THEORETICAL AND METHODOLOGICAL FOUNDATIONS OF RATIONAL USE OF LANDS OF POPULATED AREAS IN THE CONTEXT OF DIGITALIZATION

Abstract

Innovative development of the land management industry is inextricably linked with the introduction of automation and robotics in land cadastral services and the use of modern information technologies in the land management system, the peculiarity of which is the formation of large arrays of information that ensure increased efficiency of sustainable development of rural areas, improvement of technological solutions in the system of rational use of land resources of settlements in the country. To improve the efficiency of rational use of the territories of settlements in the context of rapidly changing requirements of standards and many regulatory documents, the digitalization of technologies in the land management system is of the utmost importance. The issues of development of rural areas in the Republic of Kazakhstan have remained one of the most pressing for many years. In the vast territory of the country, a significant part of it remains poorly developed and sparsely populated. The reasons for this situation are the large dispersion of the territories of rural settlements, natural and climatic conditions, terrain, insufficient funding for the development of the social and everyday sphere, which entails the desire of the population to migrate to settlements with a higher level of social comfort. "Over the past 10 years, the rural development policy has been aimed at improving the quality of life of the rural population through priority support for rural settlements with development potential, ... according to the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (hereinafter referred to as BNS), as of the beginning of 2023, there are 6,295 rural settlements (hereinafter referred to as RCS) in the republic, in which 38.2% of the country's population or 7.5 million people live."[1]

To eliminate the digital divide in rural areas, the PEBA-NGA Plan was implemented, which provides for coverage of more than 90% of settlements with a population of less than 5,000 residents with 30 Mbps broadband Internet. The Strategy for the digitalization of the agri-food sector, forestry and the rural environment is also being implemented. At the same time, it should be noted that a number of issues related to the development and implementation of unified approaches to solving the problems of digital transformation in the land management system and assessing the prospects for mass digitalization of the territories of populated areas continue to be at the stage of understanding and developing rational approaches to overcoming the limitations of the digital development of the industry, while a number of provisions related to the assessment of the conditions for initiating the processes of digital transformation of economic entities in land management and understanding the prospects for digitalization of the system of territorial development of populated areas remain not fully developed, are debatable in nature and require additional research.

Key words: Digitalization, automated information systems, lands of populated areas, transformation of economic entities, rational use of land, land cadastral services, artificial intelligence, cybersecurity, digital transformation, digitalization of the space of populated areas.

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QUANTITATIVE VARIABLES OF *ARTEMIA* IN SALT LAKE TUZKOL (BALKHASH-ALAKOL BASIN)

Abstract

Studies of salt waterbodies are topical for understanding their role in preserving and producing cysts of the valuable bioresource Artemia. A comprehensive analysis of the salt lake Tuzkol carried

out in May and August 2022. Standard methods performed sampling and processing of samples of Artemia. Artemia population represented by a bisexual race, but abundance of males is insignificant (0.02% of total population). The total abundance of artemia reached 34.0 thousand individuals/m^3 in May and 13.0 thousand individuals/m^3 in August. Nauplii and individuals at the juvenile stage formed the basis of quantitative variables of artemia. Artemia biomass reached 31.0 mg/m^3 in May and 13.0 mg/m^3 in August. Large egg-carrying females created the population biomass. One-way analysis of variance (ANOVA) did not reveal significant differences between the average values of the abundance and biomass of Artemia in different years. During research period, a slight increase in the biomass of Artemia noted, which might be due to a twofold increase in the level of TDS in lake in 2022 compared to the previous year of study. The productivity (by cysts) of Artemia varied from 10.3 to 190.8 kg/ha. The main portion of Artemia cysts concentrated in female ovisacs and the water column in May, by August the cysts prevailed (98.1%) in bottom sediment. In both research periods, cysts were not found in the coastal zone where their catching carried out. Based on benthic cysts, Tuzkol Lake classified as a highly productive waterbody in summer 2022. Bottom cysts, being at the dormant stage, provide the abundance of the first generation of Artemia and are a reserve for preserving the population. Based on this, Lake Tuzkol recommended to be used as a habitat for preserving the unique gene pool of Artemia and for studying the adaptation of halobionts to unstable conditions of the aquatic environment.

