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Diversity and taxonomic structure of Cyanoprokaryota in the Azerbaijani sector of the Caspian Sea

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Abstract: A comprehensive study and preservation of the plant world is one of the main challenges facing botanists. Cyanoprokaryota (Cyanophyta, Cyanobacteria) also known as blue-green algae is the oldest group of prokaryote organisms involved in photosynthesis having a great impact on the global ecosystem. Three billion years ago their photosynthesis caused the "oxygen revolution" changing both the Earth atmosphere and its biota. This group consists of heterogeneous pool of photosynthetic prokaryotes and covers 2000 species belonging to several hundred genera represented by unicellular, colonial, filamentous or branched-filamentous forms. Cyanoprokaryota is widely distributed in aquatic to terrestrial habitats, in extreme environments such as hot springs, hypersaline ecosystems, deserts and polar regions. The Caspian Sea is a unique, reservoir with brackish water isolated from the world ocean, extended along meridian and located in the junction of Europe and Asia. The shores of Azerbaijan, in the length of 955 km, are washed by the waters of the Middle and South Caspian. The salinity of the water ranges between 12-13.4%, with the exception of the estuarine area of the Kura River, where the waters of the South Caspian periodically subjects to desalination. Blue-green algae (Cyanoprokaryota) are an integral component of the aquatic ecosystems of Caspian and their role is diverse. So blue-green algae play an important role in the sedimentation of the Caspian, forming an oil-like compound sapropel, which, it is not unlikely that is a precursor of oil in the Caspian Sea. Therefore, like its other components, blue-green algae need careful study and protection. Provided data are based on the results of long-term study of species diversity of Cyanoprokaryota in the Caspian Sea (including the Azerbaijani sector) from the 70s of the last century to the present. As a result, information was expanded on the species diversity, ecology and distribution of blue-green algae in the Azerbaijani sector of the Caspian Sea. The paper presents generalized literature and original data on taxonomic structure and species diversity of Cyanoprokaryota Azerbaijani sector of the Caspian Sea. In total, 93 species of cyanophytes belonging to class Cyanophyceae, three subclasses, five orders, 20 families and 44 genera are known for the studied area. Orders Synechococcales (7 families, 15 genera and 27 species) and Oscillatoriales (3 families, 13 genera and 35 species) lead in taxonomic and species diversity; together they incorporate 66.7% of the species revealed. Leading families are Oscillatoriaceae (21.8%) and Microcoleaceae (12.9%). Genera *Phormidium* Kützing ex Gomont (9 species), *Oscillatoria* Vaucher ex Gomont and Chroococcus Nägeli (6 species each), *Leptolyngbya* Anagnostidis & Komárek, *Lyngbya* C. Agardh ex Gomont, *Merismopedia* Meyen (5 species each) and *Spirulina* Turpin ex Gomont (4) lead in species diversity incorporating 43% of species found; 26 genera are represented by one species. Algoflora of the Azerbaijani sector of the Caspian Sea is also enriched with 55 species of blue-green algae, of which 25 species became an addition for the Caspian Sea as a whole.

Key Words: *water body, blue-green algae, composition, ecology, distribution*

INTRODUCTION

Cyanoprokaryota (Cyanophyta, Cyanobacteria) are the oldest group of prokaryotic organisms on the Earth involved in photosynthesis and have a great impact on the global ecosystem. This group consists of heterogeneous pool of photosynthetic prokaryotes and covers more than 150 genera and 2.000 species, including unicellular, colonial, filamentous or branched-filamentous forms [Pulz, Gross, 2004; Sharma et al., 2011]. This is the oldest group of autotrophic organisms on the planet. About three billion years ago their photosynthesis caused the "oxygen revolution" changing both the Earth atmosphere and its biota. Being autotrophs, they are important contributors to primary production of aquatic and terrestrial environments, also providing coastal ecosystems with nitrogen. Cyanoprokaryota serve as a food for hydrobionts including fish and play important role in marine economy.

The Caspian Sea is the largest inland brackish water body on the planet, located at the junction of Europe and Asia. In the twentieth century, long-term decline in

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the level of Caspian Sea resulted in two extreme events which had negative consequences on the population of coastal countries: an abnormally long fall in the level between 1930 and 1977, and then an abnormally long rise from 1978 to 1995 [Roshydromet, 2016]. Petroleum products, raw industrial and agricultural flows, municipal sewage of cities and towns along the coast, transportation, oil extraction from the bottom of the sea, and oil transportation are the main pollution sources of the Caspian Sea. Pollutions from the river flows are concentrated in the North Caspian (90%), industrial wastes are mainly encountered around the Absheron Peninsula, and increased oil contamination of the South Caspian is connected with oil production and oil exploration drillings [Kotlyakov, 2004]. Industrial and urban development can probably lead to the increase of the pollution of the Caspian Sea. Another threat for the region is expected to be climate change which can result in the increase of temperature and consequent evaporation and decrease in water inflow volumes [IPCC, 2014]. Water level in the Caspian Sea undergoes regular fluctuations. Time and scale of the next sea level rise is impossible to predict. It can be triggered by different factors (including geological ones) and can have enormous impact on the richness of species, provision of ecosystem services.

