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Assessment of the species composition, abundance dynamics and bioindicator properties of algae on the southern coasts of the Caspian Sea of Azerbaijan

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Abstract: This study investigates the development of algal communities and their spatiotemporal variability along the southern coast of the Caspian Sea (Lankaran, Astara, Masalli, and Neftchala) in 2023–2024. The study identified 75 taxa including Bacillariophyta, Chlorophyta, Cyanobacteria, Rhodophyta, Charophyta, and Ochrophyta. Results varied by location and year, with the highest values observed in Lankaran (2023) and Astara (2024). Diatoms and chlorophytes were the major dominant groups in all study areas. The Shannon diversity index ranged from 3.94 to 4.42, indicating high species richness and ecological stability of the algal communities, while the Evenness index (0.944–1.03) suggests a relatively uniform distribution of individuals among species and the absence of strong dominance. Algal communities in the study areas exhibited high species richness and ecological stability. Cluster analysis revealed that algal community structure exhibited high similarity within the same seasons and significant differences between seasons, indicating that temporal variations in abundance are mainly driven by seasonal environmental factors. Water temperature showed significant variability (8.1–27.4 °C; $P < 0.0002$), but no statistically significant differences were observed in parameters such as pH, and TDS ($P > 0.05$). The increase in temperature indicates a potential risk for algal blooms. The taxonomic composition and abundance patterns of algal communities along the southern Caspian Sea coast are influenced by environmental conditions and play an important role in evaluating the ecological health of aquatic ecosystems.

Keywords: *diversity indices, hydrochemical parameters, macroalgae, phytoplankton, saprobic index, seasonal variability*

INTRODUCTION

Macroalgae are one of the important trophic components in aquatic ecosystems, acting as the main primary producers of the coastal zones. They play an important role in maintaining the biological stability of coastal zone and regulating energy cycles, significantly influencing the biogeochemical transformation of substances. As eukaryotic organisms macroalgae with photosynthetic capacity are considered primary producers in the aquatic environment and provide the initial stage of energy flow to the system [Cacabelos et al., 2010]. Seaweeds or benthic macroalgae constitute a heterogeneous group of primary producers based on their pigment composition and other fundamental biological characteristics and include three main divisions: Chlorophyta (green algae), Ochrophyta (brown algae), and Rhodophyta (red algae) [Dhargalkar, Verlecar, 2009; Hong et al., 2007; Koch et al., 2013]. The phytoplankton community of the Caspian Sea is mainly formed by diatoms (Bacillariophyta), blue-green algae (Cyanobacteria), certain green algae (Chlorophyta), and some representatives of charophyta (Charophyta). The development and spread of algae are closely related to abiotic factors such as light intensity, water temperature, salinity, pH, and the concentration of biogenic substances [Sofiyana et al., 2023].

The study of macrophyte flora in the Caspian Sea began in the 18th century, and the first studies were associated with the expeditions of scientists such as P. Pallas, K. Baer, S. Gmelin and P. Knipovich [Volkov, 1913–1917]. These studies laid the foundations for a systematic investigation of the phytobenthos of the Caspian [Vokov, 1934]. The study of the planktonic algal flora of the Caspian Sea has a rich scientific history, and a number of prominent researchers have made significant contributions at different times. The first systematic studies of Caspian phytoplankton date back to the second half of the 19th century. In the subsequent period, the studies of I.A. Kiselyov [1938] and M.S. Kireyeva and T.F. Shapova [1957] played an important role in the formation of the fundamental database on the phytoplankton of the Caspian Sea.

A.D. Zinova [1967] and E.B. Zaberzhinskaya

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analyzed the known algae taxa and compiled the first systematic database. E.B. Zaberzhinskaya [1968] analyzed the macrophyte flora of the Caspian Sea and recorded the distribution of numerous species for the Azerbaijani coast of the sea. A. Kosarev and E. Yablonskaya [1994] summarized the hydroecological conditions of the sea and regional differences in flora and fauna diversity. As a result of large-scale expeditions carried out in the 1930s–1960s, the species diversity of macroalgae and seaweeds was determined, the distribution areas of aquatic plants were mapped, and the biological and ecological characteristics of a number of species were investigated [Zinova, Perestenko, 1964; Zinova, Zaberzhinskaya, 1968].

The main goal of this study is to comparatively analyse the species diversity, taxonomic structure, and regional differences of macrophyte algal flora on the southern coasts of the Caspian Sea. Such an approach has important scientific and practical significance in terms of improving the ecological monitoring system and identifying potential bioindicator species.

MATERIAL AND METHODS

Study area. The Caspian Sea is the largest enclosed water basin on Earth, isolated from the world's oceans and containing approximately 40–45% of the global lake water. The sea is divided into the North, Middle and South parts according to its physical and geographical characteristics [Marret et al., 2004; Stolberg et al., 2006]. The South Caspian is the deepest part, reaching a maximum depth of 1025 m and accounting for approximately 66% of the total water volume [Kosarev, Yablonskaya, 1994; Aladin, Plotnikov, 2004].

The study was conducted on the Azerbaijani coast of the sea and covered four main zones: the Neftchala–Kura River delta and the Astara–Lankaran region (southwestern coast). Salinity in the open waters of the sea averages 12.8–13%, but this indicator decreases significantly in areas close to the river mouths. Especially due to the influence of the Samur and Kura rivers, the salinity of coastal waters decreases by 8–10% during the spring-summer flood period [Aliyev, 2004]. Algae distribution map of the study area was prepared using ArcGIS 10.7 software (Fig. 1).

*Data collection. S*easonal field sampling (January, April, June, October) was carried out between 2023 and 2024 along the southern and southeastern coasts (Astara, Lankaran, Masalli, Neftchala) of the Caspian Sea. A random square method was used to assess macrophyte species diversity and abundance. At each station, 3 replicate samples were taken from selected stations along the horizontal distance from the shoreline towards the sea (covering different substrate types) using square frames measuring 0.04–0.25 m². Macroalgae were collected by hand, mainly from hard substrates (stones and rocks). The study areas were located close to each other, with the distance between stations being less than 2.4 km.

In situ measurements. Environmental parameters — temperature, pH, dissolved oxygen, and turbidity determined directly in the field. WTW TDS & EC Meter 2.0 (Wissenschaftlich-Technische Werkstätten GmbH, Germany), and pH was measured using a WTW 3110 portable pH meter (Wissenschaftlich-Technische Werkstätten GmbH, Germany).

Algal sampling and identification. In the laboratory, the samples were cleaned, dried and identified under a stereomicroscope to the lowest possible taxonomic level (mainly species). All samples were then stored in 70% ethanol for long-term storage in case further analysis was required in the future. Samples belonging to the families Rhodomelaceae and Corallinaceae were treated with 10% HCl in specific procedures due to certain cell wall properties. The samples were washed with seawater, labeled and stored in 4.0% buffered formaldehyde for taxonomic analysis.

The identification of the detected species was carried out using the E. Carpenter and H. Niem [1998] identification guide and the AlgaeBase database [Guiry and Guiry, 2022] and the taxonomic classification was refined based on the World Register of Marine Species (WoRMS). A stereo microscope and regional flora sources and identification keys were used for species identification [Afanasyev et al., 2020; Karaeva 1972; Karaeva, Zaberzhinskaya, 2008; Zaberzhinskaya, 1968; Zinova, 1967; Muradova et al., 2024; Nuriyeva, 2019].