***Key words**: Artemia, salt lakes, productivity, cysts, females, males, nauplii.*

Introduction

The crustacean Artemia has a high value due to the high content of protein, essential amino acids, and vitamins in the body, as well as the ability to exist in a state of rest – diapausing cysts [1]. Artemia cysts are the best live starter feed for aquaculture objects [2]. According to research, about 85% of farmed aquatic animals use artemia cysts or nauplii as food at one stage of their development. The cysts themselves (decapsulated) or nauplii are used as food. As a result of cyst harvest more than 900 billion crustacean and fish larvae grow annually [2]. In this regard, the demand for Artemia cysts is growing and currently, its annual consumption is estimated at 3500 – 4000 tons (dry weight) [4].

Artemia distributed throughout the world and inhabits waterbodies of continental and marine origin with a salinity range of 20 – 340 g/l. Among these waterbodies, inland salt lakes play a key role, where about 90% of artemia production is obtained. Based on the productivity of Artemia (at the cyst stage), water bodies are divided into highly productive (cyst biomass >100 kg/ha); average productive (50-100 kg/ha); low productive (10-49 kg/ha); non-commercial (<10kg/ha) [5].

There are about 99 salt lakes in Kazakhstan, the fauna of which is mainly represented by crustaceans *Artemia parthenogenetica* [6]. The main fond of commercial artemia lakes (highly productive waterbodies) is located in Northern Kazakhstan; in addition to them, in the southeastern part, there are many non-commercial lakes. About 10 – 15% of the world's reserves (up to 1.5 - 3.0 thousand tons) of Artemia cysts are concentrated in these waterbodies. Regardless of their commercial significance in Kazakhstan, as in other regions, sufficient attention is paid to the study of the hydrobiological regime of salt water bodies (where Artemia inhabits) [6-7]. One of these well-studied salt water bodies is Lake Tuzkol, located in the South-East of Kazakhstan. According to the results of recent studies, it is recommended to harvest cysts in this lake [6]. Considering that approximately 90% of artemia production is obtained from inland salt lakes, the replenishment of several artemia lakes has a positive impact on the development of aquaculture. However, the high cost of cysts and the availability of coastal zone cysts for collection pose a direct threat to the Artemia population and other components of biodiversity in lakes recently included in the list of commercial lakes [8]. In order to prevent the latter, it is necessary to assess the quantitative variables of Artemia from a seasonal perspective, and based on the results obtained, to provide appropriate recommendations for the use of artemia production in this lake.

Population characteristics of Artemia in Tuzkol Lake are relatively well studied; however, that information is outdated. Therefore, the current work aims to assess the current state of artemia

populations of Tuzkol Lake and to provide appropriate recommendations for the use of artemia production in this lake.

Material and methods

Standard methods performed sampling and processing of samples of Artemia [9]. The water salinity determined using a Digital Salt Meter (Atago ES-421) device. The station coordinates were determined using a GPS navigator (Garmin). Samples were taken by filtering 50-100 liters of water through an Apstein net. The samples were fixed with 40% formaldehyde to a final concentration of 4%. Age and sex identification of Artemia, and calculation of all age groups of crustaceans, including cysts in samples, were carried out in laboratory conditions, using microscopes MBS-10 and MSKh-200 or 300. The following age groups of Artemia were identified and calculated: cysts, nauplii, juvenile crustaceans, pre-adult crustaceans, females with eggs or cysts, females without eggs, and males. For females with eggs, the number of eggs and/or cysts was calculated to calculate residual fecundity. Individual weight, and age groups of Artemia, for calculating biomass, taken from the guideline [9]. Calculation of the abundance and biomass of artemia and cysts were calculated per 1 m^3 of water column.

Benthic samples (bottom cysts) were taken with a Petersen bottom grab with a capture area of 0.025 m^2. In laboratory conditions, samples were weighed, and a known part of them was diluted with a certain volume of water and processed as a planktonic sample, with subsequent recalculation for the entire volume of the sample. In case of the presence crustacean cysts in coastal zone, sampling was carried out. Samples from the bottom of the water bodies were taken using a bottom grab. At the sites of coastal emissions, their total area was assessed. Organisms were identified under a microscope in the laboratory. The cysts in each sample were counted and weighed on a torsion or electronic scale, with a resolution of 0.0001, large invertebrates – on a cup scale, with a resolution of 0.001 g. The results obtained on the abundance and biomass of animals in the sample were then extrapolated per 1 m^2.

The corresponding modern guidelines were used to calculate production of commercial invertebrates [9].