Blue-green algae (Cyanoprokaryota) are an integral component of the Caspian aquatic ecosystems and play an important role both in the life of the sea and in the sedimentation of the Caspian, forming an oil-like compound sapropel, which is a precursor of oil in the Caspian Sea. In recent decades, an increase in the share of cyanophytes in the biomass of Caspian phytoplankton was recorded [Gasanova et al., 2015] as well as numerous events of water bloom caused by blue-green algae, primarily Nodularia spumigena [Nusrollahzadeh et al., 2011]. The importance of cyanobacteria for the Caspian ecosystem determines the need to study their diversity. This correlates with the growing attention to the problems of biodiversity and its applications associated with a greater understanding of the need to preserve it for food safety, health and the quality of human life [Alizade, 2016].

The first brief information about the blue-green algae of the Caspian Sea appeared in the second half of the 19th century and at the beginning of the 20th century [Kovalevsky, 1870; Grunow, 1878: Ostenfeld, 1901]. The organization under the USSR Academy of Sciences of the Caspian Commission for a comprehensive study of the problems of the Caspian in 1933 was of great importance for the development of work on the study of algae, including blue-greens [Kiselev, 1938; Usachev, 1938, Kireeva, Shchapova, 1957]. The monographs by A.I. Proshkina-Lavrenko and I.V. Makarova, devoted to algae of the plankton of the Caspian Sea, which are the result of many years research [1954-1964] is of particular importance. These authors conducted serious studies that provided us with valuable information about the algae of the Caspian Sea [Zaberzhinskaya et al., 1969]. However, special studies of Cyanophyta in the Caspian Sea including the Azerbaijani sector begun only in the seventies of the last century [Nuriyeva, 1981, 1991, 2007, 2010]. Prior to our research, no special works were devoted to Cyanoprokaryota in the Azerbaijani sector of the Caspian Sea.

The data we have provided are based on the results of systematic work in the Caspian Sea (including the Azerbaijani sector) from the 70s of the last century to the present at certain intervals. As a result, information on the species diversity, ecology and distribution of blue-green algae (Cyanoprokaryota) in the Azerbaijani sector of the Caspian Sea based on the results of the review and analysis of literature data and many years original algological studies according to actual nomenclatural changes were expanded. The purpose of this work is to analyze and generalize the available literary and original data according to nomenclatural changes on the species diversity, ecology and distribution of blue-green algae (Cyanoprokaryota) of the Azerbaijani sector of the Caspian Sea and to reveal the modern species diversity and taxonomic structure of blue-green algae in the Azerbaijani sector of the Caspian Sea.

MATERIAL AND METHODS

The material for this article was the results of the analysis and review of floristic, systematic and hydrobiological literature data [Kovalevskiy, 1870; Grunow, 1878; Ostenfeld, 1901; Kireeva-Shapova, 1957; Proshkina-Lavrenko, 1968; Babayev, 1965, 1968; Akhundova, 1996] and the results of long-term original research of plankton and benthos [Nuriyeva, 1981, 1991, 2007, 2010] of blue-green algae of the Azerbaijani sector of the Caspian Sea. The research material was algological samples of phytoplankton, benthos and periphyton (from both solid substrates like rocks, stones, hydraulic structures, etc. and aquatic plants and macrophytes) collected in the coastal waters of Azerbaijan from the swash zone to a depth of 50, rarely 100 m (Fig. 1). Information on species and taxonomic diversity of Cyanoprokaryota has been compiled taking into account nomenclatural updates and recent novelities in the tax-

onomy of Cyanoprokaryota [Komárek et Anagnostidis, 1998, 2005, Komárek, 2013; Komárek et al., 2014; Guiry and Guiry, 2019].

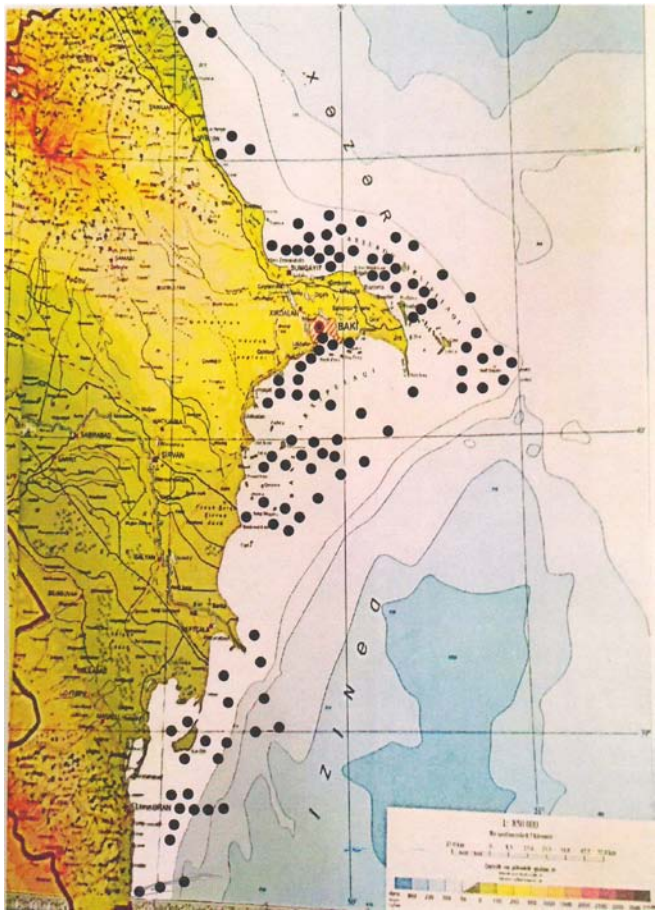

Figure 1. Distribution of sampling stations by authors in Azerbaijan sector of the Caspian Sea.