Statistical analysis. The Shannon–Wiener index was used to assess species diversity during statistical analyses. Analysis of variance (one-way ANOVA) followed by a non-parametric test (Kruskal–Wallis) on water parameters was used to determine the significance of variables between different sampling periods. Means and standard deviations are presented as “mean ± SD”. In addition, cluster analyses (Bray–Curtis similarity index; UPGMA; log10 transformed data) were carried out using PAST software (version 4.13) to detect temporal changes in phytoplankton structure [Anderson, 2008].

Saprobic indices. Organic pollution was evaluated using the Saprobic Index (SI), defined as:

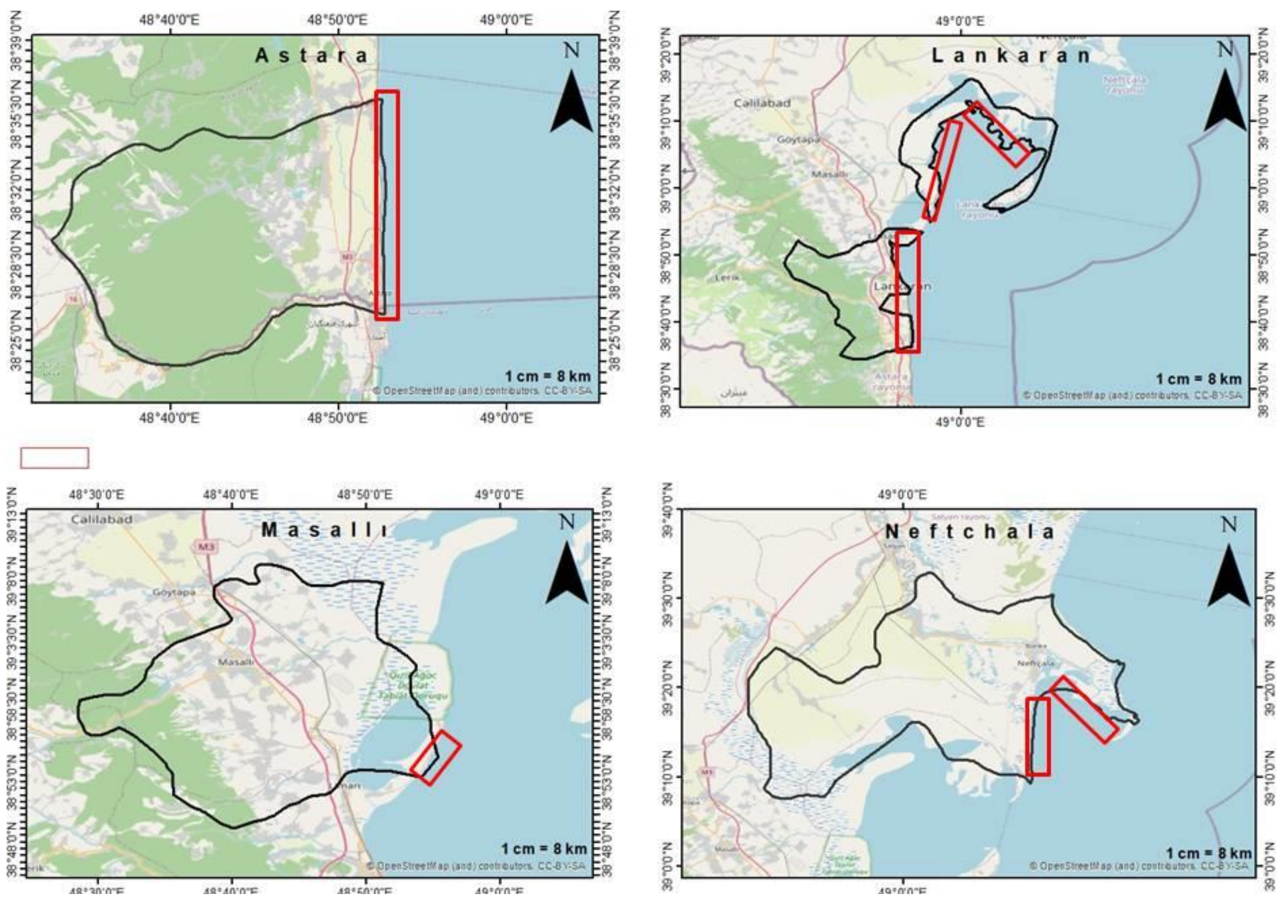

Figure 1. Study area algae sampling points in the coastal areas of the Caspian Sea (Red framed zones are study areas).

$$SI = \frac{\sum s \cdot h}{\sum h}$$

where: SI – the saprobic value assigned to species (scale 1– 4: oligio-, β-meso-, α-meso-, polysaprobic), h – the frequency of species in samples [Persoone, De Pauw, 1979].

Higher SI reflects increased organic load. Classification of saprobic categories follows S. Zahradkova, T. Soldan [2008].

RESULTS AND DISCUSSION

Taxonomic structure. A systematic list of algae species recorded during the study, their presence (+) and absence (–) indicators showing their occurrence status by year, as well as the relative contribution of different taxonomic groups to the total algae biodiversity on the southern coasts of the Caspian Sea are presented systematically in Table 1. As a result of the conducted studies, significant diversity was recorded in the species composition of phytoplankton and benthic communities in 2023 and 2024. Thus, in 2023, 67 algae species were identified in Lankaran coastal zone, 55 on Astara coast, 42 in Masalli, and 57 in Neftchala. These results reflect the dynamic variability of algal communities in both space and time in the studied areas and indicate the impact of ecological conditions on species diversity in coastal ecosystems.

Taxonomic analysis of phytoplankton and benthic algal communities in different regions of the Azerbaijani coast of the Caspian Sea in 2023 showed that algal biodiversity is spatially distributed differently. In 2003, in the coastal part of Lankaran district of the total 62 algae species, diatoms-11 genera, 12 species, charaphytes-2 genera, 5 species, chlorophytes-7 genera, 19 species, cyanophytes-10 genera, 14 species, and rhodophytes -8 genera, 8 species, 1 subspecies and brown algae-5 genera, 3 species were distinguished. In the coastal part of Astara district, the mentioned indicators change accordingly as follows: total 55 algae species, diatoms -13 genera, 17 species, charaphytes-2 genus, 4 species, chlorophytes-5 genera, 11 species, cyanophytes-11 genera, 12 species, rhodophytes-7 genera, 6 species, 1 subspecies and brown algae-3 genera, 4 species, Masalli district: total 41 algae species, diatoms-13 genera, 9 species, charaphytes-1 genera, 3 species, chlorophytes -6 genus, 13 species, cyanophytes-7 genera, 10 species, rhodophytes-5 genera, 4 species and brown algae-1 genera, 2 species, Neftchala district: total 53 algae species, diatoms-12 genera, 14 species, charaphytes-2 genera, 3 species, chlorophytes-6 genera, 14 species, cyanophytes-9 genera, 13 species, rhodophytes-8 genera, 6 species, 1 subspecies and brown algae-3 genera, 2 species were identified (Table 1).