The obtained data were compared with studies from previous years [6]. One-way analysis of variance (ANOVA) was used to determine statistically significant differences in population indicators of Artemia in different years. One-way analysis of variance (ANOVA) was carried out in R studio [10-11].

Results and discussion

The surveyed waterbody is in the mountainous part of South-Eastern Kazakhstan (Table 1). The lake is hypersaline and is filled by springs, groundwater, and precipitation.

Table 1 – Physiographic, hydrological and hydrochemical characteristics of Lake Tuzkol, 2022

Height above sea level, m	Water area, ha	Lake coordinates	Depth, m		Total dissolved solids, g/dm^3	
			May	August	May	August
1959	795	43°00'31,21"N 79°58'48,79"E	0.3-0.5	0.05-0.1	99.3-104.9	73.7-75.7

The level of development of Artemia populations in the water column in the spring-summer period of 2022 varied by season. Artemia population is represented by a bisexual race in the lake (Table 2). However, the number of males is insignificant – 0.02% of the total number of crustaceans. The ratio of males to females is high – 1:697.

Nauplii and juvenile stages dominated in Artemia population. They together created 72.4% of the total abundance of the population. Pre-adult stages of crustaceans were few – 13.2% of the total. The sexually mature part of the population was represented equally (8.7 and 5.8%) by females without eggs and females with eggs. Their fertility was 50-70 eggs in ovisacs. Males were recorded only in the coastal zone. Artemia biomass in May was formed in almost equal shares by all age stages, except for nauplii and males. The ratio of the sexually mature and immature parts of artemia population in the lake at the end of May is 1:5.9.

The abundance of free-floating cysts in the spring was very high and amounted to 143.33 thousand individuals/m^3 and 1.43 g/m^3.

The average abundance and biomass of artemia in the lake decreased from spring to summer by 2.75 and 2.25 times, respectively, and the brine shrimp population during this period was represented by a parthenogenetic race. Males and females without eggs were not recorded in August. Artemia population up to 70.56%, was formed by nauplii at the end of summer.

The remained portion of the population consisted mainly of egg-bearing females - 26.68% of the total. The share of individuals in other stages of development in the formation of the total abundance of crustaceans is scanty – 2.76%.

Only large females with eggs represented the sexually mature part of the population with high fertility from 40 to 110 eggs in ovisacs. The ratio of the mature and immature parts of artemia population is 1:2.74 in summer.

Dominant large egg-bearing females, producing 87.59% of the total biomass of crustaceans, formed the basis of artemia biomass.

Nauplii and juvenile stages of Artemia accounted for 11.79% of the total biomass of crustaceans. Overall average abundance and biomass of Artemia in the lake decreased by 2.75 and 2.25 times, respectively at the end of summer.

Table 2 – Abundance and biomass of different ages Artemia of Lake Tuzkol, 2022

nau-plii	juvenile	pre-adult	females	females with cyst	males	total	cysts in the lake
Abundance, thousand individuals/m^3							
May							
12.0	12.2	4.4	2.9	1.9	0.1	34.0	143.0
August							
8.7	0.3	0.05	0	3.3	0	12.0	270.0
Biomass, mg/m^3							
May							
2.1	6.7	7.6	7.5	7.1	0.02	31.0	1.4
August							
1.4	0.12	0.1	0	12.1	0	13.0	2.7

In order to assess the productivity of Artemia populations, productivity was calculated for individual groups: for floating cysts, for benthic cysts, for cysts in ovisacs of females, and cysts in the coastal zone (Table 3) [12].

Table 3 – Productivity of Artemia populations in Lake Tuzkol, 2022

unit of measure	floating cysts	cysts in ovisacs of females	cysts in the coastal zone	benthic cysts	total
May					
kg/ha	5.7	4.6	0	0	10.3
%	55.2	44.8	0	0	100
August					
kg/ha	2.0	1.5	0	187.3	190.8
%	1.1	0.8	0	98.1	100

The productivity of Artemia populations increased significantly from 10.3 to 190.8 kg/ha from spring to summer. The main production of Artemia cysts is concentrated in the ovisacs of females and the water column – 44.8% and 55.2%, respectively in May. The benthic cysts formed the productivity of the lakes (98.1%) in August. Based on benthic cysts, Tuzkol was classified as a highly productive waterbody in the summer. In both periods of research, cysts were not found in the coastal zone.

