4.2			Clayed silt		400	
Petukhovskiy	**Medvezhie**	**64.3**	**120…155**	**Ch - Na**	**Silt**	**Sulphide**	**14407**	**0.25-1.2**
	B.Kamennoe	2.4			Clayed silt		143	
	Aktaban	2.9			Silt		2000	
Tselinnyiy	Setovskaya				Silt			
	group:				Sapropel		1000	
	B.Zasechnoe	2.2	37-53-150	Ch - Na	Transition type	Sulphide	120	1.2
	M.Zasechnoe Dolgoe	1.8 2.6	50…60 25…30	Ch -Г- Na Ch -B	Transition type Transition type		300	1.8 2
	Krugloe	1.08	50...55	Ch -B	Transition type		100	1
Chastoozerskiy	Dolgoe	2.07			Clayed silt		800	
	Kabanie	13.8			Clayed silt		2000	
Shatrovskiy	Pustynnoe	1.54	0,2...	B-C	Sapropel		50	
Shumikhinskiy	Gorkoe	1.2	15.55	Ch -Na	Silt		1240	
	(Ptichie)							
	Solyonoe	0.5	25...30		Transition type		120	1.7
Schuchanskiy	**Gorkoe-**	**5.8**	**25...45**	**Ch -S-B**	**Sapropel**		**3077**	**1.5**
	Viktoriya			Na-M	Transition type			
Yurgamyshskiy	Okunevskoe	24	2...5	Ch-S	Sapropel		500	

Note: B-bicarbonate, Na-sodium; SA-sulfate, alkaline; Cb-carbonate; C- K-calcium; M-magnesium; C-calcium; M-magnesium; Ch - is chloride

It is worth paying a special attention to the fact that a good resource base of the region could be used better in the sanatorium economy. But the riches of the lakes is used by only few sanatoriums and this activity is not centralized, which harms the lakes and makes them unsuitable for the future use for medicinal purposes [2].

Also, the region has quite a high recreational potential (forests, lakes, resorts, quarries, within the city - beaches), so there are great opportunities for the development of mixed recreation. But due to the underdevelopment of recreational infrastructure, it is poorly used. It should be noted that uncontrolled recreation of a number of lakes, which are popular with residents of the region, has already lead to the degradation of both the lakes themselves and landscapes around them (for example, lake Gorkoe in the Zverinogolovskiy area).

In our opinion, it is necessary to introduce the rational management system together with the growth of investment, which will create an economically and environmentally beneficial recreational system on the territory of the Kurgan region.

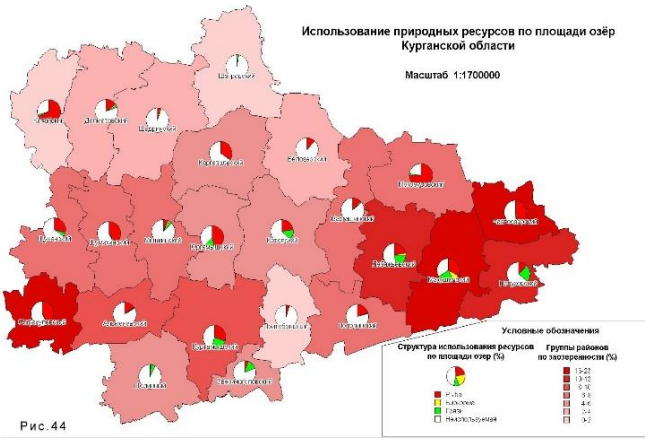

Fig. 1. Use of natural resources in terms of area of lakes of the Kurgan region [compiled by the authors]

On the basis of the analysis of the lake natural resource use of the region (picture1), it is revealed that about 60% of the area of lakes of the region is not used in the economic activity. The use of natural resources in the lakes is as follows: fishing is in the first place (28.1% in terms of the area of the region's lake); the second place takes deposits of therapeutic mud (10% in terms of the lake area) and it is extracted only from the three lakes: Medvezhie (the Petukhovskiy area), Gorkoe (the Zverinogolovskiy area), and Gorkoe-Victoria (the Schuchanskiy area); the third place goes to the production of bio-fodders (1.6% in terms of the lake area).

