PERIÓDICO TCHÊ QUÍMICA
ARTIGO ORIGINAL

INFLUÊNCIA DA MINERALIZAÇÃO DA ÁGUA NA PRODUTIVIDADE DE ZOOPLÂNCTON NOS RESERVATÓRIOS DA REGIÃO DE AKMOLA

INFLUENCE OF WATER MINERALIZATION ON ZOOPLANKTON PRODUCTIVITY IN RESERVOIRS OF AKMOLA REGION

AUBAKIROVA, Gulzhan[1*]; ADILBEKOV, Zhanat[2]; NARBAYEV, Serik[3];

[1,3]Department of Hunting and Fisheries, Faculty of Veterinary Sciences and Animal Husbandry, S.Seifullin Kazakh Agro-Technical University, Nur-Sultan, Kazakhstan

[2]Department of Veterinary Sanitation, Faculty of Veterinary Sciences and Animal Husbandry, S.Seifullin Kazakh Agro-Technical University, Nur-Sultan, Kazakhstan

** Corresponding author*
e-mail: kadr_90.taz@mail.ru

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RESUMO

O efeito da mineralização da água na produtividade do zooplâncton nos reservatórios da região de akmola é um estudo muito relevante. A composição química das águas naturais está indissociavelmente ligada à composição e estrutura do solo que, por sua vez, se formou durante a longa evolução da crosta terrestre sob a influência do clima. As águas naturais têm uma variedade excepcionalmente ampla de composição química qualitativa e quantitativa. A base para a sistematização nas classificações existentes é a quantidade de mineralização, o componente ou grupo predominante, a relação entre diferentes valores de concentrações de íons diferentes, a presença de quantidades aumentadas de quaisquer componentes específicos dos regimes de gás e sal. A relevância do trabalho se deve ao estudo insuficiente do potencial de pesca de reservatórios de tamanho médio no norte do Cazaquistão. O objetivo do trabalho foi estudar a mineralização da água como fator determinante da vida dos organismos aquáticos. Como resultado desta pesquisa, os dados confirmaram a posição de que os fatores que determinam a vida dos organismos aquáticos são a mineralização da água. Para caracterizar o zooplâncton em toda a área do lago, foram coletadas amostras levando em consideração diferentes estações. O número de organismos individuais na amostra foi determinado. O grau de mineralização dos lagos na região de Akmola foi indicado. O coeficiente de correlação para características no par "mineralização - abundância de zooplâncton" foi calculado como r = -0,96 e no par "mineralização - biomassa de zooplâncton" r = -0,85. Ao analisar os dados obtidos, observou-se uma relação inversa entre mineralização da água e abundância de zooplâncton. Quando a mineralização da água aumenta 4,03% em julho, o número de organismos zooplanctônicos diminui de 170,03 para 152,6 mil cópias/m^3. Quando a salinidade da água do lago Uyali - Shalkar aumenta de 362 (maio) para 508 mg/l (julho), a biomassa do zooplâncton diminui de 6,02 para 5,73 mg/m^3.

Palavras-chave: *zooplâncton, lago, mineralização, biomassa, produtividade.*

ABSTRACT

The effect of water mineralization on zooplankton productivity in the reservoirs of the Akmola region is a very relevant study. The chemical composition of natural waters is inextricably linked to the composition and structure of the soil, which, in turn, was formed during the long evolution of the earth's crust under the influence of climate. Natural waters have a wide variety of qualitative and quantitative chemical composition. The basis for systematization in existing classifications are the amount of mineralization, the predominant component or group, the relationship between different values of concentrations of various ions, the presence of increased amounts of any specific elements of the gas and salt regimes. The relevance of the work is due to insufficient study of the fishing potential of medium-sized reservoirs in Northern Kazakhstan. The work aimed to study the mineralization of water as a factor determining the life of aquatic organisms. As a result of this research, data confirmed the position that the factors that determine the viability of marine organisms are the mineralization of water. To characterize zooplankton across the entire lake area, samples were taken, taking into account different stations. The number of individual organisms in the sample was determined. The degree of mineralization of lakes in the Akmola region was indicated. The correlation coefficient for features in the "mineralization – zooplankton abundance" pair was calculated as r= -0.96, and in the "mineralization – zooplankton biomass" pair r= -0.85. When analyzing the data obtained, it was observed an inverse relationship

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between water mineralization and zooplankton abundance. When water mineralization increases by 4.03% in July, the number of zooplankton organisms decreases from 170.03 to 152.6 thousand copies/m3. When the salinity of the Uyali - Shalkar lake water increases from 362 (May) to 508 mg/l (July), the zooplankton biomass decreases from 6.02 to 5.73 mg/m^3.

