American Journal of Biodiversity
https://biojournals.us/index.php/AJB
ISSN: 2997-3600

Structure of Algal Community and Ecological Features of Dominant Species in the Sudochye Water Bodies

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Received: 2025, 15, Jul
Accepted: 2025, 21, Aug
Published: 2025, 25, Sep

Annotation: This study presents the results of a comprehensive investigation of algocenoses in the Sudochye lake system, including ecological monitoring, hydrobiont biodiversity assessment, and analysis of community structure under conditions of elevated mineralization. Emphasis was placed on the taxonomic composition, ecological traits, and distribution patterns of algae, along with the ecological valence of dominant species.

Long-term climatic data were also analyzed, revealing a gradual linear increase in mean annual air temperature and peak precipitation in March, June, and October. From 1979 to 2024, average annual precipitation was 113.2 mm, with anomalies up to 24.1 mm.

These findings enhance understanding of algal dynamics and the ecological status of aquatic ecosystems in arid, saline environments.

Keywords: Sudochye water body, algal identification, dominant species, species composition, 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. DP-60, "On the Development Strategy of the 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 [1].

Materials and Methods. The conservation of biodiversity at various organizational levels remains a key challenge in modern ecology. Restoration within short timeframes is complicated by natural and anthropogenic factors acting directly or indirectly. While anthropogenic impact is often the main driver of degradation, compensatory trends in some local ecosystems have also been reported [2; 9].

Standard field and laboratory algological methods were applied. Seasonal water and phytoplankton samples were collected from multiple sites in the Sudochye lake system using a Ruttner sampler and a 25 µm plankton net. Water parameters-temperature, pH, mineralization, dissolved oxygen-were measured in situ with portable multiparameter instruments [4; 5;].

Samples were preserved with 4% formalin and analyzed under light microscopy (×400-1000). Algal taxa identification followed standard floristic and taxonomic guides [8; 9]. Quantitative analysis, including species counts and biomass estimation, was conducted using the Utermöhl method [8] and a Nageotte counting chamber.

Ecological structure was assessed via species richness, dominance index, and Shannon-Wiener diversity index (Shannon & Weaver, 1949). Trophic state and saprobity evaluations were based on indicator species analysis [3; 6; 7]. Data processing and statistical analyses employed PAST [6], Excel, and SPSS software.

Results and Discussion. Fieldwork targeted four key monitoring sites with distinct ecological and hydrological characteristics:

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),

III. Lake Begdulla-Aydyn (109 m a.s.l.; 43˚07′689″ N, 58˚56′980″ E), and

IV. Lake Karateren (123 m a.s.l.; 43˚58′195″ N, 58˚53′686″ E).

Across multiple seasons, over 864 algological samples were collected. Laboratory analyses identified dominant algal taxa and their ecological traits under extreme conditions of high salinity and hydrological variability.

From 1980 to 2024, a steady increase in mean annual air temperature was observed, reaching 12.7 °C by 2024, up 1.0 °C compared to historical baselines (Fig. 1).

