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ECOLOGICAL ASSESSMENT OF LAKE AKBAS
BY HYDROPHYSICAL, HYDROCHEMICAL AND
ALGOLOGICAL INDICATORS

This paper evaluates the results of hydrophysical and hydrochemical indicators of Lake Akbas of the Kokshetau State National Natural Park, which belongs to the category of specially protected natural areas. Changes in the lake area over a period of about 50 years are shown. In terms of water color and turbidity, there has been a decrease over the past 3 years. The area of the Akbas lake basin has decreased by 15.3% over the past 50 years. During the study period, the content of dry waste in the lake water exceeded the MAC by 1.1–1.5 times annually. Lake Akbas is moderately polluted in 2018-2019 in terms of the level and quality of class III pollution. However, it was found that some hydrochemical parameters exceed the MAC. Along with the hydrophysical and hydrochemical indicators of Lake Akbas, we identified the species composition of microalgae in the lake, seasonal changes and conducted a systematic analysis. As a result of the study, the algae flora of Lake Akbas consisted of 61 species, 20 of which are indicator-saprobic microalgae. To study the sensitivity of algae to environmental factors and various chemical reactions, we carried out biotesting of water samples from Lake Akbas. Biotesting showed that the Chlorella sp-3K strain is moderately sensitive to toxic concentrations in Lake Akbas. Researches have shown that bioassays for microalgae in lake water are quick and easy and complement the results of chemical studies. According to the results of hydrophysical, hydrochemical studies and biotesting of algocenoses, it was determined that the water of Lake Akbas belongs to 3 classes of pollution.

Key words: Hydrophysical and hydrochemical indicators, algal flora, biotesting.
Экологическая оценка озера Акбас по гидрофизическим, гидрохимическим и алгологическим показателям

В этой работе дана оценка результатов гидрофизических и гидрохимических показателей озера Акбас, относящегося к категории особо охраняемых природных территорий Государственного Национального природного парка «Кокшетау». Указываются изменения площади акватории озера в период около 50 лет. По показателям цвета и мутности воды наблюдается снижение за последние 3 года. Так, площадь водоема озера Акбас за 50 лет уменьшилась на 15,3%. Сухие отходы в озерной воде в период исследований увеличивались ПДК в 1,1-1,5 раза каждый год. Озеро Акбас по уровню и качеству загрязнения демонстрирует степень III класса, т.е. умеренно загрязненное состояние, в 2018-2019 годах. Однако установлено, что некоторые гидрохимические показатели превышают предельно допустимую концентрацию. Наряду с гидрофизическими и гидрохимическими показателями озера Акбас нами была выявлена видовая состав, периодические изменения микроводорослей в озере, проведен систематический анализ. В результате исследования установлено, что альгофлора озера Акбас составляет 61 вид, из них 20 видов относятся к индикаторно-сапробным микроводорослям. Для изучения чувствительности экологических факторов и различных химических реакций к водорослям мы провели биотестирование водных образцов озера Акбас. В результате исследования, проведенного биотестированием, было установлено, что штамм Chlorella sp-3К умеренно чувствителен к концентрации ядовитых веществ в озере Акбас. Из исследований выяснилось, что биотестирование озерной воды с помощью микроводорослей дополняет результаты химических исследований. На основании комплексных результатов гидрофизических, гидрохимических исследований и биотестирования в составе альгоценоза было установлено, что вода озера Акбас по степени загрязнения относится к 3 классам.

Ключевые слова: гидрофизические и гидрохимические показатели, альгофлора, биотестирование.

Introduction

The concept of the Republic of Kazakhstan for the transition to a “green economy” provides for the sustainable use of water resources, pollution reduction, conservation and effective management of ecosystems[1]. In addition to large-scale protection of the integrity and authenticity of typical ecosystems and ecological processes, national parks protect, preserve and restore the region’s biodiversity, important species and their habitats, and natural and cultural heritage sites of global or national importance.

Thus, by focusing on one aspect of the ecosystem, it focuses on preventing the loss and damage of other resources and the environment [2].

In connection with global changes in the natural shortage of water, the problem of rational use, protection and restoration of lake resources is of particular importance. Therefore, the relevance of such studies today is beyond doubt. The actual use of the lakes is very limited. Lakes are not only an important part of the hydrological system of the North Kazakhstan region, but also a source of fresh water and recreation areas, habitats for waterfowl and fish [3].