Keywords: *zooplankton, lake, mineralization, biomass, productivity.*

1. INTRODUCTION:

The intensity of life processes in lake ecosystems is due to a variety of abiotic factors and processes, ultimately, their biological productivity.

The most important conditions that determine the life of aquatic organisms are temperature, light, the content of nutrients, etc. Marine organisms are interconnected with elements of the abiotic environment; a change in one system of connections inevitably causes a change in another (Brzoska,2012).

Kazakhstan has excellent opportunities to use internal reservoirs for fish farming. On the territory of the Republic, there are a large number of reservoirs, with the full development of which a significant increase in the catches of valuable fish species is possible (Aubakirova *et al*., 2019).

However, in many regions of Kazakhstan, until now, the fishery use of natural reservoirs is almost undeveloped or poorly developed. This is due to insufficient study of their biological resources. The need to build lake fish farming in Kazakhstan is obvious. It is dictated by the fact that this will allow you to get high-quality fish products at a relatively low cost.

The development of zooplankton is determined by interrelated and dependent on many factors conditions, the main of which are: the presence of a food substrate, growth, and reproduction conditions. In different reservoirs, these conditions are formed under the influence of the type of reservoir, as well as climatic and weather factors (Popov, 2002).

The main factors that determine the development of populations of different organisms of plankton communities are various. It is considered that for phytoplankton-light, biogenic substances, temperature, for bacteria-organic substrate and temperature, for zooplankters-filters-food substrate-Phyto-, bacterioplankton, and temperature; for predatory forms-the presence of a sufficient number of prey organisms. In some lakes, in specific periods for the development of zooplankton, the main limiting factor is the oxygen regime. Also, in each community, there are species (even among closely related forms) that respond almost oppositely to the environmental factors that determine their life activity. Thus, among the blue-green (cyanobacteria), mainly thermophilic summer forms, there is R. Oscillatoria, represented by many species that can develop at low temperatures. The same group of ways with different responses to environmental conditions are among the protozoans, rotifers, cladocerans, and copepods. The more diverse in space and time the conditions of the reservoir environment, the more ecologically heterogeneous its plankton community (Rice *et al*., 2012).

The southern location of the lakes contributes to the effect of more intense insolation, especially in low-snow winters. Reservoirs in the Middle zone of the European part are mainly lakes in the Upper Volga basin, located at latitude 58-60º. The difference in the latitudinal location of the upper Volga and TRANS-Baikal lakes is about 8º. This creates a significant advantage in the supply of insolation for TRANS-Baikal lakes. Besides, according to available data, the thickness of the snow cover in the Upper Volga lakes can exceed 70 cm, while in the TRANS-Baikal lakes, its width does not exceed 30 cm (Tikhomirov, Egorov, 1977; Bondarenko, 2009). Thus, for the development of phytoplankton under the ice in the lakes of Transbaikalia, compared with the lakes of the Upper Volga, there are definite advantages in the intensity and duration of solar insolation.

It is accepted that the year-round cycle of the lake is divided into two periods: “vegetation” (ice-free) and subglacial. It is known that usually in the lakes of the Middle zone of the European part, the open water period is more extended than the subglacial one. Environmental conditions in reservoirs during these periods differ fundamentally. The temperature under the ice varies from 0 to +5ºC 1, while in the open water period from 0 to +32ºc. The subglacial period is characterized by maximum transparency, weak insolation, minimal dynamics of the water environment, reverse temperature stratification, and specific production processes (Riviere, 2012).

First of all, this applies to lakes located near large industrial cities, the supply of the population with high-quality fish products should be a particular concern of the state. These reservoirs include lakes in the Akmola region of Northern Kazakhstan. Therefore, at this stage, there is a question of mass study of medium and small reservoirs of Kazakhstan for the needs of the fishing industry.

2. MATERIALS AND METHODS:

The content for this work was collected zooplankton samples in the lakes of the Akmola region (lakes Uyaly-Shalkar, Shnet, Shelkar, Maidan dam). During the expedition trips to the lakes, 320 hydrobiological and 120 hydrochemical samples were collected and processed.

Hydrochemical observations were carried out simultaneously with the central hydrobiological studies. Sampling was carried out from the surface and bottom layers of water according to generally accepted methods, that is, water was taken from depths of 30-40 cm and collected in a plastic container with a volume of 1 liter. All dishes were pre-prepared according to the rules for preparing containers before sampling to prevent contamination.