RESULTS AND DISCUSSION

To date, according to the generalized original and literary data of blue-green algae of plankton and benthos of the Azerbaijani sector of the Caspian Sea, 93 species of Cyanoprokaryota belonging to one class (Cyanophyceae Schaffner), three subclasses, five orders, 20 families and 44 genera have been recorded. Their taxonomic spectrum is given in the Table. The dominant position on the species diversity takes the subclass Oscillatoriophycideae L. Hoffmann, J. Komárek & J. Kastovsky incorporating 43.2% of generic spectrum and 57.0% of species diversity. Among three orders of this subclass, Oscillatoriales Schaffner (3 families, 13 genera, 37.6% of species) lead in taxonomic and species diversity. Leading families are Oscillatoriaceae Engler (21.5%) and Microcoleaceae O. Strunecky, J.R. Johansen & J. Komárek (12.9%). Generic spectrum of oscillatoriophycidians includes 19 genera. Basis of the species diversity are the genera *Phormidium* Kützing ex Gomont (9 species), *Oscillatoria* Vaucher ex Gomont and Chroococcus Nägeli (6 species each), *Lyngbya* C. Agardh ex Gomont (5 species) and *Spirulina* Turpin ex Gomont (4). Genera *Gomphosphaeria* Kützing, *Microcystis* Kützing ex Lemmermann, *Kamptonema* O. Strunecký, J. Komárek, J. Smarda and Microcoleus Desmazières ex Gomont represented in the Azerbaijani sector of the Caspian Sea by three species each. The rest of the genera have low species diversity in studied area. Although the order *Oscillatoriales* leads in the species diversity, most of its representatives occurred sporadically, singly, in the form of separate filamentous individuals in plankton. Of the species, *Spirulina subsalsa* Oersted ex Gomont, *Microcoleus amoenus* (Gomont) O. Strunecky, J. Komárek & J.R. Johansen, *P. tergestinum* (Kützing) Anagn. et Komárek, *Oscillatoria tenuis* C. Agardh ex Gomont, *Lyngbya aestuarii* Liebmann ex Gomont etc. can be shown. The latter species is bento-planktonic and occurs more frequently in benthos of the Azerbaijani sector of the sea. The benthic Cyanoprokaryota find the most favorable conditions for their development in the coast and at shallow depths with sufficient lighting, solid soils, including rocks, stones, hydraulic structures and other objects immersed in water. Epiphytes, they are found on aquatic plants and macrophytes. In benthos, the most common and abundant species include *Lyngbya semiplena* J. Agardh ex Gomont, *Kamptonema laetevirens* (H.M.Crouan & P.L.Crouan ex Gomont) Strunecký, Komárek & J.Smarda, *Coleofasciculus chthonoplastes* (Thuret ex Gomont) M.Siegesmund, J.R. Johansen & T. Friedl, *Phormidium breve* (Kützing ex Gomont) Anagn. et Komárek, *P. ambiguum* Gomont ex Gomont, *Oscillatoria tenuis* Agardh ex Gomont; *Porphyrosiphon luteus* (Gomont ex Gomont) Anagn. et Komárek, *Spirulina labyrinthiformis* Kützing ex Gomont and many others (Fig.2). Many of these species have been unknown for the studied sea area. Most of these species are found in significant numbers in the region of the Absheron peninsula. The unevenness of the coastline, shallow depths, exit of stony ridges, all this creates favorable conditions for their development. In addition, *Heteroleibleinia kuetzingii* (Schmidle) Compère, *H. kossinskajae* (Elenkin) Anagn. et Komárek, *H. ucrainica* (Širšov in Elenkin) Anagn. et Komárek which prior to our studies were not known not only for the Azerbaijani sector of the Caspian Sea, but also for the

entire Caspian are found epiphyte on aquatic plants and macrophytes. However, abundant growth of fouling algae creates difficulties in the operation of sea transport, and **developing in the open sea** on hydraulic structures - oil platforms, piles, etc. contribute to metal corrosion, causing great harm.

The second place according the number of species takes the subclass Synechococcophycidae L. Hoffmann, J. Komárek & J. Kastovsky sharing 34.1% of genera and 29.0% of species found in the the Azerbaijani sector of the Caspian Sea. It is represented by one order (Synechococcales L. Hoffmann, J. Komárek & J. Kastovsky) and 7 families. Among the families, the most abundantly represented is the family Merismopediaceae (8 species). The second place according to the species diversity takes the family Leptolyngbyaceae. Other families are less diverse (Tab.) Among the genera, the basis of species diversity is the genera: *Leptolyngbya* Anagnostidis & Komárek and Merismopedia Meyen (5 species each), *Heteroleibleinia* (Geitler) Hoffmann (3 species), *Aphanocapsa* Nägeli and Jaaginema Anagnostidis & Komárek (2 species each). More than half of the genera (53.3%) are represented by one species each. The representatives of this order in the Azerbaijani sector of the Caspian Sea are mainly represented by common species widely distributed in continental water bodies

