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SUDOCHE KO'LLAR TIZIMI ALGOTSENOZLARINING EKOLOGIK XUSUSIYATLARI

Аннотация

Ushbu maqolada Sudoche ko'llar tizimi algologik jamoalar (algotsenozlar)ni o'rganish, ekologik monitoring olib borish, gidrobiontlarning biologik xilma-xilligini va ularning ekologik jamoalari tuzilmasini yuqori mineralizatsiya gradiyenti sharoitida baholashga qaratilgan kompleks tadqiqotlar natijalari keltirilgan. Shuningdek, Sudoche ko'llar tizimi suvo'tlarining taksonomik, ekologik va algotsenotik tahlili, o'ziga xos rivojlanish va shakllanish qonuniyatlari, ekologik-geografik tavsifi, turlarning ekologik valentligi bo'yicha tadqiqot natijalari yoritilgan.

Kalit so'zlar: Sudoche ko'llar tizimi, suvo'tlari identifikatsiyasi, ekologik monitoring, *Cyanophyta*, *Bacillariophyta*, *Pyrrophyta*, *Euglenophyta*, oligotrof sharoit, mezotrof sharoit.

ЭКОЛОГИЧЕСКИЕ ОСОБЕННОСТИ АЛЬГОЦЕНОЗОВ ОЗЕРНОЙ СИСТЕМЕ СУДОЧЬЕ

Аннотация

В данной статье изложены результаты всестороннего исследования альгологических сообществ (альгоценозов) озёрной системы Судочье. В рамках работы проведён экологический мониторинг, оценено биоразнообразие водных организмов и проанализирована структура экосистем в условиях ярко выраженного градиента минерализации вод. Особое внимание уделено таксономической принадлежности видов, экологическим свойствам и пространственно-структурной организации альгоценозов.

Ключевые слова: Озёрная система Судочье, идентификация водорослей, экологический мониторинг, *Cyanophyta*, *Bacillariophyta*, *Pyrrophyta*, *Euglenophyta*, олиготрофные условия, мезотрофные условия.

ECOLOGICAL ASPECTS OF ALGAL COMMUNITIES IN THE SUDOCHE LAKE SYSTEM

Annotation

This article presents the results of a comprehensive study of algal communities (algocenoses) in the Sudoche Lake System. The research included ecological monitoring, an assessment of aquatic biodiversity, and an analysis of ecosystem structure under conditions of a pronounced water mineralization gradient. Particular attention was given to the taxonomic composition of species, their ecological characteristics, and the spatial and structural organization of algal communities.

Key words: Sudoche Lake System, algae identification, ecological monitoring, *Cyanophyta*, *Bacillariophyta*, *Pyrrophyta*, *Euglenophyta*, oligotrophic conditions, mesotrophic conditions.

Introduction. The stabilization of the ecological situation in the Aral Sea basin, the restoration of ecosystems, the improvement of water and land resource management methods in the Aral Sea region, as well as the resolution of pressing and insufficiently addressed socio-economic and medical issues, represent areas of significant scientific and practical importance.

This study is, to a certain extent, aimed at contributing to the implementation of the objectives outlined in the Decree of the President of the Republic of Uzbekistan dated January 28, 2022, No. PF-60, "On the Development Strategy of New Uzbekistan for 2022 - 2026," as well as the Decree dated November 23, 2023, No. PF-199, Annex 8, "National Program for the Sustainable Development of the Aral Sea Region for 2024 - 2028, the Expanded Implementation of Innovations and Green Technologies," along with other regulatory and legal documents governing this area [14; 15].

Literature review. Algal communities are crucial for aquatic ecosystems, driving primary production, nutrient cycling, and biodiversity. In highly mineralized lakes, phytoplankton structure and dynamics depend mainly on salinity, ion composition, temperature, and hydrology. Studies (Dyakov, 2001; Karamyshev, 2008; Utepbergenov et al., 2015) show that high salinity simplifies phytoplankton, favoring eurythermal and eurybiontic species from *Cyanophyta*, *Bacillariophyta*, and *Euglenophyta*. Biodiversity declines as tolerant species dominate, serving as sensitive indicators of environmental shifts. Therefore, studying algal communities in saline lakes reveals algae's adaptive strategies and ecosystem resilience to natural and human impacts [1; 4; 10].