The determination of dissolved oxygen and biochemical oxygen demand was carried out by the iodometric method, according to the Winkler and thermooxidation (Figure 1). The study of the oxygen regime was carried out both from the surface of the reservoir and from the depth of the lake, to calculate the value of the oxygen balance.

Permanganate oxidation was performed using the Kubel method. This method is based on the oxidation of organic substances present in the sample with a known amount of potassium permanganate solution with a concentration of 0.01 mol/l EQ. When boiling in a sulphuric acid medium for 10 minutes, potassium permanganate that Has not reacted is reduced with oxalic acid. The excess oxalic acid was titrated with a solution of potassium permanganate. This method, used in the analysis of drinking and slightly polluted natural water, is widely used because of its relative simplicity.

The study of turbidity and transparency was carried out using the "font" method. The definition of turbidity is based on determining clarity by measuring the maximum height of the water column, at which it is already possible to visually distinguish a black font or an alignment mark (for example, a black cross) on a white background. Based on the value of water transparency determined in the analysis, the value of water turbidity for pharmazine (EMF) and kaolin (mg/l) was determined using the calibration schedule. This method is used for clean and low-polluted waters and allows you to assess the transparency of water in almost any conditions and on any body of water, regardless of its depth, the presence of bridges, weather conditions, etc.

Determination of the total hardness as the total molar concentration of the equivalents of calcium and magnesium cations was determined by the titrimetric method. The decision is based on the reaction of calcium and magnesium salts with the reagent-Trilon B. the Analysis was performed at pH 10-10. 5 in the presence of a dark blue chromic acid indicator (acid chromic-blue T). The role of the indicator in determining the overall hardness is that when it is added to the analyzed water, a reaction initially occurs as a result of which all the calcium and magnesium is bound by the indicator to form a compound colored red. Further, during titration, as Trilon B is added, a more substantial colorless complex with calcium (magnesium) is established, the complex with the indicator is destroyed, and the indicator is released, coloring the solution blue.

The determination of carbonates, hydrocarbonates, and alkalinity was carried out by the titrimetric method. The resolution is based on the reaction of carbonate and bicarbonate ions with hydrogen ions in the presence, as indicators of phenolphthalein and a mixture of bromocresol green and methyl red (mixed indicator). The corresponding amount of acid consumed for the phenolphthalein titration (VF) is equivalent to free alkalinity (Schsv); the amount of acid consumed for the mixed indicator titration (VSM) is total alkalinity (Scho). Based on the results of titration, the values of free and total alkalinity of water were determined, which made it possible to calculate the concentrations of carbonate and bicarbonate ions. Concentrations of carbonate and bicarbonate ions allow us to calculate the carbonate hardness of water, which is the total content of soluble salts of carbonates and hydrocarbonates. The pH of the water was measured by the pH meter testo 206 (Testo AG Germany) (Alekin, 1970; Shishkina, 1974; Balushkina, 1979).

Zooplankton was collected by filtering 50-600 liters of water through the small Apstein network (using mill gas No. 70). Once every ten days. Filtered 50 liters of water. The samples were fixed with four percent formalin with addition. Each zooplankton sample was marked with the sample number, date, place of collection, and volume of filtered water (Kiselev, 1980; Life of freshwater, 1956).

In each reservoir, zooplankton samples were collected at three points. To identify the taxonomic composition and count the number of zooplankton, samples were analyzed in the Bogorov chamber (freshwater Life., 1956) according to the Bogorov-Gensen method (CIT. by Moruzi *et al*., 2008). If necessary, the sample was diluted with water. Then, to account for large and small species, the sample was viewed in full. Zooplankton organisms were determined using the following determinants: E. F. Manuilova (1964), L. A. Kutikova (1970), E. V. Borutsky, and others. (1991), "Determinant of freshwater invertebrates of the European part of the USSR" (1977)," Determinant of freshwater invertebrates of Russia... " (1995, 1994), N. M. Korovchinsky (2004). Determination of the naupliar and Junior copepodite stages of oarfoots was carried out up to the suborder (Kiselev, 1980; Moruzi *et al*., 2008; Manuilova, 1964; Kutikova, 1970; Borutsky, 1991; Korovchinsky, 2004).