The lakes of this region were the object of study of hydrometric indicators associated with the development of virgin and fallow lands. In the mid-1960s, scientists have found a sharp decrease in humus thickness and productivity throughout the territory of Northern Kazakhstan. These processes were characterized by an intensification of deflationary processes, including the hydromass and biomass of geosystems. During these years it mentioned in the works of G. D. Ovchinnikov (1960), A. G. Popolzin (1967), G. G. Muravlev (1973), P. P. Filonets, T. R. Omarov (1974), N. P. Beletskaya (1971, 1976), M. E. Gorodetskaya (1972) and others [4,5,6].

Lake Akbas is a freshwater lake belonging to the Ishim basin. In accordance with the Decree of the Government of the Republic of Kazakhstan dated October 18, 2012, №1323 “On some issues of the Kokshetau State National Natural Park of the Committee for Forestry and Hunting of the Ministry of Agriculture of the Republic of Kazakhstan” has the status of specially protected natural areas [7]. A satellite image of the lake is shown in Figure 1.
SNNP «Kokshetau» was created by the Decree of the Government of the Republic of Kazakhstan April 10, 1996 with the aim of preserving and restoring amazing mountain-forest and lake ecosystems, natural and archaeological monuments, the national culture of Northern Kazakhstan, which have ecological, scientific, educational and recreational significance for the inhabitants of our and other countries. The territory of the park is 182,076 hectares and covers the territory of the Aiytau district of the North Kazakhstan region and the Zerendi district of the Akmola region [8].

Due to the geographic location of the lakes located in the national park, some lakes are rapidly being decommissioned due to the fact that they are fed by sources of precipitation, melted snow and springs. The urgency of the problem of preserving the lakes of SNNP «Kokshetau» is distinguished by the value of this natural complex [9,10].

**The purpose of the research.** Assessment of water quality in the lake by long-term hydrophysical, hydrochemical indicators and the study of algae of the Akbas lake of the Aiytau branch of the Kokshetau state national natural park.

**Materials and research methods**

The ecological state of Lake Akbas has been published, and the average value of the data from many years of laboratory research has been estimated based on fishing standards. Water sampling was carried out in accordance with the interstate standard ST RK GOST R 51592-2003. Hydrophysical indicators: by smell organoleptic methods according to GOST 3351-74; Color according to GOST 31868-2012 – method of visual determination of color (method a); GOST 3351-74 t. Turbidity of 5 was determined by photometric method [11,12].

Hydrochemical parameters were determined according to GOST 26449: pH of the medium – by electrometric method; carbon dioxide, potassium, sodium, nitrates – by potentiometric titration; dissolved oxygen, dry residue mineralization, oxidation of permanganate, hydrocarbons, carbonates, chlorides – by titrimetric method; sulfates, calcium, magnesium, total – complexometric hardness; chromium (III) – by photocolorimetric method, hydrocarbons, bicarbonates, carbonates, chlorides – by titration method.

Nitrites on M 01 – 46 – 2013 by fluorimetric method; ordinary iron, zinc, lead, cadmium, copper, cobalt, manganese, molybdenum, nickel, chromium, silver, strontium, beryllium – by the method of atomic absorption spectrometry on the MGA-915 spectrometer [13,14, 15].

Sirenko’s guidelines for determining the species composition of algae and “Keys to freshwater algae of the USSR”, v. 1-14, 1951; “Keys to the blue-green algae of Central Asia”, volumes 1-3, 1987; “Key to the protococcal algae of Central Asia”, Volume 1-2, 1988; “A short guide to chlorococcal algae of the Ukrainian SSR”. Kiev, 1990; identifiers were used
The number of cells was determined using a Goryaev chamber. To assess the state of aquatic ecosystems with phytoplankton, the methods of Pantle, Bukka and modified Sladechka were used [24].

**Research results and discussion**

Lake Akbas is located to the north-west of the Syrymbet village of the Aiyrtau region, at an altitude of 220.4 m above sea level, with the geographical coordinates of the lake from 53° 31′ degrees to 67° 56′ degrees east longitude. The lake is 6.0 km long, 3.1 km wide. The length of the coastline is 19.0 km. The lake shore is open, the bottom is muddy. The catchment area is 110 km², flat, 20% plowed [25].