Research Methodology. Biodiversity conservation remains a major ecological challenge, complicated by natural and anthropogenic factors, with some local ecosystems showing compensatory trends [12; 13]. Seasonal water and phytoplankton samples from the Sudoche lake system were collected using a Ruttner sampler and 25 µm plankton net. In situ measurements of temperature, pH, mineralization, and dissolved oxygen were taken with portable multiparameter devices [7; 8]. Samples preserved in 4% formalin were analyzed by light microscopy (×400-1000), and taxa were identified using standard guides [7; 9]. Quantitative analysis employed the Utermöhl method and Nageotte chamber [11]. Ecological structure was evaluated through species richness, dominance, and Shannon-Wiener diversity indices. Trophic and saprobity status was assessed via indicator species [8]. Data were processed using PAST, Excel, and SPSS software [2; 3; 5; 6].

Analysis and results. Between 2019 and 2024, comprehensive research was conducted on the Sudoche lake system, which receives water from the Amu Darya River via its delta into the southern Aral Sea. The study applied a basin-based approach

to investigate hydrological and ecological features, assess algal communities (algcenoses), and conduct ecological monitoring across the western and eastern sectors of the Aral Sea.

Fieldwork focused on algocenosis structure, biodiversity of hydrobionts, and ecological conditions under a pronounced mineralization gradient. Monitoring was carried out at four key sites with contrasting ecological settings:

- I. Lake Akushpa (130 m a.s.l., 43°49'723" N, 58°32'134" E),
- II. Lake Bolshoye Sudochye (156 m a.s.l., 46,467 ha, 43°29' N, 58°31' E),
- III. Lake Begdulla-Aydy (109 m a.s.l., 43°07'689" N, 58°56'980" E),
- IV. Lake Karateren (123 m a.s.l., 43°58'195" N, 58°53'686" E).

These sites enabled comparative analysis of algal communities under varied environmental conditions. Over 864 algological samples were collected across multiple seasons. Laboratory analysis identified dominant taxa and evaluated their ecological traits.

Seasonal dynamics of algocenoses were influenced by abiotic factors, including fluctuations in air and water temperature, slightly alkaline pH (7.8-8.1), low transparency (0.09-0.20 m), and unstable hydro-physical parameters such as depth variation, water color, and odor (Fig. 1).

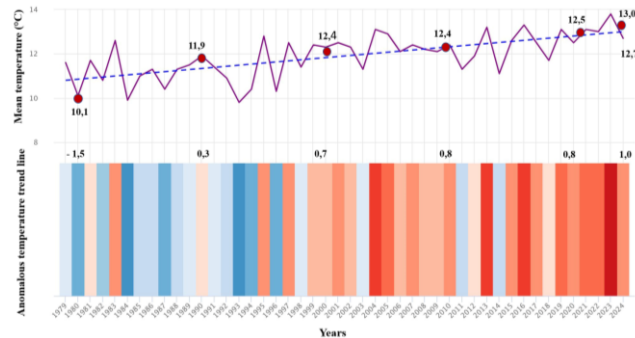


Figure 1. Mean annual air temperature, temperature variability, and rates of temperature increase in the Sudochye lake system from 1980 to 2024.

A clear pattern of seasonal and interannual variability in air temperature was recorded, with a consistent upward trend. By 2020, the mean annual air temperature reached 12.5 °C, reflecting an increase of 0.8 °C compared to previous baseline values. By 2024, this value rose to 12.7 °C, with a cumulative increase of 1.0 °C. The overall climatic trend projected a further rise towards 13.0 °C. These data indicate a steady year-on-year increase in air temperature over the past decade, contributing to changes in the thermal regime of the lake system and subsequently influencing the structure and seasonal succession of algal communities.

Based on the analysis of long-term average monthly precipitation data, considering the trend indicated by the black lines, the highest precipitation levels are primarily observed during the spring period -in March, the summer-in June, and also in October, during the autumn season (see Figure 2).