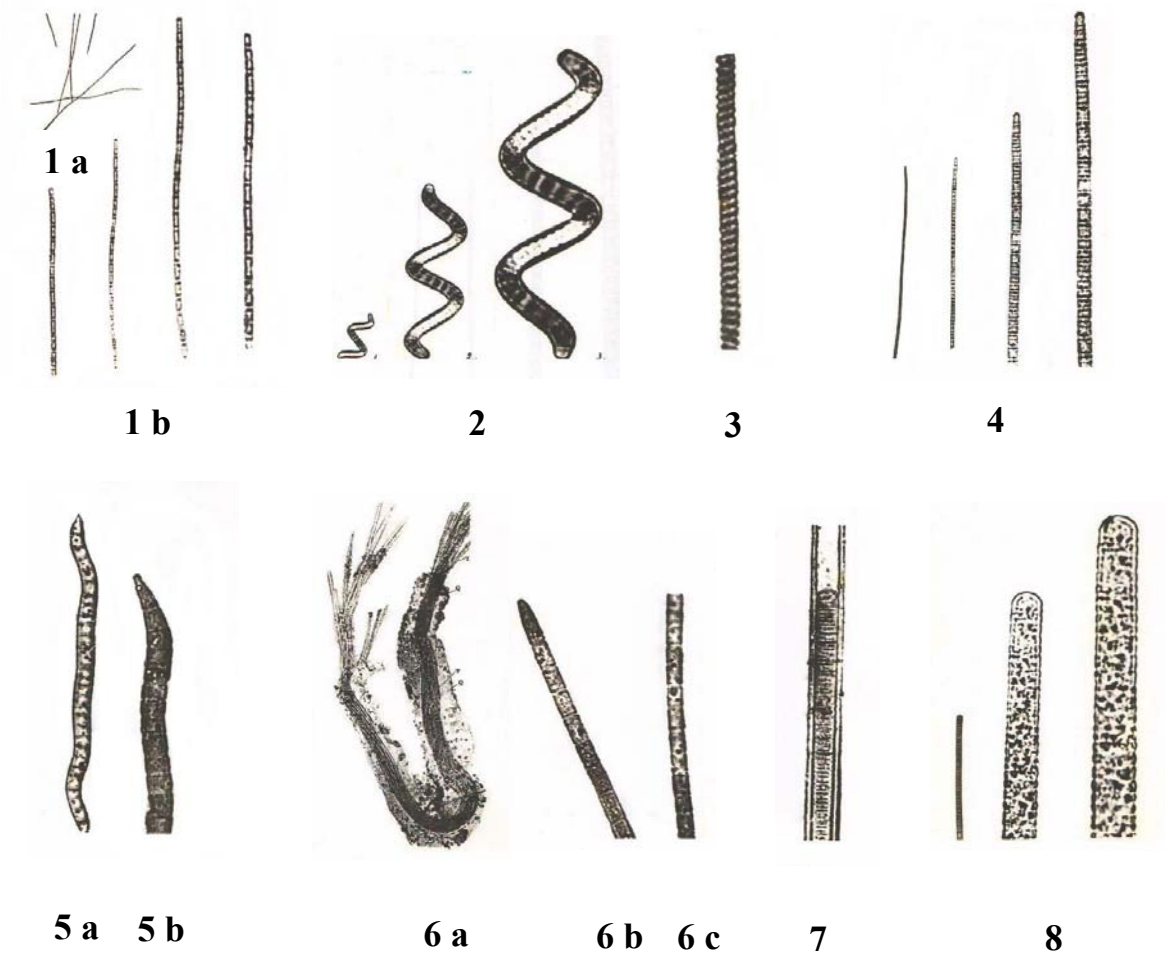

Figure 2. Blue-green algae found in the Azerbaijani sector of the Caspian Sea: 2.1. *Limnothrix redekei* (Goor) Meffert - a) accumulation of filaments, b) individual filament (at different magnifications); 2.2. *Arthrospira platensis* (Nordstedt) Gomont; 2.3. *Spirulina subsalsa* Oersted ex Gomont; 2.4. *Microcoleus amoenus* (Gomont) O. Strunecky, J. Komárek & J.R. Johansen; 2.5. *Phormidium boryanum* (Bory ex Gomont) Anagnostidis et Komárek – a) hormigonium b) end of trichome; 2.6. *Coleofasciculus chthonoplastes* (Thuret ex Gomont) M.Siegesmund, J.R.Johansen & T.Friedl – a) filament with a common sheath, b) end of trichome, c) middle part of trichome; 2.7. L*yngbya aestuarii* Liebman ex Gomont; 2.8. *Oscillatoria tenuis* Agardh ex Gomont (at different magnifications).

Table. Taxonomic spectrum (units, %) of blue-green algae (Cyanophyceae) of the Azerbaijani sector of the Caspian Sea.