In some parts of the coast there are reeds and thickets. The area of the lake in 1959 was 13 km², and in 2004 it decreased by about 2 km², or 11.08 km². This situation is associated with the narrowing of the catchment area. The lake is replenished by atmospheric precipitation and groundwater. The role of precipitation and evaporation in the water balance is increasing. In spring, the water level rises in May and reaches a maximum, then decreases in June and is minimum in winter. As soon as the temperature drops to 0°C, ice flakes begin to form in the lake. The lake freezes over in October-November.

The hydrophysical parameters of Lake Akbas are shown in Table 1 below. Considering that the organoleptic and commercial characteristics of lake water, along with changes in its physical properties (transparency, color, smell, taste) and chemical composition, reduce its quality (Lobanovo, 2002; Popov, 2003;) (hereinafter – MAC). It can be seen that the color and turbidity of the water has decreased over the past 3 years.

| Indicators                  | Measurement measures | 2015 | 2016 | 2017 | 2018 | 2019 | MAC       |
|-----------------------------|----------------------|------|------|------|------|------|-----------|
| Smell of water              | scores               | no   | no   | no   | no   | no   | not more than 2 |
| Water color                 | temperature          | 0    | 0    | 110.2| 98.6 | 97.1 | not normalized |
| Turbidity of water          | mg / dm³             | 29.54| 0    | 7.72 | 7.5  | 7.2  | not normalized |

According to the general hardness of Lake Akbas: in 2015 – solid, in 2016, 2018, 2019 – medium hard, in 2017 – very hard (Table 2). In terms of hydrogen or pH of natural waters, the water in the lake did not exceed the MAC in the years of control. In 2015, 2018, 2019, this indicator was 8.1-8.3 – slightly alkaline, in 2016 – neutral, in 2017 – 8.92 – alkaline water. Over the years of research, the amount of dry waste in the lake water has increased 1.1-1.5 times from the annual MAC. The peak was 1.5 times higher in 2017, but was 1.3–1.4 times higher than the maximum permissible concentration, although over the past two years it has slightly decreased.

According to the level of dissolved oxygen in the water of Lake Akbas, the level and quality of water pollution in 2018-2019 showed an average level of pollution of the III class. The appearance of iron compounds in surface waters is associated with mechanical destruction and melting of rocks in water under the influence of wind. Part of the iron enters through groundwater, industrial and agricultural wastewater, but the amount of iron in the lake water over the past two years was 0.5-0.6 times less than the MAC.

Compounds of $\text{HCO}_3^-$, $\text{CO}_3^{2-}$, $\text{Cl}^-$, $\text{SO}_4^{2-}$, $\text{Ca}^{2+}$, $\text{Mg}^{2+}$, $\text{Na}^+$, $\text{K}^+$ ions in natural water determine the mineralization of water. Calcium ions in water are in the form of $\text{Ca} \left(\text{HCO}_3\right)_2$ and $\text{CaSO}_4$. As the salinity of the water increases, their content decreases due to the slow solubility of calcium salts in water. It turned out that the amount of calcium in the water of Lake Akbas from 2015 to 2019 was 5.29 – 21.9 times less than the MAC.

Magnesium in chemical composition is close to calcium, but has low biological activity. The predominance in natural waters is rare, but the rapid solubility in the form of $\text{MgSO}_4$ increases its amount in water, which is clearly seen in Table 2 above. In the dynamics of long-term monitoring, it was found that magnesium exceeds the MPC in 2015 (2.4 times), 2016 (2.01 times), 2017 (4.38 times), 2018 (4.1 times) ), 2019 (3.8 times).