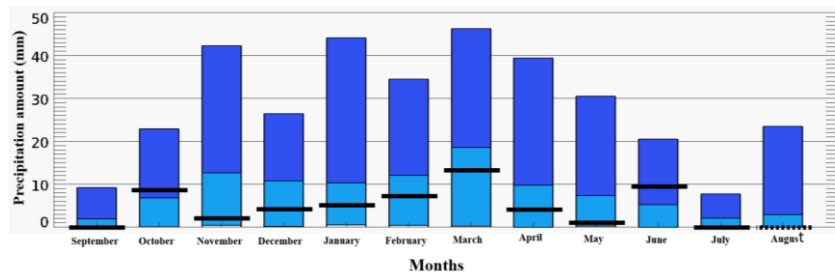


Figure 2. Long-term mean monthly precipitation (mm)

Long-term monthly precipitation data show clear seasonal variation, with peaks in March, June, and October, and minimal rainfall in September, May, July, and almost none in August. This pattern reflects the region's arid climate, especially in summer, impacting the hydrological regime and aquatic ecosystems.

Between 2005 and 2009, the Aral Sea experienced significant hydrological declines: sea level dropped from -30.33 m (-25%) to -27.53 m (-32%), inflow from the Amu Darya fell from 8.40 km³ (-20%) to 2.56 km³ (-26%), catchment area reduced from 19,600 km² (-51.4%) to 13,500 km² (-64.6%), and total volume decreased from 125 km³ (-66.7%) to 105 km³ (-72%). Salinity sharply increased from 90.0 g/L (+73.4%) to 102 g/L (+76.6%) (see Figure 3).

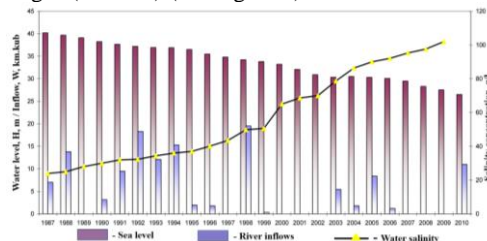


Figure 3. Trends in water level, salinity, and river discharge in the Greater Aral Sea (1987-2010)

In spring, high trophic levels and weak water circulation in the Sudochye lake system promoted growth of diatoms (*Bacillariophyta*) and cyanobacteria (*Cyanophyta*), tolerant to temperature and salinity changes. In low-transparency areas,

dominant species included *Melosira varians*, *Synedra tabulata*, *Fragilaria crotonensis*, and filamentous cyanobacteria. Algae with broad ecological plasticity-especially *Synedra*, *Melosira*, *Aphanizomenon*, and *Oscillatoria*-thrived in eutrophic and mesotrophic conditions. Key factors like temperature, pH, turbidity, and mineralization shaped algal community structure, favoring species adapted to deltaic variability.

Hydrological data from the past five years showed peak water surface areas in July 2020 (14,672 ha), April 2021 (13,411 ha), and June 2019 (12,977 ha). Salinization and shrinking water area intensified thermal fluctuations, altering algal biodiversity and seasonal dynamics. Increasing salinity and temperature instability led to declines in eurythermic and oligotrophic species, while euryhaline and mesotrophic taxa expanded. *Melosira*, *Synedra*, and *Fragilaria* remained dominant due to their resilience; more sensitive species declined or vanished.

These hydrological shifts caused major changes in the structure and function of Sudochoye ecosystems, emphasizing the need for long-term monitoring and adaptive biodiversity management. Climatic factors-water availability, temperature, and precipitation-continue driving changes in species composition and ecosystem stability.

Diatoms dominate phytoplankton, especially from classes *Centrales* and *Pennatophyceae*, including orders *Discoidales*, *Cymbellales*, *Araphidales*, and *Raphidales*. Families such as *Coscinodiscaceae*, *Tabellariaceae*, *Fragilariaceae*, and *Achnantheaceae* prevail, with dominant genera *Melosira*, *Tabellaria*, *Synedra*, *Fragilaria*, and *Achnanthes*. Key species-*Melosira varians*, *Melosira distans*, *Synedra tabulata*, and *Synedra pulchella* var. *minuta*-show high ecological plasticity, adapting to salinity, pH, and hydrochemical variations, reflecting combined effects of temperature, water clarity, depth, mineralization, and seasonal climate variability (Tabl.1).

Table 1.