The comparative analysis of the economic efficiency of the lake natural resource use in the region's areas has revealed two types of districts: economically profitable and economically unprofitable. The first type includes areas: the Lebyazhevskiy, the Belozerskiy, the Petukhovskiy, the Shumikhinskiy, the Vargashinskiy and the Makushinskiy, with the highest level of the production of natural resources per unit of the lake land. Due to the therapeutic mud these areas have a high ratio index (the average for the region is 306.2 thousand rubles).

The most economically unprofitable are the Kataiskiy, the Pritobolnyiy and the Shadrinskiy areas (picture 2) [2].

The conducted calculations have shown that the full economic assessment of the three lake resources in the region will comprise about 350 billion rubles (at full extraction and use of therapeutic mud in three areas), and their ratio index will be 315.6 thousand rubles per capita. Taking into account the fact that only 0.006% of mud is extracted, the real evaluation of lake resources comprises 2254.07 million rubles, which means that their real ratio index is 2.05 thousand rubles.

Satellite images Landsate, programs "MapInfo Professional", "PCI Geomatica" [6] and algorithms have helped to identify promising lakes for the extraction of bio-fodder - gammarus and of balneological resources.

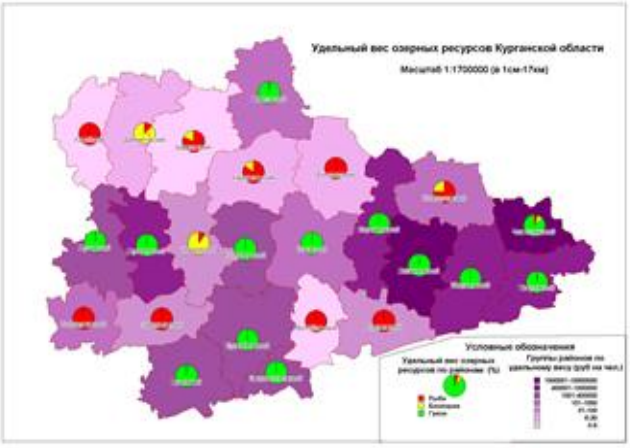

Fig. 2. Ratio index of lake resources of the Kurgan region [compiled by the authors]

It is revealed that the total number of lakes with gammarus is 2957, with an area of 1891.5 km2. The Eastern part of the region is studied in more details (picture 3). The research data have showed that the number of promising lakes is 1157, with an area equal to 902 km2, of which the most promising reservoirs are 377, with an area of 442 km2 (the average area is 1.2 km2). The calculated and actually known data have allowed extrapolating the average productivity of these lakes, which comprised 18.9 t/km2. Also, it is calculated that only this part of the region has a stock of gammarus by 12-13 times more than we know.

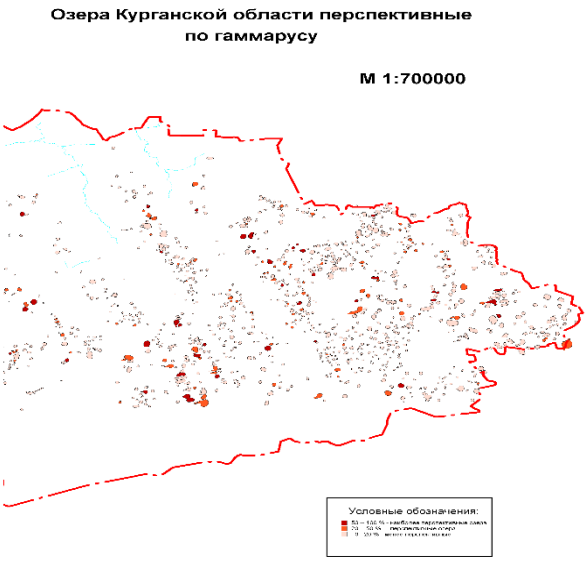

Fig. 3. Promising lakes of the Kurgan region in terms of gammurus [compiled by the authors]

Consequently, this stock can bring additional income to the regional budget from this lake bio-resource by several times more in comparison with the actual income.

The difficult situation is with the study of the prospects of the production of artemia as there is little information about it since it is extracted only in two lakes: Filatovo (the Lebyazhevskiy area) and Sorochie (the Tselinniy area). Other types of bio-fodders, in particular bloodworms, koretra and daphnia can be used as additional fodders to biological resources.