Sodium ions are the predominant cations. However, over the years of research in the lake, the amount of sodium was 3.1-3.8 times less than the MAC.
Table 2 – Hydrochemical composition of water in Lake Akbas

| Indicators by years | MAC | Notes |
|---------------------|-----|------|
| 2015 | 2016 | 2017 | 2018 | 2019 |
| Solidness mg-eq/l | 9,7 | 7,27 | 15,14 | 4,6 | 4,2 | not normalized |
| pH pH.Unit rev | 8,24 | 7,2 | 8,92 | 8,3 | 8,1 | 6,0-9,0 | not more |
| Dry waste mg/l | 1100 | 1200 | 1550 | 1439 | 1377 | 1000 | more |
| Oxygen dissolved in water mgO₂/l | 0 | 0 | 0 | 7,3 | 7,6 | not less than 4 |
| Common iron mg/l | 0 | 0 | 0 | 0,18 | 0,15 | 0,1 | not more |
| Calcium mg/l | 34 | 11,4 | 10,8 | 8,9 | 8,2 | 180 |
| Magnesium mg/l | 96 | 80,4 | 175,2 | 164 | 152 | 40 | more |
| Sodium mg/l | 38 | 31 | 32,5 | 33,6 | 31 | 120 | not more |
| Potassium mg/l | 138 | 184,8 | 183 | 176,3 | 163 | 50 | more |
| Nitrite mg/l | 0,27 | 0,06 | 0,42 | 0,87 | 0,85 | 3 | not more |
| Nitrates mg/l | 0 | 0,05 | 0,3 | 1,9 | 12,3 | 45 | not more |
| Carbonates mg/l | 0 | 1,1 | 2,04 | 8< | 8< | not normalized |
| Hydro-carbonates mg/l | 73,2 | 67,1 | 51,24 | 48,3 | 42,6 | 350 | not more |
| Chlorides mg/l | 560,78 | 728,1 | 890,07 | 846 | 514 | 500 | more |

Potassium ions are found in small amounts in natural waters due to their slow movement and high biological requirements for living organisms. Potassium ions for Lake Akbas are higher than sodium, and the minimum threshold in 2015 was 2.8 times higher than the maximum permissible concentration, and the maximum threshold in 2016 was 3.7 times higher.

Nitrogen is found in surface waters in the form of inorganic (ammonium nitrogen, nitrite, nitrate) and organic (amino acids and proteins in the tissues of organisms, their decomposition products). It was shown that the amount of nitrite in these years was 3.4 – 50 times less than the MAC. Although the concentration of nitrates in the studied lake did not exceed the MAC, in the period from 2015 to 2019 there was a steady increase from 0.05 to 12.3 mg / l.

Chlorine ions are found in natural waters in the form of sodium chloride, magnesium chloride, calcium chloride and, in rare cases, potassium chloride. Mineralization is increased by increasing chlorine ions. The concentration of chlorides for Lake Akbas is low compared to the MAC, the lowest level of this indicator in 2016 was 8.7 times, the maximum level in 2015 was 2.1 times less.

Most of the sulphate gets through the death of living organisms into water, domestic and agricultural wastewater [14]. As a result of hydrochemical studies carried out from 2015 to 2019, the amount of sulfate exceeded the MAC. In particular, in 2015 and 2019 it added a little and amounted to 560.78 – 514 mg / l, in 2016 – 1.4; in 2017 – 1.8; In 2016, it increased 1.7 times.

According to the indicators of the ionic composition of Lake Akbas, in 2015 there was weak fresh water with sulfate-chloride sodium, in 2016 – magnesium-sulfate, in the form of weak fresh water with sulfate-magnesium sodium from 2017 to 2019 (Table 3).

As a result of our research, the content of cadmium among heavy metals was 50 times higher than the MPC in 2016 (Figure 2). This indicator was equal to the MAC in 2017, and in 2018-2019, on the contrary, it was less than 0.0001 mg / l. Contamination of Lake Akbas with other heavy metals did not exceed the permissible level (Table 4, Figure 2).