Dominant Diatom Species in the Sudochoye Lake System and Their Ecological Characteristics

Species	Genus	Dominance	Ecological Traits
<i>Melosira varians</i> Agardh	<i>Melosira</i>	High abundance and widespread distribution	High adaptability to variations in salinity and pH
<i>Melosira distans</i> (Ehr.) Kuetz.	<i>Melosira</i>	High abundance	Tolerant to mineralization changes
<i>Synedra tabulata</i> (Ag.) Kuetz.	<i>Synedra</i>	Frequent occurrence	Adapted to hydrological fluctuations
<i>Synedra pulchella</i> var. <i>minuta</i> Hust.	<i>Synedra</i>	Widespread in spring and autumn	Resilient to pH and salinity shifts

Members of the *Fragilariaceae* and *Achnantheaceae* families significantly influence the ecological structure of aquatic ecosystems and serve as key bioindicators of water quality. The species composition of algal communities shows clear seasonal variation tied to hydrological and environmental changes.

High species diversity and ecological heterogeneity in the Sudochoye lake system reflect complex algal adaptations to fluctuating conditions, supporting ecosystem stability and resilience. Trophic classification is based on nutrient preferences and tolerance to salinity and organic enrichment (Table 2).

Table 2.

Dominant Diatom Species and Their Trophic Groups in the Sudochoye Lake System

Taxonomic Group	Species	Family	Trophic Group
<i>Melosira varians</i> Ag.	<i>Melosira varians</i>	<i>Coscinodiscaceae</i>	Mesotrophic – Eutrophic
<i>Melosira distans</i> (Ehr.) Kuetz.	<i>Melosira distans</i>	<i>Coscinodiscaceae</i>	Mesotrophic
<i>Synedra tabulata</i> (Ag.) Kuetz.	<i>Synedra tabulata</i>	<i>Fragilariaceae</i>	Oligotrophic – Mesotrophic
<i>Synedra pulchella</i> var. <i>minuta</i> Hust.	<i>Synedra pulchella</i> var. <i>minuta</i>	<i>Fragilariaceae</i>	Mesotrophic
<i>Fragilaria crotonensis</i> Kitton	<i>Fragilaria crotonensis</i>	<i>Fragilariaceae</i>	Eutrophic

Melosira varians (brackish-water, oligobeta-mesosaprobic) indicates declining water levels, while *Melosira distans* (brackish, euryhaline, xeno-oligosaprobic) signals reduced surface water. Their dominance reflects hydrological changes, aiding water regime assessment for ecological monitoring and management.

Euryhaline to mesohalobic species like *Synedra pulchella* var. *minuta* (2.2), *Synedra tabulata* (2.7), and *Synedra ulna* (1.95) tolerate wide mineralization fluctuations. Species such as *Achnanthes linearis* var. *cryptocephala* (0.4), *Melosira distans* (0.5), and *Achnanthes lanceolata* (0.75) serve as indicators of high, variable mineralization in Sudochoye waters.

The adaptability and survival of species with varied saprobic statuses-*Synedra ulna* (1.95), *Melosira varians* (1.85), and *Achnanthes minutissima* var. *cryptocephala* (1.45)-allow predictions of future biodiversity in these ecosystems.

Conclusion. Changes in the water regime of the Sudochoye lake system-driven by temperature, precipitation fluctuations, and human impacts-have significantly altered aquatic ecosystems, affecting algal community composition, diversity, and trophic status.

Species shifts in algocenoses are mainly driven by physical parameters such as light availability, air temperature (+1.5 °C to +27.5 °C), water temperature (+4.0 °C to +11.0 °C), transparency (0.12-0.20 m), turbidity, and pH (7.82-8.07). Morpho-edaphic conditions, including depth (0.5-1.15 m), surface area, and mineral-organic content, also shape internal ecosystem dynamics. Certain diatoms like *Synedra pulchella* var. *minuta* and *Synedra tabulata* demonstrate high ecological tolerance, indicating strong adaptability to unstable deltaic conditions.

Climatic data from 1979-2024 indicate a steady increase in mean annual air temperature, with peak rainfall occurring in March, June, and October. Average annual precipitation was 113.2 mm, with anomalies reaching up to 24.1 mm.

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