Taxonomic analysis of algal communities in various regions of the Azerbaijani coast of the Caspian Sea in 2024 showed that the species composition and distribution of taxonomic groups have undergone certain changes compared to the previous year. In 2024, in the Caspian coastal zone of Lankaran district of the total 61 algae species: diatoms-9 genera, 12 species, charaphytes-2 genera, 4 species, chlorophytes-7 genera, 15 species, cyanophytes-10 genera, 18 species, and rhodophytes-7 genera, 8 species and brown algae-3 genera, 4 species were distinguished. In the coastal zone of the Astara district, the mentioned indicators change accordingly as follows: total 64 algae species, diatoms -10 genera, 13 species, charaphytes-2 genera, 5 species, cyanophytes-9 genera, 14 species, chlorophytes-6 genera, 17 species, rhodophytes-10 genera, 11 species, 1 subspecies and brown algae-3 genera, 3 species, Masalli district: total 51 algae species, diatoms-13 genera, 13 species, charaphytes-2 genera, 5 species, chlorophytes -5 genera, 12 species, cyanophytes-9 genera, 13 species, rhodophytes-7 genera, 6 species and brown algae-2 genera, 2 species, Neftchala district: total 48 algae species, diatoms-9 genera, 12 species, charaphytes-2 genera, 6 species, chlorophytes-5 genera, 13 species, 9 cyanophytes-6 genera, 9 species, rhodophytes-5 genera, 6 species and brown algae-2 genera, 2 species were distinguished in Table 1. The results show that in 2023, chlorophytes and diatoms were dominant in all study areas, with the highest species diversity recorded on the Lankaran coast, indicating more favorable ecological conditions in that area. In 2024, the highest species diversity was observed in the Astara region (63 species), and the lowest in the Neftchala region (48 species), with diatoms and chlorophytes prevailing as dominant taxa in both years.

In addition, as a result of the comparative analysis of the community structure formed in January, April, July and October of 2023 and 2024, a total of 75 taxa of algae were identified in the study areas (Table 1). The identified taxa included diatoms with 13 genera, 17 species, charaphytes-2 genera, 6 species, chlorophytes-7 genera, 19 species, cyanophytes-10 genera, 15 species, rhodophytes-10 genera, 11 species and 1 subspecies, and brown algae-5 genera, 6 species. A total of 29 algae species were recorded from the Caspian Sea coastal zone of Lankaran district in March-December 2022, 11 of which were identified in the territory of the Gizilaghac National Park. The detected species belonged to the Chlorophyta (9 species), Bacillariophyta (7 species), Cyanobacteria (6 species), Charophyta (4 species) and Rhodophyta (3 species) divisions from a taxonomic point of view. Comparative analysis shows that in that year, diatoms and green algae dominated in species diversity, which once again confirmed the dominant position of these groups in the coastal ecosystem [Muradova et al., 2024].

High values of the Shannon diversity index (3.94–4.42) and Evenness index (0.944–1.03) indicate that algal communities in the studied areas are characterized by both high species richness and even abundance distribution among species. These indicators confirm that ecological stability is maintained in coastal ecosystems and that dominant species was not sharply prevalent. Despite seasonal changes, the community structure was generally balanced and stable Figure 2.

The dendrogram obtained from the cluster analysis clearly illustrates the monthly structure of seaweed abundance patterns. The hierarchical grouping of samples reflects variations in community composition over time, revealing both stable periods and phases of change. The analysis shows that several samples cluster together at relatively high similarity levels, forming compact groups in the dendrogram. These clusters predominantly include months that are temporally close, indicating that similar ecological conditions prevailed during these periods. This pattern suggests that the structure of the algal community remains relatively stable within such intervals, with no substantial shifts in dominant species composition. In contrast, other clusters are linked at greater distances, reflecting lower similarity between the corresponding months. These separations indicate noticeable differences in seaweed abundance, pointing to temporal variability in community structure. The increased linkage distances between certain groups highlight periods during which the abundance patterns undergo more pronounced changes. These factors directly affect the development dynamics of phytobenthos and phytoplankton communities, causing variations in species composition and abundance indicators Figure 3.

Table 1. Marine algae species and contribution of different taxonomic groups to the total algae in southern Caspian Sea.

Taxa	Species	2023				2024			
		L	A	M	N	L	A	M	N
1	2	3	4	5	6	7	8	9	10
Bacillariophyta		19.3	30.9	21.9	26.4	23.6	16.3	23.1	27
Surirellales, Surirellaceae, Amphora	*Amphora beaufortiana*	+	+	+	-	+	+	+	+
Achnanthales, Achnanthidiace, Achnanthidium	*Achnanthidium saprophilum*	+	+	-	-	+	-	-	+
Sellaphorales, Pinnulariaceae, Caloneis	*Caloneis amphisbaena*	+	+	+	+	-	+	+	+
Naviculales, Neidiaceae, Neidium	*Neidium productum*	+	+	-	+	-	+	+	+
Cocconeidales, Cocconeidaceae, Cocconeis	*Cocconeis costata*	+	+	+	+	+	-	+	-
Surirellales, Surirellaceae, Iconella	*Iconella capronii*	+	+	-	+	+	-	+	-
Mastogloiales, Mastogloiaceae, Mastogloia	*Mastogloia angulata*	+	+	+	+	-	+	+	-
Stauroneidaceae, Craticula	*Craticula halophila*	-	+	-	+	+	+	+	+
Fragilariales, Fragilariaceae, Ulnaria	*Ulnaria acus*	+	+	+	-	+	-	-	+
Cymbellales, Cymbellaceae, Cymbella	*Cymbella cistula*	+	+	+	-	+	+	-	+
	Cymbella lanceolata	+	+	-	+	+	+	+	+
Bacillariales, Bacillariaceae, Nitzschia	*Nitzschia dissipata*	+	+	-	+	+	+	+	-
	Nitzschia palea	+	+	-	+	-	-	+	+
	Nitzchia denticula	-	+	+	+	+	+	+	+
Tryblionella	*Tryblionella acuminata*	-	+	+	+	-	+	-	+
	Tryblionella victoriae	-	+	+	+	+	+	-	+
Melosirales, Melosiraceae, Melosira	*Melosira inflexa*	-	+	-	+	+	+	+	-
Ochrophyta		4.8	7.2	4.8	3.7	6.9	3.8	4.1	4.7
Phaeophyceae, Ectocarpales, Acinetosporaceae, Pylaiella	*Pylaiella littoralis*	+	+	-	-	-	+	+	-
Chordariaceae, Monosiphon	*Monosiphon caspicus*	-	-	-	-	+	+	-	-
Ectocarpaceae, Ectocarpus	*Ectocarpus siliculosus*	+	+	+	-	+	+	-	+
	Ectocarpus humilis	-	+	+	+	+	-	-	-
Myrionemataceae, Myrionema	*Myrionema strangulans*	+	+	-	-	-	+	+	+
Litosiphonaceae, Litosiphon	*Litosiphon laminariae*	-	-	-	+	+	+	-	-
Cyanobacteria		22.5	21.8	24.4	24.5	25.8	17.9	27	21.4
Cyanophyceae, Nostocales, Rivulariaceae, Calothrix	*Calothrix scopulorum*	+	+	+	+	+	+	+	+
Chroococcales, Chroococcaceae, Chroococcus	*Chroococcus dimidiatus*	-	+	+	+	+	+	+	+
	Chroococcus minimus	+	+	-	+	+	+	+	-
	Chroococcus turgidus	+	+	+	+	+	+	+	+
	Chroococcus limneticus	+	-	-	+	+	+	+	+

Table 1 (continues). Marine algae species and contribution of different taxonomic groups to the total algae in southern Caspian Sea.