The area of the Akbas lake basin has decreased by 15.3% over the past 50 years. During the study period, the content of dry waste in the lake water exceeded the MAC by 1.1–1.5 times annually. Lake Akbas is moderately polluted in 2018-2019 in terms of the level and quality of class III pollution. The amount of sulfate was 514 – 890.07 mg / l, which exceeded the permissible concentration. The highest levels of cadmium were found to be 50 times the maximum concentration in 2016 and below the maximum concentration in the last three years.
Table 3 – Indicators of the ionic composition of Lake Akbas

| Years | Measures | Mass concentration of cations | Mass concentration of anions | The sum of ions, mg/l | Formula of salt composition of water | Name of water |
|-------|----------|-------------------------------|-------------------------------|---------------------|-------------------------------------|---------------|
|       |          | Na⁺+K⁺ | Ca²⁺ | Mg²⁺ | Cl⁻ | SO₄²⁻ | HCO₃⁻ |       |         |                     |               |
| 2015  | mg / dm³ | 176   | 34   | 96   | 165,2 | 560,78 | 73,2 | 1105,18 | 1,11 SO₄67 Cl 27 [HCO₃ 6] Mg46 Na44 [Ca10] | chloride water - sulphate sodium-magnesium, slightly fresh |
|       | mg / dm³ | 7,66  | 1,7  | 7,9  | 4,66  | 11,68 | 1,2  |         |                     |               |
|       | % eq / dm³ | 44,38 | 45,79 | 9,83 | 6,84  | 26,58 | 66,58 |         |                     |               |
| 2016  | mg / dm³ | 215,8 | 11,4 | 80,4 | 40,32 | 728,1 | 67,1 | 1143,12 | 1,14 SO₄87 [Cl 7 HCO₃ 6] 7,2 Na57 Mg40[Ca3] | water magnesium sulfate - sodium, slightly fresh |
|       | mg / dm³ | 9,39  | 0,57 | 6,61 | 1,14  | 15,16 | 1,1  |         |                     |               |
|       | % eq / dm³ | 56,65 | 3,43 | 39,92 | 6,54  | 87,14 | 6,32 |         |                     |               |
| 2017  | mg / dm³ | 215,5 | 10,8 | 175,2 | 162,8  | 890,07 | 51,24 | 1505,49 | 1,51 SO₄77 [Cl 19 HCO₃ 4] 8,92 Mg59 Na39 [Ca2] | sulphate water sodium magnesium slightly fresh |
|       | mg / dm³ | 9,37  | 0,54 | 14,41 | 4,59  | 18,53 | 0,84 |         |                     |               |
|       | % eq / dm³ | 38,53 | 2,22 | 59,25 | 19,15  | 77,34 | 3,5  |         |                     |               |
| 2018  | mg / dm³ | 209,9 | 8,9  | 164  | 154   | 846  | 48,3 | 1431,1 | 1,43 SO₄77 [Cl 19 HCO₃ 3] 8,3 Mg58 Na40 [Ca2] | sulphate water sodium magnesium slightly fresh |
|       | mg-eq/ dm³ | 9,13  | 0,44 | 13,49 | 4,34  | 17,61 | 0,79 |         |                     |               |
|       | % eq / dm³ | 39,58 | 1,93 | 58,49 | 19,1  | 77,43 | 3,48 |         |                     |               |
| 2019  | mg / dm³ | 194   | 8,2  | 152  | 102   | 514  | 42,6 | 1012,8 | 1,51 SO₄75 [Cl 20 HCO₃ 5] 8,1 Mg59 Na40 [Ca1] | sulphate water sodium magnesium slightly fresh |
|       | mg-eq/ dm³ | 8,44  | 0,41 | 12,51 | 2,88  | 10,7  | 0,7  |         |                     |               |
|       | % eq / dm³ | 39,52 | 1,92 | 58,56 | 20,15  | 74,96 | 4,89 |         |                     |               |

Notes: [ ] –less than 25%

Table 4 – Actual concentration of heavy metal pollution in Lake Akbas, mg / l

| Name of contaminants | 2015 | 2016 | 2017 | 2018  | 2019  | MAC | Notes |
|---------------------|------|------|------|-------|-------|-----|-------|
| Zinc                | 0,0007 | 0,011 | 0,053 | 0,16  | 0,11  | 5   | not more |
| Lead                | 0,025 | 0,0025 | 0,0025 | 0,005 | 0,008 | 0,03 | not more |
| Cadmium             | 0,001 | 0,05  | 0,001 | <0,0001 | <0,0001 | 0,001 | more |
| for example         | 0,0004 | 0,0014 | 0,0164 | 0,08  | 0,09  | 1   | not more |
| Cobalt              | 0,024 | 0,001 | 0,01  | 0,0006 | 0,0005 | 0,1 | not more |
| Manganese           | 0,0006 | 0,0006 | 0,0006 | 0,007  | 0,008 | 0,1 | not more |
| Molybdenum          | 0,003 | 0,003 | 0,003 | <0,001 | <0,001 | 0,25 | not more |
| Nickel              | 0,0008 | - | - | 0,007 | 0,005 | 0,1 | not more |
In addition to hydrophysical and hydrochemical studies, we carried out studies of algae for a comprehensive assessment of the ecological state of Lake Akbas.