To account for rare large forms, as well as ovulatory individuals, the sediment was viewed. To determine the production of zooplankton, 50 specimens of each species were measured, taking into account the stage of development and gender. It is noted (Galkovskaya, 2005) that filtration of bathometric samples through the network (compared to sedimentary samples) leads to a noticeable understatement of the number and biomass, since large mobile crustaceans can avoid fishing gear, and small rotifers and Copepoda nauplias are not held by gas with a mesh greater than 45 microns. Therefore, when calculating the biomass for rotifers, a conversion factor of 2.0 was used; for crustaceans-1.5 with a population of less than 1 thousand copies/m3. Additionally, to reduce the error, when sampling water was filtered through a network located in the water (only its upper edge was above the water) so that rotifers under pressure were not forced through the cells of the net.

Since samples were taken by filtering the volume of water through the Apstein network, the population of each species was calculated as follows:

$$N_i=n_{пр}*1000/V_{пр},$$

where N_i – the number of species in the sample, ex./м^3; $n_{пр}$ – ч the number of organisms of the species in the sample, ex.; $V_{пр}$ – the volume of filtered water, l.

Data on the biomass of each zooplankton species was obtained by multiplying the individual mass of each organism (w_i) by its number (N_i):

$$B=\sum N_i*w_i$$

Measurements of the organisms were measured under a binocular microscope according to age stages: adult forms, young (Guide.., 1983, 1992). The calculation of the individual mass of organisms in the sample was performed using the formula (balushkina, Vinberg, 1979a, 1979b)

$$w=q*l^b,$$

Where w - the body mass of the organism, mg; l - the body length of the organism, mm; q - the body mass at the body length. Equal to 1 mm; b - exponent (for isometric growth (Rotifera) is 3, for allometric growth (Copepoda, Cladocera) - more or less than 3). For rotifers, the q values proposed by A. Ruttner-Kolisko (1977) were used. The weight of Copepoda nauplii was calculated with the formula of a rotational ellipsoid: V = 4/3 a*b*c where a, b, c – 1/2 of length, width, and height of body, mm, assuming a specific gravity of animals equal to 1.

A Petersen dredger took samples of zoobenthos with a ground capture area of 1/40 m2. Sample processing with determination of species composition and number of organisms was performed using conventional methods (Sharapova, Falomeeva, 2006).

To assess species diversity, the Shannon index was used (Shannon, 1963), since it is considered the most informative and convenient. It is assumed that the index values higher than 3- corresponds to clean waters, from 1 to 3 – moderately polluted; less than 1 – dirty (Ruttner-Kolisco, 1977; Sharapova *et al*., 2006; Shannon *et al*., 1961).

The Shannon index quantifies the structure of the community and is calculated using the formula:

$$H=-\sum n_o*\log_2 n_o,$$

n_o – relative number of species in the sample.

Statistical processing of the material was performed using the Microsoft Excel application package. The average value ($\bar{x}$), the error of the average value ($S_{\bar{x}}$), the standard deviation (σ), and the coefficient of variation (*Cv*) were calculated. The difference in average values was estimated using the student's criterion and the probability P, which was recognized as statistically significant at P ≥ 0.95, using the algorithms of A. N. Plokhinsky (1961), G. F. Lakin (1973), and L. A. Vasilyeva (2004).

3. RESULTS AND DISCUSSION:

To assess the biological resources of small freshwater reservoirs in Northern Kazakhstan, we conducted monitoring studies of many reservoirs in the Akmola region. Their hydrochemical regime, mineralization, and classification of reservoirs by trophic levels were studied. The species composition, number, and biomass of zooplankton communities were identified. Dependencies between individual parameters of the hydrochemical regime and indicators characterizing the well-being of hydrobiont communities were established.

Since the development of zooplankton is significantly affected by water mineralization, we evaluated this relationship.

When analyzing the data obtained, we tried to identify the relationships between various parameters that characterize the chemical quality of water (mineralization) and parameters that describe the state of zooplankton communities (number, biomass).

It is known that environmental conditions influence many properties of living organisms. The high-confidence effect of the amount of mineral substances in water on the biomass of zooplankton communities was found to be 94 %.

Table 1 shows the results of a study of the mineralization of lakes in the Akmola region. According to the classification of I. V. Baranov (Alekin, 1970, 1973), the studied water of the lake. Shnet, Shelkar, Uyaly-Shalkar, Maidan square is medium-mineralized (table.1). As a result of observations, it was found that the level of mineralization in the lake. Uyali-Shalkar is significantly higher (from 362-532 mg/l). The lowest rates were observed in the lake Chelkar of Arshaly district (186-305 mg/l).