1	2	3	4	5	6	7	8	9	10
Chroococcales, Microcystaceae, Merismopedia	*Merismopedia minima*	+	+	+	+	+	+	-	+
Oscillatoriales, Microcoleaceae, Limnospira	*Limnospira platensis*	+	+	+	-	+	+	+	-
Lyngbya	*Lyngbya aestuarii*	+	-	+	+	+	+	+	+
	Lyngbya confervoides	+	+	+	+	+	+	-	+
Oscillatoriaceae, Phormidium	*Phormidium ambiguum*	+	+	+	-	+	+	+	-
	Phormidium corallinae	+	-	+	+	+	+	+	+
Oscillatoria	*Oscillatoria sancta*	+	+	+	+	+	+	+	+
Leptolyngbyales, Leptolyngbyaceae, Planktlyngbya	*Planktolyngbya limnetica*	+	+	-	+	+	-	+	-
Nostocales, Rivulariaceae, Rivularia	*Rivularia atra*	+	+	-	+	+	+	+	-
Spirulinales, Spirulinaceae, Spirulina	*Spirulina major*	+	+	-	+	+	+	+	-
Charophyta		8.1	7.2	7.3	5.6	6.9	6.4	6.2	14.2
Zygnematophyceae, Spirogyrales, Spirogyraceae, Spirogyra	*Spirogyra crassa*	+	+	+	-	+	+	-	+
	Spirogyra majuscula	+	-	+	+	+	+	+	+
	Spirogyra porticalis	+	+	+	+	+	+	+	+
Charophyceae, Charales, Characeae, Chara	*Chara aspera*	+	+	-	-	+	+	+	+
	Chara crinita	-	-	-	+	-	+	+	+
	Chara baltica	+	+	-	-	-	-	+	+
Chlorophyta		30.6	20	31.7	26.4	25.8	21.7	25	30.9
Ulvophyceae, Ulvales, Kornmanniaceae, Blidingia	*Blidingia minima*	+	+	+	+	+	+	+	-
	Blidingia marginata	+	-	-	+	+	+	+	+
Ulvellales, Ulvellaceae, Ulvella	*Ulvella lens*	+	-	+	+	+	+	-	+
	Ulvella viridis	+	-	-	+	-	+	+	-
Cladophorales,Cladophoraceae, Chaetomorpha	*Chaetomorpha aerea*	+	+	+	+	+	+	+	+
	Chaetomorpha linum	+	+	+	+	+	+	+	+
Epicladia	*Epicladia flustrae*	+	-	-	+	+	+	-	-
Cladophora	*Cladophora albida*	+	+	-	+	-	+	-	+
	Cladophora ruchingeri	+	+	+	+	-	+	-	+
	Cladophora fracta	+	+	+	+	+	+	-	-
	Cladophora glomerata	+	+	-	+	-	+	+	+
	Cladophora sericea	+	+	+	+	+	+	+	+
	Cladophora vagabunda	+	+	-	+	+	-	+	-
Rhizoclonium	*Rhizoclonium riparium*	+	+	+	-	+	-	+	-

Table 1 (continues). Marine algae species and contribution of different taxonomic groups to the total algae in southern Caspian Sea.

1	2	3	4	5	6	7	8	9	10
Ulvaceae, Ulva	*Ulva compressa*	+	-	+	-	+	+	+	+
	Ulva clathrata	+	+	+	+	+	+	+	+
	Ulva intestinalis	+	-	+	-	+	+	+	+
	Ulva prolifera	+	-	+	-	+	+	-	+
	Ulva tepida	+	-	+	-	+	+	-	+
Rhodophyta		14.5	12.7	9.7	13.2	13.1	16.6	12.5	14.2
Colaconematophyceae, Colaconematales, Colaconemataceae, Colaconema	*Colaconema elegans*	+	-	-	+	+	+	-	+
Florideophyceae, Corallinales, Ceramiaceae, Corallina	*Corallina officinalis*	-	-	+	+	-	+	-	+
Acrochaetiales, Acrochaetiaceae, Acrochaetium	*Acrochaetium secundatum*	+	-	-	+	-	+	-	-
Kylinia	*Kylinia parvula*	+	+	-	+	-	+	+	+
Ceramium	*Ceramium secundatum*	+	-	+	+	+	+	+	-
	Ceramium siliquosum var. *elegans*	+	+	-	-	-	+	-	-
Ceramiales, Rhodomelaceae, Laurenciocolax	*Laurenciocolax polyspora*	+	+	-	-	+	+	+	+
Lophosiphonia	*Lophosiphonia obscura*	-	+	+	-	+	+	+	-
Vertebrata	*Vertebrata fucoides*	+	+	-	+	+	+	+	-
Callithamniaceae, Callithamnion	*Callithamnion kirillianum*	+	+	-	-	+	+	-	-
Polysiphonia	*Polysiphonia stricta*	+	+	-	+	+	+	-	+
	Polysiphonia sanguinea	-	-	+	-	+	+	+	+

Note: L-Lankaran, A-Astara, M-Masalli, N-Neftchala

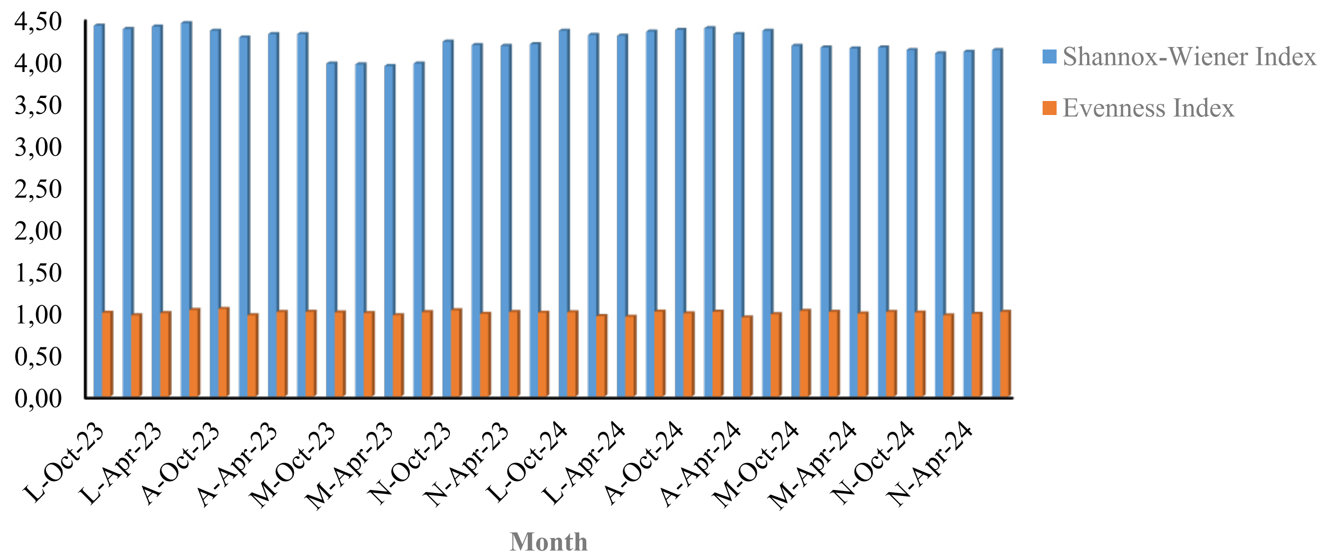

Figure 2. Biodiversity indicators by year: Shannon and Evenness indices.

