International Journal on Algae, 2022, 24(2): 105–120

Species Structure of Algae of the Saline Coastal Reservoirs of the Pryazov National Natural Park, Ukraine*

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Received 10 January 2022/Accepted 19 February 2022/Published 22 June 2022

ABSTRACT: The paper is devoted to the research of the species composition and taxonomic structure of algae in the saline coastal reservoirs of the Pryazov National Natural Park (PNNP). It is established that the species composition of algae in the studied reservoirs under modern conditions includes 153 species. These species represented 7 phyla, 11 classes, 32 orders, 61 families, 92 genera. The highest species richness at the phyla level showed *Cyanoprokaryota* (43.8% of the total number of species), *Bacillariophyta* (32.0%) and *Chlorophyta* (20.9%). These phyla include 148 species and form the basis of the species composition in the studied water bodies. The leading orders of algae in the researched reservoirs were *Oscillatoriales* and *Synechococcales* (23 and 20 species, respectively). The most diversely represented families were: *Oscillatoriaceae* (13 species), *Nostocaceae, Leptolyngbyaceae, Naviculaceae* (8 each), *Microcoleaceae, and Bacillariaceae* (7 each). The top list of the genera by this parameter: *Leptolyngbya* (6 species), *Lyngbya, Nostoc*, *Phormidium*, *Nitzschia* (5 each), *Calothrix*, *Kamptonema*, *Cocconeis*, *Navicula* (4 each). The highest frequency of occurrence among the identified species had also diatoms, cyanoprokaryotes and green algae: *Halamphora coffeiformis* (5.26%), *Lyngbya aestuarii* (4.21%), *Cladophora siwaschensis* (3.51%), *Hantzschia amphioxys* (3.33%), *Nodularia harveyana* (2.98%). Our research demonstrates that the species composition of algae of the studied saline coastal reservoirs of PNNP is quite impoverished in comparison with the partial soil algae flora, as well as the species list of algae in the freshwater reservoirs of Ukraine and seas. Specific features of the taxonomic composition of the saline coastal reservoirs are manifested in the association of organisms of fresh, marine and terrestrial habitats.

KEY WORDS: algae, saline reservoirs, Pryazov National Natural Park, North-Western Azov area

* Originally published in *Algologia*, 2022, 32(1): 68–87 ISSN 1521-9429

INTRODUCTION

The significant part of the nature reserves of the northwestern Azov region is located within the Pryazov National Natural Park (hereinafter – PNNP). Natural complexes of this territory are characterized by the presence of Azov seacoast, sandspits and coastal reservoirs (bays, estuaries of various types and numerous ephemeral reservoirs) (Barabokhaet al., 2012). Algae are an integral part of various terrestrial and aquatic ecosystems, including saline coastal bodies of this area. These organisms are producers of organic matter, play an important role in gas exchange, take part in the formation of the organic sediments and mineral deposits. In addition, algae are very accurate indicators of the ecological status of different natural objects, have much perspective in the biotechnological use.

The first studies of algae in the northwestern coast of the Azov Sea were carried out by Merezhkovsky (1902). There is only one reference to a source without a list of identified species in the available literature (Merezhkovsky, 1902; Proshkina-Lavrenko, 1963). There were 19 listed species of algae for Utlyuk Estuary according to the results of the scientific expedition of 1904 and by the materials of Generalova (Volkov, 1927; Generalova, 1951). Studies of planktonic diatoms of the Azov Sea, its bays and estuaries were carried out in 1936–1939 and in 1954–1956 (Proshkina-Lavrenko, 1963).

Recent studies of the Utlyuk Estuary are related to the study of macroalgae (Gromov, 2012) and sand littoral microalgae (Garkusha, 2016).

In the middle of the 20th century, algological studies were conducted in the Molochnyi Estuary (Proshkina-Lavrenko, 1950, 1951). There were 63 identified species and three infraspecific taxa of algae in phytoplankton (Ivanov, 1960) and 100 species in phytobenthos (Vladimirova, 1960). However, the publications give taxonomic names only of dominants and some related organisms. More detailed information about the dominant complex of algae in the reservoir is presented in the publications of Prikhodkova (1969, 1992).