Taxon (subclass, order, family)	Number of		
	families	genera	species
Synechococcophycidae	7/ 35.0	15/34.1	27/ 29.0
Synechococcales	7 / 35.0	15/ 34.1	27/29.0
Coelosphaeriaceae	-	2/ 4.5	2/2.1
Leptolyngbyaceae	-	3/ 6.8	7/ 7.5
Merismopediaceae	-	3/ 6.8	8/8.6
Pseudanabaenaceae	-	2/ 4.5	2/ 2.1
Synechococcaceae	-	1/ 2.3	1/1.1
Synechococcales familia incertae sedis	-	3/ 6.8	6/7.0
Trichocoleusaceae	-	1/ 2.3	1/1.1
Oscillatoriophycideae	7/ 35.0	19/43.2	53/ 57.0
Chroococcales	3/15.0	3/ 6.8	7/ 7.5
Aphanothecaceae	-	1/ 2.3	1/1.1
Chroococcophyceae	-	2/ 4.5	7/ 7.5
Gomphosphaeriaceae	-	1/ 2.3	3/ 3.2
Microcystaceae	-	1/ 2.3	3/ 3.2
Oscillatoriales	3/ 15.0	13/ 29.5	35/37.0
Coleofasciculaceae	-	3/ 6.8	3/ 3.2
Microcoleaceae	-	7/ 16.7	12/12.9
Oscillatoriaceae	-	3/ 6.8	20/21.8
Spirulinales	1/ 5.0	1/ 2.3	4/ 4.3
Spirulinaceae	-	1/ 2.3	4/ 4.3
Nostocophycidae	5/25.0	10/ 22.7	13/ 14.0
Nostocales	5/ 25.0	10/ 22.7	13/14.0
Aphanizomenonaceae	-	5/ 11.4	8/8.6
Rivulariaceae	-	2/ 4.5	2/ 2.1
Scytonemataceae	-	1/ 2.3	1/1.1
Tolypothrichaceae	-	1/ 2.3	1/1.1
Nostocaceae	-	1/ 2.3	1/1.1
In total, units/%	20/100	44/100	93/100

(in rivers and their estuaries, reservoirs and in eutrophic lakes). In this sea area, more frequently appeared species are *Aphanocapsa pulverea* (Wood) Forti emend. Elenkin, *Merismopedia tenuissima* Lemmermann, *M. punctata* Meyen, *M. glauca* (Ehrenberg) Kützing, *Limnococcus limneticus* (Lemmermann) Komárková, Jezberová, O.Komárek & Zapomelová, etc. Along with them, species that cause water bloom such as *Microcystis aeruginosa* (Kützing) Kützing and *Aphanocapsa grevillei* (Berkeley) Rabenhorst, the last of which in the Azerbaijani sector of the Caspian Sea is found not only in the plankton, but also at the bottom at shal-

low depths, on stones and rocks. These species are also found in desalinated areas of the Southern seas, such as the Azov and Black. The filamentous cyanobacteria Limnothrix redekei (Goor) Meffert (Fig. 2, 1) quite often occurred in plankton in the summer-autumn period and in some years reached a considerable number up to 755.2 thousand cells / L [Nuriyeva, 2010]. This species commonly occurs in lakes and can cause water bloom [Kondrat'yeva, 1968].

The order Nostocales (subclass Nostocophycidae L. Hoffmann, J. Komárek & J. Kastovsky) in the Azerbaijani sector of the Caspian Sea is represented by a considerably less number – 13 species (13 infraspecific taxa) belonging to five families (Scytonemataceae Rabenhorst ex Bornet et Flahault, Rivulariaceae Kützing ex Bornet et Flahault, Tolypothrichaceae Hauer, Mareš, Bohunická, Johansen et Berrendero-Gomes, Aphanizomenonaceae Elenkin, Nostocaceae C.A. Agardh ex Kirchner) and 10 genera. The family Aphanizomenonaceae dominates in number with five genera (*Anabaenopsis* V.V. Miller, *Aphanizomenon* Morren ex Bornet & Flahault, *Chrysosporum* E. Zapomelová, O. Skácelová, P. Pumann, R. Kopp & E. Janecek, *Dolichospermum* (Ralfs ex Bornet & Flahault) P. Wacklin, L. Hoffmann & J. Komárek and *Nodularia* Mertens ex Bornet & Flahault) and eight species. The rest of families are represented by one or two species.

Although species of the order Nostocales are represented by a small number of species, they nevertheless play an important role in the life of the sea. Some species of blue-green algae, for example, *Aphanizomenon flosaquae* (L.) Ralf ex Born. & Flah., is found in the Caspian Sea and is known for its toxicity. Under favorable conditions, annually at the end of summer it causes water bloom. During the period of intensive reproduction, alga is toxic to fish and all aquatic animals and can cause conjunctivitis in humans and irritate human skin [Kondrat'yeva, Kovalenko, 1975].