As a result of the study of algae in water samples taken from Lake Akbas, 61 species of microalgae were identified. 47.5% of the identified species were green algae (Chlorophyta), 26% were diatoms (Bacillariophyta), 23% were blue algae (Cyanophyta), and 4% were euglena algae (Euglenophyta) (Fig. 3).

The identified species are divided into 4 sections, 9 classes, 12 rows, 16 genera, 27 relatives.
Among the microalgae found in Lake Akbas were the green algae *Chlorella vulgaris*, *Chlorella* sp, *Ankistrodesmus longissimus*, *Scenedesmus acuminatus*, *Scenedesmus quadricauda*, *Chlamydomonas reinhardtii*. From diatoms *Navicula dicephala*, *Navicula radiosa*, *Navicula specula*, *Synedra ulna*, *Nitzschia palea* were more than others. There are also *Ulothrix tenerrima Kutz.*, *U. Variabilis Kutz.*, from blue-green algae – *Phormidium tenue.*, *Anabaena variabilis*, *Spirulina major*, *Oscillatoria tenuis*, *Oscillatoria chalybea* and many others.

The sensitivity of algae to various pollutants depends on their absorption of substances from the environment throughout the body. In addition, some types of algae are indicators of the presence of certain pollutants in the water.

Water pollution of Lake Akbas is primarily associated with the entry of various pollutants into the reservoir. Most pollutants are caused by precipitation. The share of household waste pollution is also high.

When assessing the ecological state of water bodies, not only physicochemical methods are widely used, but also the role of indicator-saprobic microalgae.

After determining the species composition of microalgae living in Lake Akbas, we settled on the indicator-saprobic species of microalgae. It is impossible to determine the spectrum of all pollutants using indicator species. But it allows you to quickly determine the fact of environmental pollution.

As a result of algological studies, it has been established that 20 species of microalgae found in the reservoir of Lake Akbas are indicator-saprobic species (Table 5).

| №  | Saprobic species indicator | Saprobic S |
|----|---------------------------|------------|
| 1  | *Merismopedia glauca* (Ehr ) Nag | β          |
| 2  | *Merismopedia major* (Ehr) Nag | β – о       |
| 3  | *Merismopedia tenuissima* lemm. | β – α       |
| 4  | *Microcystis aeruginosa* | β          |
| 5  | *Anabaena affinis* | β          |
| 6  | *Oscillatoria tenius* Ag. | α          |
| 7  | *Oscillatoria chalybea* (Mert.) Com | α          |
| 8  | *Oscillatoria Limnetica* lemm. | o – β      |
| 9  | *Oscillatoria brevis* (Kuetz.) Com | α          |
| 10 | *Scenedesmus acuminatus* | β          |
| 11 | *Scenedesmus quadricauda* var. | β          |
| 12 | *Pediastrum boryanum* Meyen | β          |
| 13 | *Chlorella vulgaris* | ρ-α        |
| 14 | *Ulothrix zonata* | о          |
| 15 | *Cladophora glomerata* | β          |
| 16 | *Euglena viridis* | ρ-α        |
| 17 | *Euglena hemichromata* Skuja | β          |
| 18 | *Nitzschia palea* | α          |
| 19 | *Fragilaria capucina* | β–о        |
| 20 | *Synedra ulna* | χ – α      |

First of all, nutrient media were prepared for control and experiments for biotesting Lake Akbas. Then a test organism, the *Chlorella sp-3K* strain, was introduced into it. The dynamics of cell growth was studied for 8 days, and a comparative analysis of the data was carried out. Mineral salts necessary for cell nutrition were added to the preparation of pure control water and culture medium of lake water in an amount corresponding to standard culture medium 04.