Researchers of the Melitopol phycological school studied the algae of the North-Western Azov Sea in the late 20th – early 21st centuries. They mainly focused on salt marshes, ephemeral reservoirs, as well as peloidogenesis and the participation of algae in this process (Solonenko, 1999, 2013, 2014, 2015; Maltseva, 2000, 2002, 2004; Solonenko et al., 2004, 2005, 2006a, b, 2008, 2009a, b, 2010, 2011, 2014, 2020; Yarovoy, 2007, 2009; Yarovy et al., 2007, 2013, 2014, 2016, 2017; Yarova et al., 2008, 2012; Bren et al., 2009, 2019; Arabadzhi, 2016a, b; Arabadzhi et al., 2016, 2017, 2019; Maltseva et al., 2019).

Thus, 65 and 37 species of cyanoprokaryotes were found in the upper reaches of the Utlyuk Estuary and in the Sivashik Estuary, respectively (Arabadzhi, 2016a, b; Arabadzhi et al., 2019). There were 72 algal species (Solonenko et al., 2006a; Arabadzhi-Tipenko et

al., 2019) are listed for salt marshes and ephemeral reservoirs of the Fedotova spit (Solonenko et al., 2006a, 2009b; Solonenko, 2015), Berdyansk spit – 79 (Yarova et al., 2008; Solonenko, 2015; Arabadzhi, 2016a), Tubal'skyi Estuary – 127 species of algae (Maltseva, 2000, 2002, 2004; Solonenko et al., 2008; Solonenko, 2015; Arabadzhi, 2016a; Arabadzhi et al., 2016, 2017).

The results of algae studies of the Berdyansk Bay are described in the paper by Gromov, which presents a list of 14 species (Gromov, 2012).

Thus, algological studies of the estuaries of the northwestern Azov region were conducted mainly in the middle of the 20th century. These studies have covered ephemeral reservoirs and salt marshes of the coastal spit. The bays of the Azov Sea remain the least studied. The certain changes in the hydrological regime of saline coastal reservoirs of the PNNP (two dams were built on the Utlyuk Estuary, small rivers in the region grow shallow, salinity differences and drying of the Molochnyi Estuary, etc.) have prompted a need to obtain data on species composition and systematic structure of algae.

MATERIALS AND METHODS

Field researches and sampling was carried out during 2010–2019 on the ten polygons within the PNNP territory (Fig. 1). The polygons were located in the Zaporizhzhja Region, within the Dnieper-Azov geobotanical district (Didukh, Shelyag-Sosonko, 2003). According to algofloristic zoning, the territory belongs to the European algofloristic region, the Eastern European algofloristic province, the Black Sea-Azov district (Palamar-Mordvintseva, Tsarenko, 2015).

FIG. 1: Map of research polygons (the boundaries of the polygons are marked by yellow color, the number of each polygon is marked in the red labels)

The material was sampled according to the generally accepted methods in hydrobiology and soil phycology (Hollerbakh, Shtina, 1969; Abakumov, 1983; Topachevskyi, Masyuk, 1984). In total, we collected and processed 148 samples: in ephemeral reservoirs – 66, in lagoon-like and lake-like estuaries – 46 and 26, respectively, in bays – 10.

Cultural processing and identification of algae was carried out in the laboratory of algoecological research of terrestrial and aquatic ecosystems at the Department of Botany and Landscape Gardening of Bogdan Khmelnytsky Melitopol State Pedagogical University. Algae were studied by direct microscopy and cultural methods (soil, soil-water and agar cultures). Bold's medium with single and triple nitrogen content (1N BBM and 3N BBM) was used during cultivation, with and without addition of aqueous extract from the studied soil (Hollerbakh, Shtina, 1969; Abakumov, 1983; Topachevskyi, Masyuk, 1984).

Algae were identified mostly in a live state. *Bacillariophyta* representatives were additionally identified in the permanent mounts (Topachevskyi, Masyuk, 1984). Algae were identified by floristic compilations (Zabelina et al., 1954; Dedusenko-Shchegoleva, Hollerbakh, 1962; Huber-Pestalozzi, 1962; Ettl, 1978, 1988; Matvienko, Dogadina, 1978; Vinogradova et al., 1980; Kondratieva, 1984; Krammer, Lange-Bertalot, 1986, 1988, 1991, 2004; Moshkova, Hollerbach, 1986; Tsarenko, 1990; Andreieva, 1998; Komárek, Anagnostidis, 1998, 2005; Komárek, 2013).

Names of phyla, classes, orders, families, genera, and species are given in accordance with the system adopted in the monograph (Kostikov et al., 2001) with an update on the summary *Algae of Ukraine* (2006, 2009, 2011, 2014) and considering the current nomenclature changes of individual species and intraspecific taxa (www.algaebase.org).