The obtained data were compared with studies from previous years [6]. In order to determine whether there is a statistically significant difference between the average values of the abundance and biomass of Artemia in different years, One-way analysis of variance (ANOVA) was used [10-11].

This analysis did not reveal significant differences in the mean values of the Artemia variables (Table 4).

Table 4 – Results of one-way ANOVA by abundance and biomass of artemia of Tuzkol Lake in different years (2015, 2017, 2022)

Variable	Abundance, thousand individuals/m^3	Biomass, mg/m^3
Df	4	4
Sum of squares	1315.871	29854.09
Square mean	328.968	7463.52
F value	67.136	25.369
Significance	<.001**	<.001**

Notes. Significance codes: ** «0.001»

The total abundance of Artemia in 2022 increased slightly (in May 34.0 thousand individuals/m^3, in August 13.0 thousand individuals/m^3) compared to 2017 data (in May 30.2 thousand individuals/m^3, in August 14.8 thousand individuals/m^3) and 2015 (in August 5.5 thousand individuals/m^3). Overall, an increase in the biomass of Artemia populations was noted in 2022. It reached 31.0 mg/m^3 in May and 13.0 mg/m^3 in August, which exceeded the data for the previous year (8.48 mg/m^3 in August 2015) and 2017 (8.48 mg/m^3). The exception was the average biomass value (74.25 mg/m^3) of Artemia in May 2017. The described changes in the quantitative variables of Artemia may be associated with a twofold increase in the level of total dissolved solids in the lake in 2022 compared to 2017 [6] since the increase in the level of total dissolved solids has a favorable effect on the vital activity of Artemia crustaceans. They are most productive in waterbodies with a salinity of 70 to 230 g/dm^3 [5,13 – 14]. During the previous research period, the level of total dissolved solids in the lake varied in the range from 46.7 to 52.8 g/dm^3 [6].

Conclusion

Thus, Artemia population is represented by a bisexual race, but the number of males is insignificant in Tuzkol Lake. The total abundance of Artemia in 2022 was 34.0 thousand individuals/m^3 in May, and 13.0 thousand individuals/m^3 in August. Nauplii and individuals at the juvenile stage of development dominated the population. The biomass of the crustacean reached 31.0 mg/m^3 in May, 13.0 mg/m^3 in August. The large egg-bearing artemia females prevailed in biomass. The obtained data were compared with studies from previous years. One-way analysis of variance (ANOVA) did not reveal significant differences between the average values of the abundance and biomass of Artemia in different years. In general, a slight increase in the biomass of Artemia crustaceans was noted in 2022, which may be due to a twofold increase in water salinity in the lake in 2022 compared to the previous year of the study. The productivity (by cysts) of Artemia populations varied from 10.3 to 190.8 kg/ha. The cysts were not found in the coastal zone of the Lake where their catching is primarily carried out. The production of Artemia cysts is concentrated in the ovisacs of females and the water column in the spring. The benthic cysts formed the productivity of the lakes (98.1%) in August. Based on the volume of benthic cysts, Tuzkol Lake was classified as a highly productive waterbody in the summer of 2022. Bottom cysts, being at the dormant stage, provide the abundance of the first generation of Artemia and are a reserve for preserving the population. Based on research results, Lake Tuzkol is recommended to be used as a habitat for preserving the unique gene pool of Artemia and for studying the adaptation of halobionts to unstable conditions of the aquatic environment.

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ТҰЗКӨЛ ТҰЗДЫ КӨЛІНДЕГІ АРТЕМИЯНЫҢ САНДЫҚ КӨРСЕТКІШТЕРІ (БАЛҚАШ-АЛАКӨЛ СУАЛАБЫ)

Аңдатпа

Тұзды су ағзаларын зерттеу олардың құнды биоресурстық артемия цисталарын сақтау мен өндірудегі рөлін түсіну үшін өзекті болып табылады. Тұзкөл тұзды көліне кешенді талдау 2022 жылдың Мамыр-тамыз айларында жүргізілді. Артемия сынамаларын іріктеу және өңдеу стандартты әдістер көмегімен жүзеге асырылды. Артемия популяциясы бисексуалды нәсілмен ұсынылған, бірақ көлде аталықтар саны төмен (жалпы халықтың 0,02%). Тұзкөл көліндегі артемияның жалпы саны мамыр айында 34,0 мың адамға/м3, тамызда 13,0 мың адамға/м3