While studying prospective lakes in terms of balneological resources, it was revealed that large and medium-sized lakes, located in the bottoms of pradolinas, contain therapeutic mud and brine. The consideration of the minimum thickness of mud deposits of the actually studied lakes allowed us to estimate the general prospective reserves of therapeutic mud. Fresh water bodies were not included in the research sample, the estimate of the total reserves of sapropel lakes is a bit underestimated. Sapropel type of therapeutic mud is very common and is the cheapest in price. On the basis of the made map “Promising lakes of the Kurgan region, in terms of balneological resources” (picture 4), the promising lakes have been identified in the amount of 319 with an area of 1084 km2, the average area of which is 3.4 km2. And it is 5 times more than actually known, their area is bigger by 2 times and, consequently, the economic assessment of these lakes has to be on average by 2 times higher.

Out of administrative areas, the Lebyazhevskiy, the Makushinskiy, the Mokrousovskiy, the Safakulevskiy, the Belozerskiy and the Shumikhinskiy areas stand out in terms of long-term benefits of both resources though even nowadays these are areas with the best situation from the economic point of view. Good prospects for gammarus and therapeutic mud is observed in the areas of the Almenevskiy, the Vargashinskiy, the Kurtamyshskiy, the Petukhovskiy, the Polovinskiy, the Shchuchanskiy and the Yurgamyshskiy.

Fig. 4. Promising lakes of the Kurgan region in terms of balneological resources [compiled by the authors]

The Kargapolskiy, the Mishkinskiy, the Tselinniy and the Shadrinskiy areas have average prospects in terms of lake resources (there are both resources in the lakes but in a small amount). The Dalmatovskiy, the Zverinogolovskiy, the Katayskiy, the Ketovskiy, the Pritobolny and the Shatrovsky areas have absolutely no prospects or very little prospects.

IV. Conclusions

Currently, in the regional policy of the Kurgan region, more and more attention is paid to the issues of lakes’ natural resource management. Guided by the decisions of the government of the Russian Federation in relation to the rational use of aquatic biological resources and the creation of favorable conditions for the development of fisheries, the following activities are being carried out:

- The Department of natural resources of the Kurgan region together with the Kurgan regional fishery council takes steps aimed at the conservation and

planned increase of aquatic biological resources of the region, the issue of anti-poaching and illegal fishing is particularly controlled as well.

- For the organization of production (catch) and preservation of balance of aquatic bio-resources in the lakes, the Department of agro-industrial complex of the Kurgan region defined the recommended capture level. Statistics shows that in recent years there has been a decrease in these indicators for all the three considered bio-resources [4], [7]. This is especially true of therapeutic mud, for example, in lake Medvezhie (the Petukhovskiy area). Due to the loss of hydro-chemical equilibrium of the water ecosystem, brine is in the state of irreversible degradation.
- In accordance with the order of the Federal Agency for fisheries dated September 26, 2017 No. 648 "on approval of the plan of artificial reproduction of aquatic biological resources in 2018", in the spring of 2018, 100 reservoirs of the Kurgan region on the area of 55.9 thousand hectares were stocked with pelyad and sazan and other fries. A year before the stock of lakes with fish larvae was carried out in 87 reservoirs on the area of 45.5 thousand hectares. These activities were carried out at the expense of the users of fishing sites [4], [7].

The approaches to the wildlife conservation realized in the European community [8] are changing priorities in the modern ecosystem management. The Government of the Russian Federation should include the wildlife in the modern state strategy for the conservation of biodiversity of lake resources in the region.

Based on the results of the statistical analysis of lake natural resource use of Zauralie, described in this article, it is recommended for the regional authorities to develop a regional target program, including a full inventory of lakes in the region to assess and register the biological resources of the region. It is necessary to develop measures of economic interest in order to attract small and medium-sized businesses to invest and to exploit biological resources in the region economically profitably.

Based on the received data, it will be possible to carry out activities, aimed at the reproduction of lake bio-resources and therapeutic mud in the Kurgan region, with greater economic efficiency. We also propose to change a number of measures in design and development, in the application of administrative, economic and market methods in the use of lake resources in the region.

Within the framework of the regional program for the development of tourism, it is necessary to expand the use of balneological resources of the region's lakes for medical and health purposes [9].

The authors of the article believe that the realization of the proposed recommendations will contribute to the replenishment of their own revenues to the regional budget.

The modern concepts and methodology of ecosystem management [10] allow broadening our understanding of the directions and possible efficiency of the management of biological resources of the lake ecosystems of the Kurgan region.

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