Species *Nodularia spumigena* Mert. ex Born. & Flah., *Dolichospermum flosaquae* (Brébisson ex Bornet & Flahault) P. Wacklin, L. Hoffmann & J. Komárek also belong to toxic species that can cause water bloom. *Nodularia spumigena* produces the nodularin toxin, which has an effect on fish and inhibits the development of eggs [Burkholder, 1998; Ryabushko, 2003], lives mainly in the northern part of the Caspian Sea, less often in the Middle and South. Local water bloom of water in the form of small spots in the life of the sea plays a positive role, since its waters are enriched with biogenes. Strong "blooming" often leads to deterioration in water quality and ultimately leads to the death of animals. Heterocytous species most common in the Azerbaijani sector of the Caspian include the taxa formerly belonging to genus *Anabaena*: *Chrysosporum bergii* (Ostenfeld) E. Zapomelová, O. Skácelová, P. Pumann, R. Kopp & E. Janecek and *C. minor* (Kiselev) Komárek, *Anabaena kisselevii* Proshkina-Lavrenko and two widespread halophilous species from the genus *Nodularia*: *N. harveyana* (Thwaites) Thuret and *N. spumigena* Mertens ex Bornet et Flahault. In a systematic respect, species of the genus *Anabaenopsis* are very interesting, which were previously considered tropical. The most common in the Azerbaijani sector of the Caspian Sea are *A. cunnigtonii* W.R. Taylor , *A. tanganyikae* (G.S. West) Woloszyńska & V. V. Miller. Species such as *Calothrix scopulorum* Agardh ex Bornet et Flahault, *Rivularia atra* Roth ex Bornet et Flahault belong to species distributed in the benthos of the Azerbaijani sector of the Caspian Sea.

Figure 3. Satellite image of the blooming of phytoplankton in the Azerbaijani sector of the Caspian Sea (NASA, 2017).

CONCLUSION

Blue-green algae, as an integral part of natural ecosystems, play an important role in the development of nature in our planet. Recent years' achievements in the development of science provided more deeply studies of water resources of water pools including blue-green algae. The problem of food, which provides the growing population of the planet with adequate nutrition has become an important economic and political factor in the modern world. Blue-green algae as all other components of the Caspian Sea need comprehensive study

and protection. There is an increasing interest in new, unconventional sources of protein, fats, carbohydrates, vitamins, enzymes, and other physiologically active substances. Algae in this regard are very promising organisms. It is assumed that the proportion of algae in the human diet will grow steadily in the future. However, the Caspian Sea, with regards to increasing pollution, is in a very difficult environmental situation, which leaves its mark on phytobenthos and phytoplankton. The changes in the marine ecology affect the species composition of algae (including blue-green) and the structure of phytocenoses, whereas in marine coastal ecosystems it is algae that are the leading components. The coastal waters of the Caspian Sea of Azerbaijan constantly undergo anthropogenic load. Intoxication of organism occurs in the places with the increased concentration of pollution especially oil pollution (for example, in Baku bay, in Sumgayit), so algae resistant to pollution die. In this regard, in recent years, the problem of maintaining the ecological health of a unique natural object, such as the Caspian Sea, is of special importance.

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REFERENCES

Akhundova N.A. (1996) Fitoplankton Yuzhnogo Kaspiya (sostav, ekologiya, kolichestvennoye razvitiye, znacheniye): Avtoref. diss.…kand. biol. nauk. Baku. 24 p. (In Russian)

AlgaeBase: http://www.algaebase.org

Ali-zade V.M. (2016) Radi zhizni na zemle. AMEA-nın Xəbərlər Məcmusı, 3(4): 31-35.

Babayev G.B. (1965) O fitoplanktone zapadnoy chasti Srednego i Yuzhnogo Kaspiya. Gidrobiol. zhur., 1(6): 11-19. (In Russian)

Babayev G.B. (1968) Coctav i raspredeleniye fitoplanktona v Srednem i Yuzhnom Kaspii. V kn.: Biologiya Srednego i Yuzhnogo Kaspiya. Izd-vo Nauka, M., pp. 50-63. (In Russian)

Burkholder J.M. (1998) Implications of harmful microalgae and heterotrophic dinoflagellates in management of sustainable marine fisheries. *Ecol Appl,* 8(1) (Suppl.): 37- 62.

Gasanova A.Sh., Kovaleva G.V., Guseynova K.M., Guseynova M.K. (2015) Fitoplankton pribrezhnich melkovodiy rossiyskoqo sektora Kaspiya. Vestnik Dagestanskoqo nauchnoqo centra, (57): 14-19.

Grunow A. (1878) Algen Diatomaceen aus dem Kaspischen Meere. O.Schneider, S. Naturwiss. Beitr. Kenntn. Kaukasuslander. Drezden, 6: 98-132.

Guiry M.D. and Guiry G.M., AlgaeBase. Worldwide electronic publication, Nat. Univ. Ireland, Galway, 2019.

IPCC (2014) AR5 Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandre. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. ipcc.ch/report/r5/wg2/

Kireyeva M.S., Shchapova T.F. (1957) Materialy po sistematicheskomu sostavu i biomasse vodorosley i vysshey vodnoy rastitel'nosti . *Tr. Inst. okeanol. AN SSSR*, 23: 125-137. (In Russian)

Kiseyev I.A. (1938) O fitoplanktone Kaspiyskogo morya. V kn. Materiali po gidrobiologii i litologii Kaspiyskogo morya. M.: L.: Izd-vo AN SSSR, pp. 229-254. (In Russian)

Komárek J., Anagnostidis K. (1998) Cyanoprokaryota 1. Teil: Chroococcales. SüBwasserflora von Mitteleuropa. Jena, etc.: Elsevier, 19(1): 548 p.

Komárek J., Anagnostidis K. (2005) Cyanoprokaryota. 2. Teil: Oscillatoriales. SüBwasserflora von Mitteleuropa. Jena, etc.: Elsevier, 19(2): 759 p.