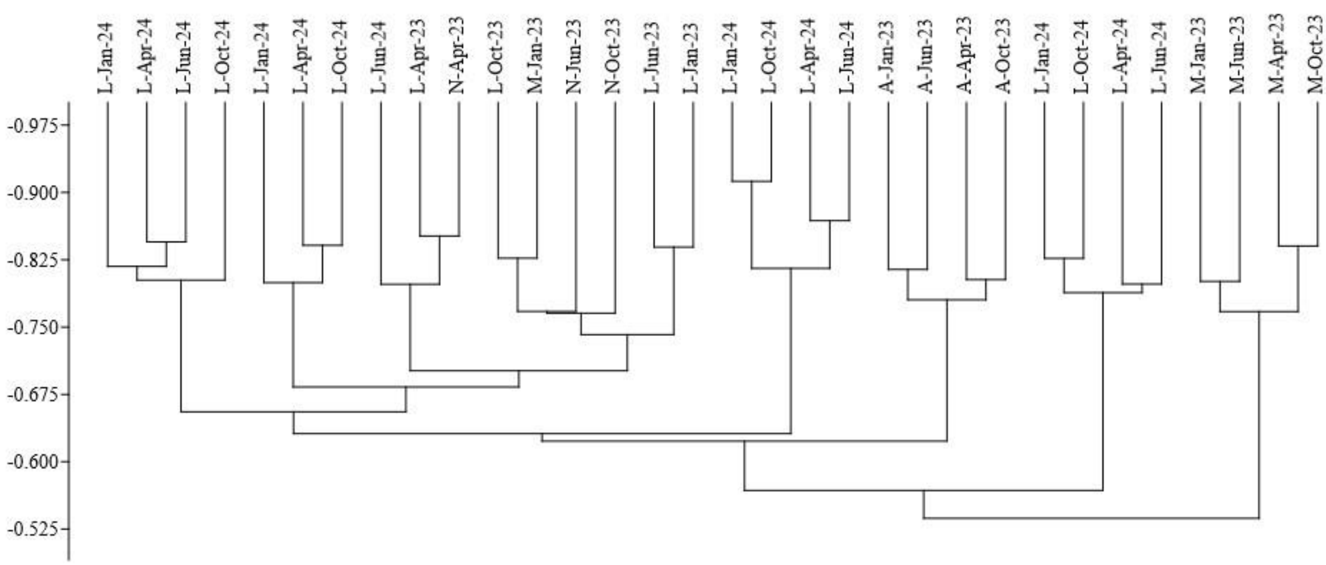

Figure 3. Bray–Curtis similarity index (UPGMA; log10 transformed) results of total marine algae density in different time periods during study.

Hydrochemical parameters and seasonal variation. Statistical results on monthly changes in surface water temperature, salinity, pH, and total dissolved solids (TDS) along the southern coasts of the Caspian Sea are presented in Table 2.

The average annual water temperature in the study area (southern coasts) is 13-14°C in the Middle Caspian. The average annual temperature change in the Southern Caspian is more intense than in other areas of the sea. However, temperature values during the study were relatively similar to previous years [Reynolds, 2006]. For example, average temperatures during the study ranged from 8.1°C (January) to 27.3°C (June). On the other hand, our mean temperature findings for 2023 and 2024 were different from each other. For example, the annual mean temperature finding in 2023 was lower (16.10 ± 1.40°C) than the finding in 2024 (16.84 ± 1.47°C). Rising temperatures, in particular, stimulate the growth of blue-green algae (Cyanobacteria) and can cause them to dominate over other groups. This is why cyanobacterial "blooms" occur more frequently in warmer months [Reynolds, 2006, Schabhüttl et al.,

Table 2. Descriptive statistical results of hydrophysical parameters in the southern coasts of the Caspian Sea.

Parameter	Temperature (°C)			pH			TDS g/L		
	Min	Max	Mean±SD	Min	Max	Mean±SD	Min	Max	Mean±SD
L-Oct-23	15.5	18.2	16,6±1,4	8.2	8.6	8.40 ± 0.20	7.25	10	8.72 ± 1.38
L-Jan-23	8.1	10	8.7±1,06	7.9	8.2	8.07 ± 0.15	9.5	11.2	10.30 ± 0.85
L-Apr-23	11.3	14.6	13.1±1,6	7.8	8.3	8.03 ± 0.25	8.9	10.25	9.75 ± 0.74
L-Jun-23	23.3	26.3	24.9±1,5	7.6	8.1	7.83 ± 0.25	9.3	12.2	10.90 ± 1.47
A-Oct-23	15.5	17.2	16.2±0,8	8.2	8.5	8.33 ± 0.15	9.2	10.3	9.67±0.57
A-Jan-23	8.3	10.1	8.9±0,1	7.9	8.2	8.07 ± 0.15	7.28	10	8.73±1.37
A-Apr-23	12.3	16.6	14 ±2.2	7.9	8.2	8.03 ± 0.15	9.7	11.2	10.37±0.76
A-Jun-23	25.1	27.3	26.57 ± 1.27	7.6	8.1	7.83 ± 0.25	7.9	10.1	8.75±1.18
M-Oct-23	15.5	19.2	16.97 ± 1.97	8.2	8.4	8.27 ± 0.12	8.9	10.25	9.75±0.74
M-Jan-23	8.3	10.1	8.93 ± 1.01	7.9	8.1	8.03 ± 0.12	9.6	13.2	11.67±1.86
M-Apr-23	12.3	15.6	14.07 ± 1.66	7.8	8.3	8.03 ± 0.25	8.25	10.1	9.42±1.02
M-Jun-23	23.3	27.3	25.57 ± 2.05	7.5	8.1	7.80 ± 0.30	9.4	12.2	10.6±1.44
N-Oct-23	16.2	19.2	17.63 ± 1.50	8.2	8.3	8.23 ± 0.06	10.2	12.2	10.97±1.08
N-Jan-23	8.2	10.1	8.93 ± 1.02	7.9	8.2	8.07 ± 0.15	8.25	10.1	9.42±1.02
N-Apr-23	11.5	15.6	13.50 ± 2.05	7.5	8.3	7.93 ± 0.40	8.5	13.2	10.97±2.36
N-Jun-23	24.2	27.4	25.57 ± 1.58	7.4	8.1	7.73 ± 0.35	7.5	10.1	8.77±1.30
Average (2023)	14.9	17.8	16.1± 1.4	7.8	8.25	8.04±0.19	8.7	11.0	9.8±1.13
L-Oct-24	15.5	18.2	16.6±1.42	8.2	8.6	8.40±0.20	9.13	12.2	10.84±1.57
L-Jan-24	8.2	10	8.8±1.04	7.9	8.2	8.10±0.17	7.55	10	8.82±1.23
L-Apr-24	11.3	14.6	13.07±1.66	7.8	8.3	8.03±0.25	9.45	11.2	10.28±0.88
L-Jun-24	23.3	26.3	24.97±1.53	7.8	8.1	7.90±0.17	8.9	10.25	9.75±0.74
A-Oct-24	15.5	17.2	16.3±0.85	8.2	8.5	8.33±0.15	9.3	10.3	9.70±0.53
A-Jan-24	8.2	9.9	8.8±0.95	7.9	8.2	8.07±0.15	8.28	10	9.06±0.87
A-Apr-24	12.3	16.6	14.07±2.25	8	8.2	8.07±0.12	9.7	11.2	10.37±0.76
A-Jun-24	25.3	27.3	26.63±1.15	7.6	8.1	7.83±0.25	7.9	10.1	8.75±1.18
M-Oct-24	15.6	19.2	17.0±1.93	8.2	8.4	8.30±0.10	9.4	12.2	10.63±1.43
M-Jan-24	8.3	10.1	8.93±1.01	7.9	8.1	8.03±0.12	8.9	10.25	9.78±0.77
M-Apr-24	12.4	15.6	14.1±1.61	7.8	8.3	8.03±0.25	9.6	13.2	11.73±1.89
M-Jun-24	23.3	27.3	25.57±2.05	7.6	8.2	7.87±0.31	8.25	10.1	9.42±1.02
N-Oct-24	16.2	19.2	17.63±1.50	8.3	8.5	8.37±0.12	10.2	12.2	11.00±1.06
N-Jan-24	8.2	10.1	8.93±1.02	7.9	8.2	8.07±0.15	8.35	10.1	9.45±0.96
N-Apr-24	11.5	15.6	13.53±2.05	7.6	8.3	7.97±0.35	8.5	13.2	11.03±2.37
N-Jun-24	24.2	27.2	25.53±1.53	7.7	8.1	7.90±0.20	7.5	10.2	8.80±1.35
Average (2024)	14.9	17.7	16.84 ± 1.47	7.9	8.3	8.08 ± 0.19	8.8	11.0	9.99 ± 1.09