The results of these studies suggest that the degree of mineralization of water, the studied lakes, can be attributed to fresh since the amount of ions contained in the water does not exceed 1g/kg.

The influence of water mineralization on zooplankton productivity was studied on the example of lake Uyaly-Shalkar.

The dependence of the level of zooplankton development on the total water mineralization in lake Uyaly-Shalkar is shown in Figure 2. The higher the mineralization, the lower the number. A similar trend is observed for the "mineralization – biomass" pair.

When analyzing the data obtained, we observed an inverse relationship between water mineralization and zooplankton abundance. When water mineralization increases by 4.03% in July, the number of zooplankton organisms decreases from 170.03 to 152.6 thousand copies/m^3.

When the salinity of the Uyali - Shalkar lake water increases from 362 (May) to 508 mg/l (July), the zooplankton biomass decreases from 6.02 to 5.73 mg/m^3.

To confirm this, the correlation coefficient was calculated in these pairs of features; in the pair "mineralization – zooplankton number," it was r= -0.96, and in the pair "mineralization – zooplankton biomass" r= -0.85.

4. CONCLUSIONS:

Thus, when studying the features of the hydrochemical regime for organoleptic limiting parameters in three reservoirs, the hydrochemical scheme of water was within the normal range. When considering the influence of the hydrochemical regime on the example of water mineralization on productivity, we noted that with an increase in water mineralization in July by 4.03%, the number of zooplankton organisms decreases from 170.03 to 152.6 thousand copies/m^3. A similar trend is observed for the "mineralization – biomass" pair.

According to the classifier of O. A. Alekin oz. Uyaly-Shalkar belongs to the hydrocarbonate class, a group of calcium, of the first type; oz. Snet – sulphate class, group of calcium of the first type; oz.Shelkar - to the chloride class, sodium group, of the second type; Maidan dam-of the hydrocarbonate class, calcium group, of the second type.

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***Table 1**. Water mineralization in the lakes of Akmola region, mg/dm^3*

Reservoirs	Mineralization, mg / l		
	May	July	September
Oz.Shnet	256±3,32	445±4,01	413±5,26
Oz.Shelkar	186±2,13	261±3,22	305±4,0
Oz.Uyaly-Shalkar	362±4,02	508±6,24	462±5,44
Maidan Square	302±4,0	387±4,04	463±5,62

***Figure 1.** The study of the hydrochemical regime of water was carried out using the NKV-12 Express laboratory*

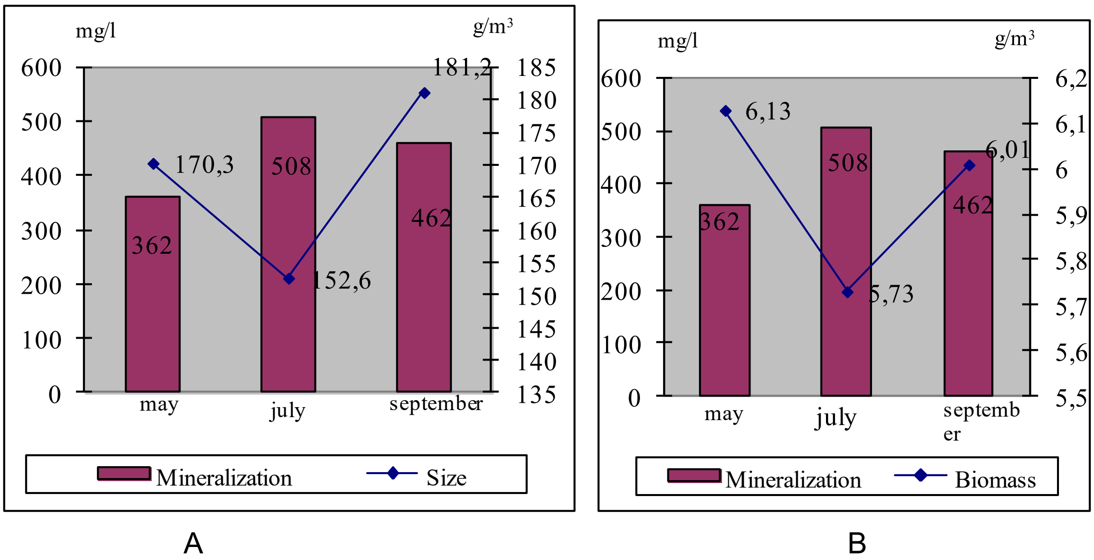

Figure 2. *Influence of water mineralization (A - on the number of zooplankton, B - for zooplankton biomass)*