Komárek J., Kaštovský J., Mareš J., Johansen J. R. (2014) Taxonomic classification of cyanoprokaryotes (cyanobacterial genera). 2014 using a polyphasic approach. Preslia, 86: 295-335.

Kondrat'yeva N.V. (1968) Vyznachnyk prisnovodnykh vodorostey Ukrayins′koyi RSR. 1. Cyn′ozeleni vodorosty - Cyanophyta. Chastyna 2. Kyev: Nauk. Dumka, 522 p. (In Ukrainian)

Kondrat'yeva N.V., Kovalenko O.V. (1975) Kratkiy opredelitel' vidov toksicheskikh sinezelenykh vodorosley. Kiyev: Nauk. dumka: 80 p. (In Russian)

Kotlyakov V.M. (2004) Kaspiyskoye more [The Caspian Sea]. In Natsional'nyy atlas Rossii [The National Atlas of Russia]. Moscow: Federal'noye agentstvo geodezii i kartografii (ROSKARTOGRAFIYA) pp.258–262. http://natsional'nyyatlas.rf/cd2/258-262/258-262.html.

Kovalevskiy A.O. (1870) Spisok vodorosley, sobrannykh v Kaspiyskom more. Prot.zased.yestestvoispyt. Kazansk. un-ta za 1869-1870 gg.: 67-68. (In Russian)

Nasrollahzadeh H.S., Makhlough A., Pourgholam R.,

Vahedi F., Quanqermeh A., Foong S.Y. (2011) The study of *Nodularia spumigena* bloom event in the Southern Caspian Sea. *APPL ECOL ENV RES*, 9(2): 141-155.

Nuriyeva M.A. (1981) Sin'ozeleni vodorosli zakhi dnoi chasti Kaspiyskogo morya. *Ukr. bot. zhurn*., XXXVII (6): 41-45. (In Ukrainian)

Nuriyeva M.A. (1991) Novyye dlya Kaspiyskogo morya vidy Cyanophyta. *Al'gologiya,* 1(3): 61-66. (In Russian)

Nuriyeva M.A. (2010) Raznoobraziye Oscillatoriaceae (Kirchn.) Elenk. (Cyanophyta) Yuzhnogo Kaspiya. *Tr. Inst. Botaniki NANA*, XXX: 155-160 (In Russian)

Nuriyeva M.A. (2007) K al'goflore Absheronskogo poluostrova Kaspiyskogo morya. *Tr. Inst. Botaniki NANA*, XXVII: 153-158. (In Russian)

Ostenfeld C.H. (1901) Phytoplankton from the Caspian sea. Videns. Medd. fra Naturk. Foren. Kjobenhavn., 129-215.

Proshkina-Lavrenko A.I., Makarova I.V. (1968) Vodorosli planktona Kaspiyskogo morya. L. Nauka, Leningr. otd-niye, 291 p. (In Russian)

Pulz O, Gross W (2004) Valuable products from biotechnology of Microalgae., *Appl Microbiol Biotechnol* 65: 635-648.

Roshydromet (2016) Water balance and level fluctuations of the Caspian Sea. Modeling and prediction. Chief Editor: E.S. Nesterov. Moscow: Triada Ltd., 378 p. Available at:http://method.meteorf.ru/publ/books/kaspiy.pdf.

Ryabushko L.I. (2003) Atlas toksichnykh mikrovodorosley Chernogo i Azovskogo morey. Sevastopol', 140. (In Russian)

Sharma N.R. et al.(2011) Sustainability and cyanobacteria (blue-green algae): facts and challenges. *J. Appl Phycol.* 23:1059-1081. DOI 10.1007/s10811-010-9626-3

Usacev P.I. (1938) Novie i redkie vidi sinozelenix vodorosley v planktone Kaspiyskogo morya. V kn.: Matepiali po gidrobiologii i litologii Kaspiyskogo morya. M.: L.: Izd-vo AN SSSR, pp. 99-113. (In Russian)

Zaberzhinskaya E.B., Karayeva N.I., Makarova I.V. (1969) Istoriya izuceniya vodorosley Kaspiyskogo morya. V kn.: Letopis nauki v Azerbaydzhane (estestvoznanie). Baku Elm, pp.173-178. (In Russian)

Xəzər dənizinin Azərbaycan sektorunda Cyanoprokaryota müxtəlifliyi və taksonomik strukturu