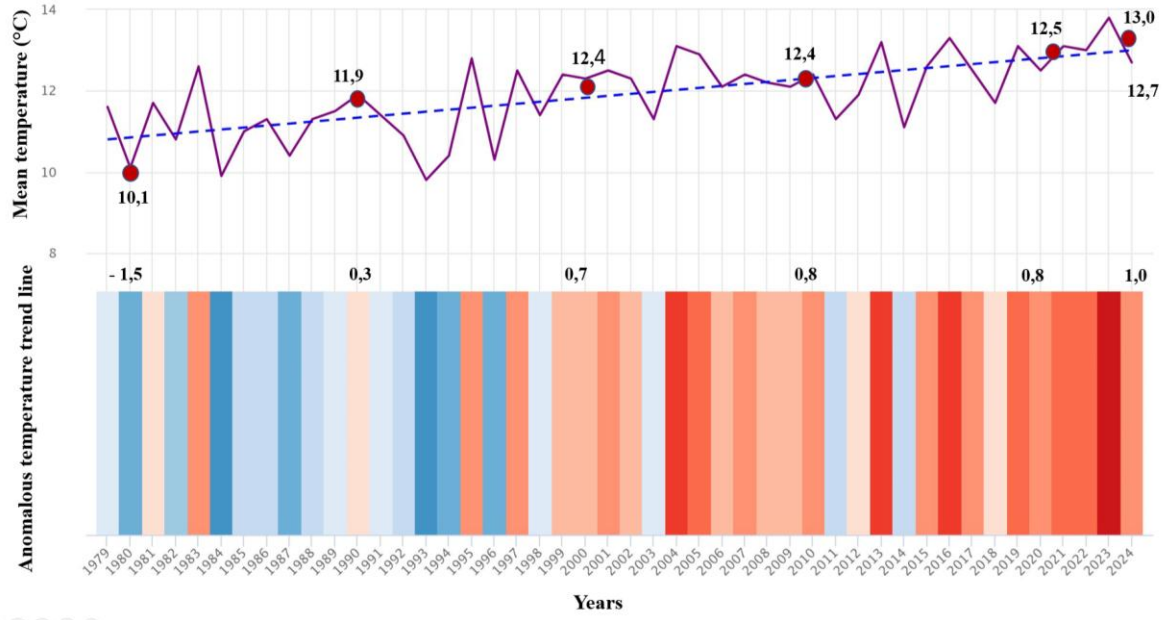

Figure 1. Mean annual air temperature, temperature variability, and rates of temperature increase in the Sudochye lake system from 1980 to 2024.

This warming trend contributed to significant changes in the thermal regime of the lake system, impacting algal succession and seasonal community structure.

Precipitation patterns showed strong seasonal variability, peaking in March, June, and October, with minimal rainfall during July, September, and May, and near absence in August.

These data confirm the arid character of the regional climate, influencing both water availability and ecosystem dynamics.

Historical data illustrate dramatic hydrological degradation in the Aral Sea basin: by 2005, sea level dropped to -30.33 m, inflow reduced by 20%, and salinity rose to 90 g/L.; by 2009, further declines saw sea level at -27.53 m, inflow down to 2.56 km³, and salinity peaking at 102 g/L (Fig. 2).

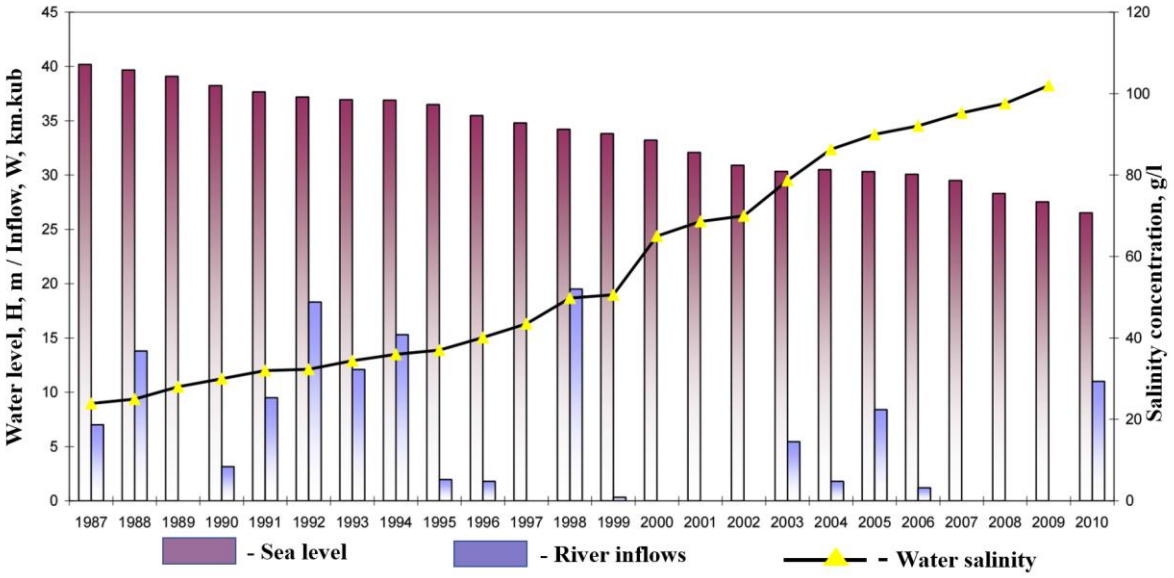

Figure 2. Trends in water level, salinity, and river discharge in the Greater Aral Sea (1987-2010)

The algal communities showed clear seasonal variation, strongly influenced by abiotic factors such as temperature, pH (7.8-8.1), low transparency (0.09-0.20 m), and unstable hydro-physical conditions.

Under elevated trophic levels and limited circulation, especially in spring, diatoms (*Bacillariophyta*) and cyanobacteria (*Cyanophyta*) dominated. Key taxa included: *Melosira varians, Synedra tabulata, Fragilaria crotonensis,* Filamentous cyanobacteria (*Aphanizomenon, Oscillatoria*).

Species with broad ecological plasticity prevailed in both mesotrophic and eutrophic waters, adapting to fluctuations in salinity, temperature, and light. These conditions led to stable algocenoses adapted to the delta's dynamic environment.