жетті. Көбінесе науплии және дамудың кәмелетке толмаған кезеңіндегі адамдар артемия популяциясының негізін құрады. Артемияның биомассасы мамыр айында 31,0 мг/м3, тамызда 13,0 мг/м3 жетті. Популяция биомассасы ірі жұмыртқа салатын аналықтар құралған. Дисперсияны бір жақты талдау (ANOVA) әр жылдардағы артемияның көптігі мен биомассасының орташа мәндері арасындағы айтарлықтай айырмашылықтарды анықтаған жоқ. Зерттеу кезеңінде артемия шаян тәрізділерінің биомассасының шамалы ұлғаюы байқалды, бұл зерттеудің алдыңғы жылымен салыстырғанда 2022 жылы судағы жалпы еріген қатты заттар деңгейінің екі есе артуына байланысты болуы мүмкін. Артемия популяцияларының өнімділігі (цисталар бойынша) 10,3-тен 190,8 кг/га-ға дейін өзгерді. Артемия цисталарының негізгі бөлігі мамыр айында аналық бездерде және су бағанында шоғырланған, тамыз айына қарай төменгі шөгінділерде цисталар басым болды (98,1%). Зерттеудің екі кезеңінде де цисталар жағалау аймағында табылған жоқ. Бентостық цисталар негізінде Тұзкөл көлі 2022 жылдың жазында өнімділігі жоғары су айдыны ретінде анықталды. Бентостық цисталар тыныштық сатысында бола отырып, артемияның бірінші буынының көптігін қамтамасыз етеді және олар популяцияны сақтау үшін резерв болып табылады. Осыған сүйене отырып, Тұзкөл көлін артемияның бірегей гендік қорын сақтау және галобионттардың су ортасының тұрақсыз жағдайларына бейімделуін зерттеу үшін тіршілік ету ортасы ретінде пайдалану ұсынылады.

Кілт сөздер: артемия, тұзды көлдер, өнімділік, цисталар, аналықтар, аталықтар, науплии.

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КОЛИЧЕСТВЕННЫЕ ПОКАЗАТЕЛИ АРТЕМИИ В ОЗЕРЕ ТУЗКОЛЬ (БАЛХАШ-АЛАКОЛЬСКИЙ БАССЕЙН)

Аннотация

Исследования соленых водоемов являются актуальными для понимания их роли в сохранении и добычи цист ценного биоресурса артемии. Комплексные исследования соленого озера Тузколь проводилось в мае и в августе 2022 г. Отбор и обработка проб рачков артемии проводились согласно общепринятым методикам. В озере популяция артемии представлена бисексуальной расой, но количество самцов незначительное (0,02% от общей популяции). Общая численность артемии в 2022 г. озера Тузколь составила в мае 34,0 тыс. экз./м^3, в августе 13,0 тыс. экз./м^3. Часто основу численности популяции формировали науплиусы и особи на ювинильной стадии развития. Биомасса рачка достигла 31,0 мг/м^3 в мае, 13,0 мг/ м^3 в августе. Основу биомассы артемии создавали крупные яйценосные самки. Однофакторный дисперсионный анализ (ANOVA) не выявил существенных различий между средними значениями численности и биомассы артемии в различные годы. В период исследований, отмечено небольшое увеличение биомассы рачков артемии, что возможно связано с двукратным увеличением минерализации воды в озере в 2022 г. по сравнению с предыдущим годом исследования. Продуктивность (по цистам) популяций артемии варьировала от 10,3 до 190,8 кг/га. В мае основная продукция цист артемии сосредоточена в овисаках самок и в толще воды, в августе в озёрах основу продуктивности составляли донные цисты 98,1%. В оба периода исследований, цисты в береговых полосах откуда преимущественно осуществляется их промысел не обнаружены. Летом 2022 г. оз. Тузколь по бентосным цистам классифицировалось как высокопродуктивный водоем. Донные цисты находясь в состоянии покоя обеспечивают численность первой генерации артемии и являются резервом для сохранения популяции. Исходя из этого озера Тузколь рекомендуется использовать как местообитание для сохранения уникального генофонда артемии и для изучения адаптации галобионтов к неустойчивым условиям водной среды.

***Ключевые слова*:** артемия, соленые озера, продуктивность, цисты, самки, самцы, науплии