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Bitki aləminin hərtərəfli öyrənilməsi və qorunması botaniklərin qarşısında duran əsas məsələlərdəndir. Cyanoprokaryota (Cyanophyta, Cyanobacteria)– göy-yaşıl yosunlar fotosintez prosesində iştirak edən və qlobal ekosistemə böyük təsir edən prokariyot orqanizmlərinin ən qədim qrupudur. Onlar təkamül ağacının əsasında bitkilərdən üç milyard il bundan əvvəl ayrılmış və özlərinin sərbəst budağını əmələ gətirmişdilər. Bu qrup fotosintetik qrupların heterogen birliyi olub birhüceyrəli, kolonial, sapvari və ya şaxəli sapvari formalara malik 150-dən çox cinsə aid 2000 növü birləşdirir. Cyanoprokaryota sudan quruyadək, qaynaq bulaqlar, çox duzlu sular, səhra və qütb regionları kimi ekstremal mühitlərdə geniş yayılmışlar. Xəzər dənizi – unikal, dünya okeanından təcrid olunmuş şortəhər sulu, meridian istiqamətində uzanan sututarıdır, Avropa və Asiyanın qovşağında yerləşir. Orta və cənub Xəzərin suları 955 km uzunluğunda Azərbaycan sahillərini yuyur. Suyun duzluluğu 12-13.4‰ arasında dəyişir, yalnız cənub Xəzərin Kürün mənsəbində olan hissəsi daima şirinləşməyə məruz qalmaq olar. Göy-yaşıl yosunlar Xəzər su ekosisteminin ayrılmaz komponentidir və onlar müxtəlif rola malikdir. Belə ki, onlar Xəzərdə çöküntü əmələgəlmə prosesində mühüm rol oynayır, neftəbənzər birləşmələr sapropel əmələ gətirir və ehtimal olunur ki, bu da neftin sələfidir. Buna görə də, digər komponentlər kimi göy-yaşıl yosunlar diqqətlə tədqiq edilməli və qorunmalıdır. Tərəfimizdən təqdim olunan məlumatlar ötən əsrin 70-ci illərindən hazıradək müəyyən intervallarla Xəzər dənizində planlı şəkildə aparılan işlərin nəticələrinə əsaslanır. Ədəbiyyat məlumatlarının və çoxillik alqolojı tədqiqatların təhlili nəticələrinə əsasən tədqiq olunan sahənin göy-yaşıl yosunlarının növmüxtəlifliyi, ekologiyası və yayılması barədə məlumatlar genişlənib. Bütövlükdə, öyrənilən ərazi üçün Cyanophyceae sinfinin üç yarımsinfi, beş sırası, 20 fəsiləsi və 44 cinsinə aid 93 növ göy-yaşıl yosun məlumdur. Synechococcales (7 fəsilə, 15 cins, 27 növ) və Oscillatoriales (3 fəsilə, 13 cins, 35 növ) sıraları növ müxtəlifliyi ilə üstünlük təşkil edir, bu da ümumi növlərin 66.7% təşkil edir. Xəzər dənizinin Azərbaycan sektorunun alqoflorasına 55 növ, göy-yaşıl yosun əlavə edilmişdir, bunlardan 25 növ bütövlükdə Xəzər üçün əlavədir.

Açar sözlər: *sututarı, göy-yaşıl yosunlar, növ tərkibi,*

ekologiya, yayılma

Разнообразие и таксономическая структура Cyanoprokaryota азербайджанского сектора Каспийского моря

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Всестороннее изучение и сохранение растительного мира является одной из главных задач, стоящей перед ботаниками. Cyanoprokaryota (Cyanophyta, Cyanobacteria) являются наиболее древнейшей группой прокариотных организмов, участвующих в фотосинтезе и оказывающие большое влияние на глобальную экосистему. Более трех миллиардов лет они отошли от основного ствола растительной эволюции и образовали свою самостоятельную ветвь. Это группа состоит из гетерогенной совокупности фотосинтетических прокариот и охватывает более 150 родов и 2000 видов, включая одноклеточные, колониальные, нитевидные или разветвлено-нитевидные формы. Cyanoprokaryota широко распространены в средах обитания от водных до наземных, в экстремальных средах, таких как горячие источники, сверх солевые воды, пустыни и полярные регионы. Каспийское море – уникальный, изолированный от Мирового океана солоноватоводный, вытянутый в меридиальном направлении водоем, расположенный на стыке Европы и Азии. Берега Азербайджана, длиною в 955 км, омываются водами Среднего и Южного Каспия. Соленость воды колеблется в пределах 12-13.4‰, за исключением предустьевого пространства Куры, где воды Южного Каспия периодически подвергаются опреснению. Синезеленые водоросли (Cyanoprokaryota) являются неотъемлемым компонентом водных экосистем Каспия и их роль здесь многообразна. Так синезеленые водоросли играют немаловажную роль в осадкообразовании Каспия, образуя нефтеподобное соединение сапропель, которая, не исключено, что в Каспийском море является предшественником нефти. Поэтому как и другие ее компоненты синезеленые водоросли нуждаются в тщательном изучении и охране. Приведенные нами данные основываются на итогах планомерных работ на Каспийском море (включая азербайджанский сектор) с 70-х годов прошлого столетия по настоящее время с определенными интервалами. В результате расширены сведения о видовом разнообразии, экологии и распространении синезеленых водорослей (Cyanoprokaryota) азербайджанского сектора Каспийского моря. По результатам обобщения и анализа литературных данных и многолетних оригинальных альгологических исследований согласно номенклатурным изменениям выявлено 93 вида, относящихся к классу Cyanophyceae, к трем подклассам, пяти порядкам, 20 семействам и 44 родам. Доминирующее положение по таксономическому и видовому разнообразию занимают порядки Synechococcales (7 семейств, 15 родов, 27 видов) и Oscillatoriales, который включает 3 семейства, 13 родов и 35 видов; вместе они охватывают 66.7% от общего видового разнообразия. Альгофлора азербайджанского сектора Каспийского моря пополнена 55 видами синезеленых водорослей, из которых 25 видов явились дополнением и для Каспийского моря в целом.

Ключевые слова: *водоем, синезеленые водоросли, видовой состав, экология, распространение*