For the study, 2 different variants of lake water were taken. In Option 1, lake water was diluted by half, and in Option 2, the first sample of lake water was taken without changes. The number of introduced chlorella cells was the same in all variants 5x106 ± 0.6 ml (table 2).

Nutrient media for control and experiment and the *Chlorella sp-3K* strain were used for biotesting Lake Akbas.

When observing the dynamics of cell growth for 8 days, it was found that the number of cells of the *Chlorella sp-3K* strain in pure control water increased by 22.8 × 106 ± 0.65 in 4 days. The number of cells of the *Chlorella sp-3K* strain in the lake water diluted by half increased to 19.1x106 ± 0.45 per ml in the first 4 days, and no increase was observed in the following days. In 2 variants of the first sample of lake water taken without changes, the
number of cells increased to $17.5 \times 10^6 \pm 0.5$ per 1 ml in the first 4 days, and no increase was observed on the following days (Table 6).

In figure 5 shows the dynamics of cell growth during biotesting of the water of Lake Akbas using the Chlorella sp-3K strain.

Figure 4 – Indicator of the saprobity of the algal flora of Lake Akbas quantitative ratio of species

Figure 5 – Growth dynamics of the Chlorella sp-3K strain in a water sample from Lake Akbas and control

Table 6 – Growth of Chlorella sp-3K cells during biotesting in the water of Lake Akbas

| Tests    | Number of cells in 1 ml per day |
|----------|--------------------------------|
|          | 0    | 2     | 4     | 6     | 8     |
| Control  | $5 \times 10^6 \pm 0.25$ | $19,2 \times 10^6 \pm 0.6$ | $22,8 \times 10^6 \pm 0.65$ | $22,5 \times 10^6 \pm 0.55$ | $22 \times 10^6 \pm 0.54$ |
| 1-variant| $5 \times 10^6 \pm 0.3$    | $13,8 \times 10^6 \pm 0.36$| $19,1 \times 10^6 \pm 0.45$| $18,4 \times 10^6 \pm 0.5$ | $16,3 \times 10^6 \pm 0.48$ |
| 2-variant| $5 \times 10^6 \pm 0.3$    | $10,4 \times 10^6 \pm 0.35$| $17,5 \times 10^6 \pm 0.5$ | $15,1 \times 10^6 \pm 0.49$| $13,2 \times 10^6 \pm 0.46$ |
There was a decrease in the number of chlorella cells in the test water compared to the control. This is due to the fact that Lake Akbas contains more fluoride, iron and copper, which inhibit the growth of the *Chlorella sp-3K* strain.

Biotesting showed that the *Chlorella sp-3K* strain is moderately sensitive to toxic concentrations in Lake Akbas.

Studies have shown that bioassays for microalgae in lake water are quick and easy and complete the results of chemical studies. Thus, the biotesting results supplemented the previous data and correctly responded to the toxicity of the *Chlorella sp-3K* strain in water bodies.

In the period of the work it was proved that the results of hydrochemical, algal and biotesting studies carried out on Lake Akbas completed each other. According to these indicators of a comprehensive assessment of the lake water, the water of Lake Akbas belongs to the 3rd class of pollution and is moderately polluted.

**Conclusion**

Lake Akbas has been studied and analyzed using hydrophysical, hydrochemical and algological studies. The ecological state of Lake Akbas has been published, and the average value of the data of long-term laboratory studies has been estimated based on the lists of fishing standards. As a result of research in 2015-2019, according to the hydrophysical, hydrochemical studies and the results of complex testing of algocenoses and biotesting, it was determined that the water of Lake Akbas belongs to 3 classes of pollution.

The amount of sulfate was 514 – 890.07 mg/l, which exceeded the permissible concentration. It was found that the maximum level of cadmium is 50 times higher than the MAC in 2016, but below the MAC for the last three years.

In studies of algae, microalgae in the beta-mesosaprobic zone accounted for 40% of all algae in the reservoir, and the saprobity index 1.95 according to the Pantle-Bucchi method proved that Lake Akbas belongs to the β-mesosaprobic zone. Biotesting showed that the *Chlorella sp-3K* strain is moderately sensitive to the concentration of toxic substances in Lake Akbas.

**Conflict of interest**

All authors are familiar with the text of the article and declare that they have no conflict of interests.

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