Note: Jan-January, Oct-October, Apr-April, Jun-June; 23-2023, 24-2024.

2013]. In addition, as temperatures increase, there is a change in phytoplankton biomass and species diversity. Interesting results show that maximum growth in some phytoplankton communities was recorded around 18°C, while the proportion of cyanobacteria increased at higher temperatures. This suggests that climate change could alter the structure of algal communities in closed water bodies such as the Caspian Sea. Rising water surface temperatures during the summer months extend the vegetation period of algae, resulting in accelerated reproduction of some species and an increased risk of harmful algal blooms. For this reason, temperature indicators are considered one of the main indicators in monitoring algal populations. In 2023, the surface water temperature varied between 8.1°C (January) and 27.3°C (June), with an annual average of 16.10 ± 1.40°C. In 2024, the temperature varied between 8.2°C (January) and 27.4°C (June), with an annual average of 16.84 ± 1.47°C. The interannual comparison showed a statistically significant difference in temperature indicators ($P < 0.0002$).

pH indicates the acidity-alkaline balance of water and directly affects the enzyme activity, photosynthesis rate, and nutrient uptake of phytoplankton. The optimal pH for most algae is in the range of 7.5–8.5. pH outside this range can disrupt cellular metabolism, causing some species to decline and others to dominate. In particular, when pH increases, the growth of blue-green algae (Cyanobacteria) can be stimulated. Analysis of pH values shows that in 2023, the values recorded in surface waters ranged between 7.5 and 8.6, with an annual average of 8.04 ± 0.19. A similar trend was observed in 2024, with pH values ranging from 7.6–8.6, averaging 8.08 ± 0.19. Statistical results showed that there was no significant difference in pH levels in both interannual and monthly comparisons ($P > 0.05$).

As TDS increases, the osmotic pressure of the water increases, which affects the water balance and growth processes of algae cells. Freshwater algae thrive in low TDS conditions, while high TDS favors salt and mineral-tolerant species (especially diatoms and some cyanobacteria) [Wetzel, 2001; Paerl & Huisman, 2008]. Seasonal and spatial variations in pH and TDS in the Caspian Sea play an important role in shaping the species composition of phytoplankton, the occurrence of "bloom" events, and the overall productivity of the ecosystem. The amount of total dissolved solids (TDS) in water varied between 7.25–13.40 g/L in 2023, with an average value of 9.80 ± 1.13 g/L. In 2024, TDS values varied between 7.50–13.20 g/L, with an annual average value of 9.99 ± 1.09 g/L. Based on the results of statistical analysis, the observed changes in TDS indicators were not considered significant ($P > 0.05$).

Hydrological observations conducted in the southern coasts of the Caspian Sea during 2023–2024 showed that surface water temperature exhibited a statistically significant difference in terms of seasonal variability ($P < 0.0002$), while the changes recorded in salinity, pH, and TDS indicators over years and months were not statistically significant ($P > 0.05$); these results indicate that temperature is the main ecological factor affecting phytoplankton dynamics in the region, while other hydrochemical parameters create relatively stable background conditions.

Bioindicator potential of diatoms within phytoplankton. Saprobic analysis of phytoplankton species showed that the saprobic state of the aquatic environment changed within the β-mesosaprobic zone during the study period. The total saprobic index in 2023 was calculated as 2.51, and in 2024 as 2.60 (Table 3). According to the Pantle–Buck saprobic index system, these indicators characterize moderate organic pollution and correspond to β-mesosaprobic conditions [Nurdin, et al., 2025]. The increase in the index in 2024 indicates a relatively high organic matter load in the watershed.

The increase in the abundance of *Nitzschia denticula* Grunow*, Nitzschia palea* (Kützing) W.Smith, *Nitzschia dissipata* (Kützing) Grunow, and *Craticula halophila* (Grunow) D.G.Mann species with high saprobic values is an important bioindicator of the intensification of organic pollution and eutrophication processes. In particular, species belonging to the genus *Nitzschia* A.H.Hassall are known as tolerant indicator taxa that are widespread in waters rich in organic matter and exposed to anthropogenic influences [Barinova et al., 2006]. The observation of high abundance of the species *Craticula halophila* only in 2024 suggests that changes in the water salinity-pollution regime have occurred. The results show that organic pollution in the study area is stable and the structure of the phytoplankton community responds sensitively to changes in water quality, which once again confirms the role of phytoplankton as a reliable bioindicator in aquatic ecosystems. The determined β-mesosaprobe saprobic index values correspond to moderate anthropogenic loading and are consistent with the results of other saprobic monitoring studies; as the β-mesosaprobe zone is usually considered characteristic of moderately organically polluted waters.

Table 3. Annual variation in the total saprobic index based on diatom indicators and ecological assessment of water quality in the study area (2023–2024).