Hydrological Dynamics and Ecological Impact. Over the past five years, the largest surface area of the Sudochye lake system was recorded in July 2020 (14,672 ha), with notable extents in April 2021, June 2019, and October 2020. Continued salinization and surface area reduction intensified temperature fluctuations and altered thermal regimes, significantly influencing algal biodiversity.

A clear shift in species composition was observed: eurythermic and oligotrophic species declined, while euryhaline, mesotrophic taxa-notably *Melosira*, *Synedra*, and *Fragilaria*-remained dominant due to their high ecological plasticity. Species sensitive to salinity and temperature stress diminished or disappeared.

These ecological shifts impacted both the structure and function of aquatic communities, underlining the importance of long-term monitoring and adaptive conservation strategies.

Seasonal sampling confirmed diatom dominance, particularly from *Centricae* and *Pennatophyceae* classes. Key orders included *Discoidales, Cymbellales*, *Araphinales*, and *Raphinales;* primary families were *Coscinodiscaceae, Tabellariaceae, Fragilariaceae*, and *Achnanthaceae.* Dominant genera included *Melosira*, *Tabellaria*, *Synedra*, *Fragilaria*, and *Achnanthes*. Species such as *Melosira varians*, *M. distans*, *Synedra tabulata*, and *S. pulchella var. minuta* demonstrated broad tolerance to salinity and pH variability.

The taxonomic structure reflected a combination of oligotrophic, mesotrophic, and eutrophic species, shaped by abiotic drivers such as temperature, depth, transparency, and water chemistry.

Families like *Fragilariaceae* and *Achnanthaceae* were particularly important as bioindicators of water quality. The seasonal variability in algal composition mirrored changes in hydrological conditions, highlighting complex adaptive strategies that promote ecosystem resilience.

For instance, *Melosira varians* (oligobeta - mesosaprobic) indicates declining water levels, while *Melosira distans* (euryhaline, xeno - oligosaprobic) reflects increased hydrological stress. Their persistence offers valuable insight into environmental trends and supports ecological monitoring and resource management.

Based on saprobic indices and salinity tolerance, euryhaline to mesohalobic diatoms such as *Synedra pulchella var. minuta* (2.2), *Synedra tabulata* (2.7), and *Synedra ulna* (1.95) demonstrate strong resilience to wide mineralization fluctuations. Species like *Achnanthes linearis var. cryptocephala* (0.4) and *Melosira distans* (0.5), categorized as xeno-oligosaprobic, along with *Achnanthes lanceolata* (0.75, xeno-beta-mesosaprobic), are reliable bioindicators of elevated and variable salinity in Sudochye water bodies.

Table 1. Dominant Diatom Species and Their Trophic Groups in the Sudochye Lake System

Taxonomic Group	Species	Family	Trophic Group
Melosira varians Ag.	*Melosira varians*	*Coscinodiscaceae*	Mesotrophic – Eutrophic

Melosira distans (Ehr.) Küetz.	*Melosira distans*	*Coscinodiscaceae*	Mesotrophic
Synedra tabulata (Ag.) Küetz.	*Synedra tabulata*	*Fragilariaceae*	Oligotrophic – Mesotrophic
Synedra pulchella var. *minuta* Hust.	*Synedra pulchella* var. *minuta*	*Fragilariaceae*	Mesotrophic
Fragilaria crotonensis Kitton	*Fragilaria crotonensis*	*Fragilariaceae*	Eutrophic

The persistence of species with diverse saprobic statuses-including *Synedra ulna* (1.95, beta-mesosaprobic), *Melosira varians* (1.85), and *Achnanthes minutissima var. cryptocephala* (1.45, oligo-beta-mesosaprobic)-reflects their high ecological adaptability and enables predictive assessment of future biodiversity trends under ongoing hydrological stress.

Conclusion. For example, *Melosira varians* Ag., an oligobeta-mesosaprobic brackish-water species, indicates declining water levels, while *Melosira distans* (Ehr.) Küetz., tolerant of euryhaline and xeno-oligosaprobic conditions, reflects intensified hydrological stress. Their dominance underscores ongoing water regime changes and provides valuable metrics for ecological monitoring and resource management. Diatoms such as *Synedra pulchella var. minuta* (2.2), *Synedra tabulata* (2.7), and *Synedra ulna* (1.95) show strong resilience to salinity fluctuations, while *Achnanthes linearis var. cryptocephala* (0.4), *Melosira distans* (0.5), and *Achnanthes lanceolata* (0.75) serve as reliable bioindicators of elevated mineralization. The persistence of species across a range of saprobic statuses-including *Synedra ulna, Melosira varians*, and *Achnanthes minutissima var. cryptocephala* -demonstrates high ecological adaptability, supporting predictive evaluations of future biodiversity trends amid ongoing environmental stress.

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