Year	Total saprobic index	Saprobic zone	Ecological assessment
2023	2.51	β-mesosaprobic	Medium organic pollution
2024	2.60	β-mesosaprobic	Moderate–increasing organic pollution

CONCLUSION

Studies conducted in 2023–2024 on the Azerbaijani coast of the Caspian Sea showed that algal communities have high taxonomic diversity. A total of 75 taxa were identified, with Chlorophyta and Bacillariophyta being the dominant groups. The highest species diversity was recorded on the coasts of Lankaran and Astara. The variation of the Shannon diversity index between 3.94–4.42 confirmed high biodiversity and ecological stability in coastal algal communities. Temperature was the main factor affecting phytoplankton dynamics, while salinity, pH and TDS remained relatively constant. According to the results of saprobic analysis, the water bodies belonged to the β-mesosaprob zone in both years, and the increase in the saprobic index in 2024 (2.60) indicated an increase in organic pollution. The increase in species belonging to the genus *Nitzschia* confirmed the intensification of organic pollution and eutrophication. The species composition and abundance structure of algal communities on the southern coasts of the Caspian Sea are formed under the influence of ecological factors, and these communities play a key role in assessing the state of aquatic ecosystems. These findings highlight the critical role of algal bioindicators in monitoring environmental changes and provide a scientific basis for predicting the ecological trajectory of the Caspian Sea under ongoing climatic and anthropogenic pressures.

REFERENCE

Afanasyev, D. F., Sushkova, E. G., Kamnev, & A. N. Marine and brackish species of Cladophoraceae and Aegagropila, found in the Ponto-Caspian basin. The field guide Moscow: Publ. house Pero, 2020. 76p.

Aladin, N. V., & Plotnikov, I. S. (2004). Hydrobiology of the Caspian Sea. In J. C. J. Nihoul, P. O. Zavialov, P. P. Micklin (Eds.), *Dying and dead seas* (pp. 185–226). Kluwer Academic Publishers.

Aliyev, A. M., Alizadeh, E. A., & Bagirov, R. M. (2004). *Climate of Azerbaijan*. National Academy of Sciences.

Anderson, M. J. (2008). PERMANOVA+ for PRIMER: *Guide to software and statistical methods*. Primer-E.

Anton, A., Randle, J. L., Garcia, F. C., Rossbach, S., Ellis, J. I., Weinzierl, M., & Duarte, C. M. (2020). Differential thermal tolerance between algae and corals may trigger the proliferation of algae in coral reefs. *Global Change Biology, 26*(8), 4316–4327. https://doi.org/10.1111/gcb.15141

Barinova, S. S., Medvedeva, L. A., & Anisimova, O. V. (2006). *Biodiversity of environmental indicator algae*. Pilies Studio.

Cacabelos, E., Olabarria, C., Incera, M., & Troncoso, J. S. (2010). Effects of habitat structure and tidal height on epifaunal assemblages associated with macroalgae. *Estuarine, Coastal and Shelf Science*, *89*(1), 43–52.

California Academy of Sciences. (n.d.). *California Academy of Sciences*. https://www.calacademy.org

Carpenter, K. E., & Niem, V. H. (Eds.). (1998). *The living marine resources of the Western Central Pacific (FAO species identification guide for fishery purposes).* Food and Agriculture Organization of the United Nations.

Catalanotti, C., Yang, W., Posewitz, M. C., & Grossman, A. R. (2013). Fermentation metabolism and its evolution in algae. *Frontiers in Plant Science*, 4, 150. https://doi.org/10.3389/fpls.2013.00150

Dhargalkar, V. K., & Verlecar, X. N. (2009). Southern Ocean seaweeds: A resource for exploration in food and drugs. *Aquaculture*, *287*(3–4), 229–242.

Dumont, H. J. (1995). Ecocide in the Caspian Sea. *Nature*, 377, 673–674. https://doi.org/10.1038/377673a0

Guiry, M. D., & Guiry, G. M. (2023). *AlgaeBase*. National University of Ireland, Galway. https://www.algaebase.org

Hong, D. D., Hien, H. M., & Son, P. N. (2007). Seaweeds from Vietnam used for functional food, medicine and biofertilizer. *Journal of Applied Phycology, 19*(6), 817–826.

Karaeva, N. I., & Zaberzhinskaya, E. B. (2008). Dynamics of *Zostera noltii* Hornem at the Azerbaijan Caspian coast. *Visnyk of Odessa National University*, *13*(4), 196–199.

Karaeva, N. I. (1972). *Benthic diatom algae of the Caspian Sea*. USSR Academy of Sciences. [Караева Н.И. (1972) Диатомовые водоросли бентоса Каспийского моря, "Элм". Баку, 258 с.].

Karpinsky, M. G. (2010). On peculiarities of introduction of marine species into the Caspian Sea. *Russian Journal of Biological Invasions*, *1*(1), 7–10. https://doi.org/10.1134/S2075111710010029

Kireeva, M. S., & Shchapova, T. F. (1957). Materials on the systematic composition and biomass of algae and higher aquatic vegetation of the Caspian Sea. *Proceedings of the Institute of Oceanology of the USSR Academy of Sciences: Biological Studies of the Seas,* 23, 125–137.

Kiselev, I. A. (1938). On the phytoplankton of the Caspian Sea. In *Materials of hydrobiology and lithology of the Caspian Sea* (pp. 229–254). USSR

Academy of Sciences.

Koch, M., Bowes, G., Ross, C., & Zhang, X. H. (2013). Climate change and ocean acidification effects on seagrasses and marine macroalgae. *Global Change Biology, 19*(1), 103–132.

Kosarev, A. N., & Yablonskaya, E. A. (1994). *The Caspian Sea*. SPB Academic Publishing.

Marret, F., Leroy, S. A. G., Chalié, F., & Gasse, F. (2004). New organic-walled dinoflagellate cysts from recent sediments of Central Asian seas. *Review of Palaeobotany and Palynology*, *129*(1–2), 1–20. https://doi.org/10.1016/j.revpalbo.2003.10.002

Muradova, A. B., Mukhtarova, S. C., & Feyziyev, Y. M. (2024). The algae of the southern coasts of the Caspian Sea (Lankaran District). *Acta Botanica Caucasica*, *3*(3), 84–95.

Nasrollahzadeh, H. S., Zubir, B. D., Foong, S. Y., & Makhlough, A. (2008). Trophic status of the Iranian Caspian Sea based on water quality parameters and phytoplankton diversity. *Continental Shelf Research*, *28*(9), 1153–1165.

Nurdin, J., Aziz, R., Nur, L., & Janra, M. N. (2025). Water quality assessment based on saprobic index of phytoplankton with emphasis on several potentially harmful algal blooms (HABs). *Biodiversitas Journal of Biological Diversity*, *26*(2), 890–899. https://doi.org/10.13057/biodiv/d260238

Nuriyeva, M. A. (2019). Diversity and taxonomic structure of Cyanoprokaryota in the Azerbaijani sector of the Caspian Sea. *Plant & Fungal Research*, *2*(2), 2–10. https://doi.org/10.29228/plantfungalres.18

Paerl, H. W., & Huisman, J. (2008). Blooms like it hot. *Science*, *320*(5872), 57–58. https://doi.org/10.1126/science.1155398

Persoone, G., & De Pauw, N. (1979). Systems of biological indicators for water quality assessment. In *Biological indicators for water quality assessment* (pp. 39–75). ECSC, EEC, EAEC.

Petrov, K. M. (1967). Underwater vegetation of the coastal zone of the Caspian Sea near Azerbaijan. In *Experience of geological-geomorphological and hydrobiological studies of the coastal zone of the sea.* Nauka.

Reynolds, C. S. (2006). *The ecology of phytoplankton*. Cambridge University Press.

Schabhüttl, S., Hingsamer, P., Weigelhofer, G., Hein, T., Weigert, A., & Striebel, M. (2013). Temperature and species richness effects in phytoplankton communities. *Oecologia*, *171*(2), 527–536.

Singh, S. P., & Singh, P. (2015). Effect of temperature and light on the growth of algae species: A review. *Renewable and Sustainable Energy Reviews*, *50*, 431–444.

Sofiyana, M. S., Sholihah, M., & Setyaningsih, D. (2023). Macroalgae community structure and diversity in Peh Pulo Beach, Blitar Regency. *Al-Hayat: Journal of Biology and Applied Biology*, *6*(2), 137–146. https://doi.org/10.21580/ah.v6i2.17767

Stolberg, F., Borysova, O., Mitrofanov, I., Barannik, V., & Eghtesadi, P. (2006). *Caspian Sea: GIWA regional assessment* 23. University of Kalmar Press.

Vokov, L. I. (1934). Vegetation of the Caspian Sea. *Izvestiya Rostov State Pedagogical Institute*, 1, 69–77.

Wetzel, R. G. (2001). *Limnology: Lake and river ecosystems* (3rd ed.). Academic Press.

World Register of Marine Species. (n.d.). WoRMS. https://www.marinespecies.org

Zaberzhinskaya, E. B. (1968). *Algae flora of macrophytes of the Caspian Sea* (PhD thesis). Baku. [Забержинская Э.Б. (1968) Флора водорослей макрофитов Каспйского моря.Автореф.дисс. на соиск.уч. ст.к.б.н., Баку, 234 с.].

Zahradkova, S., & Soldan, T. (2008). Saprobic system. In S. E. Jørgensen & B. D. Fath (Eds.), *Encyclopedia of ecology* (pp. 3242–3343). Elsevier.

Zinova, A. D. (1967). *Identifier of green, brown and red algae of the southern seas of the USSR.* Nauka Publishing House. [Зинова А. Д. (1967) Определитель зеленых, бурых и красных водорослей южных морей СССР. Академия Наук СССР Ботанический Институт Издательство «НАУКА» Москва Ленинград, 396 с.]

Zinova, A. D., & Perestenko, L. P. (1964). New parasitic red algae in the Caspian Sea. *Novosti Sistematiki Nizshikh Rastenii*, 132–138. [Зинова А. Д., Перестенко Л. П. (1964) «Новые паразитические красные водоросли Каспийского моря» // Нов. систем. Низших Раст., 132–138.]

Zinova, A. D., & Zaberzhinskaya, E. B. (1968). New species of red algae in the Caspian Sea. *Novosti Sistematiki Nizshikh Rastenii*, 28–33. [Зинова А. Д., Забержинская Э.Б. (1968) «Новый вид красных водорослей в Каспийском море», Ноябрь. Сист. Нижших Раст., 28–33.]

Azərbaycanın Xəzər dənizinin cənub sahillərində yosunların növ tərkibinin, bolluq dinamikasının və bioindikator xüsusiyyətlərinin qiymətləndirilməsi

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Bu tədqiqat 2023-2024-cü illərdə Xəzər dənizinin cənub sahili boyunca (Lənkaran, Astara, Masallı və Neftçala) yosun icmalarının inkişafını və onların məkan-zaman dəyişikliyini araşdırır. Tədqiqat Bacillariophyta, Chlorophyta, Cyanobacteria, Rhodophyta, Charophyta və Ochrophyta şöbələrinə daxil olan növlər olmaqla 75 taxson müəyyən edilmişdir. Nəticələr yer və il üzrə dəyişmiş, ən yüksək dəyərlər Lənkaranda (2023) və Astarada (2024) müşahidə edilmişdir. Diatom və xlorofit bütün tədqiqat sahələrində üstünlük təşkil edən əsas qrup olmuşdur. Şhannox müxtəliflik indeksi 3.94–4.42 arasında dəyişmişdir ki, bu da yosun icmalarında yüksək növ müxtəlifliyi və ekoloji sabitliyi göstərir, eyni zamanda Evenness Bərabərlik indeksi (0.944–1.03) fərdlərin növlər arasında nisbətən bərabər paylandığını və güclü dominantlığın olmadığını göstərir. Klaster təhlili göstərmişdir ki, yosun icmalarının strukturu eyni fəsillər daxilində yüksək oxşarlıq, fəsillər arasında isə əhəmiyyətli fərqlər nümayiş etdirir və bu, bolluq göstəricilərinin zaman üzrə dəyişməsinin əsasən mövsümü ekoloji amillərlə əlaqəli olduğunu təsdiqləyir. Suyun temperaturu əhəmiyyətli dəyişkənlik göstərmişdir (8.1–27.4°C; $P < 0.0002$) və TDS göstəricilərində statistik cəhətdən əhəmiyyətli fərqlər müşahidə edilməmişdir ($P > 0.05$). Temperaturun artması yosun çiçəklənməsinin intensivləşmsi ilə əlaqələndirilmiş və potensial risk faktoru kimi qiymətləndirilmişdir. Cənubi Xəzər sahili boyunca yosun icmalarının taksonomik tərkibi və bolluq modelləri ətraf mühit şəraitindən təsirlənir və su ekosistemlərinin ekoloji sağlamlığının qiymətləndirilməsində mühüm rol oynayır.

Açar sözlər: *müxtəliflik indeksləri, hidrokimyəvi parametrlər, makroyosunlar, fitoplankton, saprobik indeks, mövsümi dəyişkənlik*

Оценка видового состава, динамики обилия и биоиндикаторных характеристик водорослей на южном побережье Каспийского моря Азербайджана

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Данное исследование охватывает развитие сообществ водорослей и их пространственно-временную изменчивость вдоль южного побережья Каспийского моря (Лянкяран, Астара, Масаллы и Нефтчала) в 2023–2024 годах. В ходе исследования было выявлено 75 таксонов, относящихся к отделам Bacillariophyta, Chlorophyta, Cyanobacteria, Rhodophyta, Charophyta и Ochrophyta. Результаты варьировали в зависимости от района и года исследования, при этом наибольшие значения наблюдались в Лянкяране (2023) и Астаре (2024). Диатомовые водоросли и хлорофиты являлись доминирующими группами во всех исследованных районах. Индекс разнообразия Шеннона варьировал в пределах 3.94 до 4.42, что указывает на высокое видовое разнообразие и экологическую устойчивость водорослевых сообществ, тогда как индекс выравненности (0.944–1.03) свидетельствует о относительно равномерном распределении особей между видами и отсутствии выраженного доминирования. Кластерный анализ показал, что структура сообществ водорослей характеризуется высокой степенью сходства в пределах одного сезона и значительными различиями между сезонами, что указывает на то, что изменения показателей численности в основном связаны с сезонными экологическими факторами. Температура воды демонстрировала значительную изменчивость (8.1–27.4°C; $P < 0.0002$), тогда как различия и TDS не были статистически значимыми ($P > 0.05$). Повышение температуры было связано с усилением цветения водорослей и оценено как потенциальный фактор риска. Таксономический состав и структура обилия водорослевых сообществ вдоль южного побережья Каспийского моря формируются под влиянием экологических факторов и играет важную роль в оценке экологического состояния водных экосистем.

Ключевые слова: *индексы разнообразия, гидрохимические параметры, макроводоросли, фитопланктон, сапробный индекс, сезонная изменчивостъ*