The degree of similarity of floristic lists was determined using the Sörensen-Chekanovsky coefficient (Shmidt, 1984). Cluster analysis and construction of dendrites of floristic similarity was carried out in Statistica 10 (amalgamation rule – single linkage, proximity measure – Euclidean distance).

RESULTS AND DISCUSSION

In total, of 153 algae species were found during the researches of salty coastal reservoirs of the PNNP (Arabadzhi et al., 2016, 2019; Solonenko, Bren, 2020; Yarova et al., 2012, 2014). These species represented seven phyla: *Cyanoprokaryota* – 67 species (43.8% of the total species number), *Bacillariophyta* – 49 (32.0%), *Chlorophyta* – 30 (19.5%), *Rhodophyta* – 3 (1.9%), *Charophyta* – 2 (1.4%), and *Xanthophyta* and *Cryptophyta* – 1 each (0.7%). These species belong to 11 classes, 32 orders, 61 families, and 92 genera (Table 1).

The uniqueness of the algae flora on the order level lies in the absence of purely freshwater and some typical marine groups of organisms. Thus, we did not find

representatives of *Euglenophyta* (widespread in fresh standing and flowing waters), and zero species of *Haptophyta* and *Phaeophyta* (integral part of marine ecosystems). There were no common organisms of marine habitats – species of *Dinophyta*, *Raphidophyta*, *Dictyochophyta*, *Eustigmatophyta*. *Cryptophyta* (typical in salt and fresh oligotrophic reservoirs) and *Xanthophyta* (soil, sea and freshwater algae) in the study reservoirs were represented by only one species each: *Cryptomonas* cf. *ovate* Ehrenb. and *Heterococcus akinetus* Lokhorst, respectively.

TABLE 1: Systematic structure of algae in the saline coastal reservoirs of PNNP

Phylum	Quantity of the taxons				
	Classes	Orders	Families	Genera	Species*
Cyanobacteria	1	5	19	34	67 (43.8)
Bacillariophyta	3	12	20	29	49 (32.0)
Chlorophyta	3	10	16	22	30 (19.5)
Rhodophyta	1	1	2	3	3 (1.9)
Charophyta	1	2	2	2	2 (1.4)
Cryptophyta	1	1	1	1	1 (0.7)
Xanthophyta	1	1	1	1	1 (0.7)
Total	11	32	61	92	153 (100)

* The percentage in parentheses is for species in relation to the total number of found species.

Thus, the algal flora of the studied reservoirs is quite depleted, with the highest diversity of cyanoprokaryotes, diatoms and green algae.

Special features of the floristic spectrum are also noted on the orders level (Table 2). The list of leading ones includes nine orders represented by 134 species (87.5% of the total number of detected algae species). The first and second places in the list were taken by *Oscillatoriales* and *Synechococcales* (23 and 20 species, respectively) – the typical organisms of relatively stable and ephemeral reservoirs, flooded soils (including saline). The third and fourth places were taken by the orders *Nostocales* (13) and *Naviculales* (12 species).

The order *Naviculales* is an important component of algae flora of water bodies of various types from fresh to hyperhaline. Representatives of *Nostocales* are the most common part of algae groups of terrestrial and coastal water complexes (Topachevskyi, Masyuk, 1984; Kostikov et al., 2001; Vinogradova, 2006, 2012; Komárek, 2013; Solonenko, 2015). Thus, the first four leading orders concentrate 44.4% of the current

species diversity of algae in the studied saline coastal reservoirs. The rest of the list included the orders *Bacillariophyta* and *Chlorophyta*.

TABLE 2: Leading orders of algae inthe saline coastal reservoirs of PNNP

Position (place)	Order	Number of species
1	*Oscillatoriales*	23
2	*Synechococcales*	20
3	*Nostocales*	13
4	*Naviculales*	12
5	*Chroococcales, Sphaeropleales, Scenedesmales*	8 each
7	*Bacillariales, Fragilariales*	7 each
8	*Cladophorales, Chlorellales, Achnanthales*	6 each
9	*Surirellales, Cocconeidales*	5 each
Totally in the leading orders		134

The specificity at this taxonomic level lies in the presence in the leading orders *Chlorellales*, *Mischococcales*, *Chlamydomonadales*, which are leading in the partial algae flora of soils (the latter one also in continental reservoirs) of different physical and geographical zones of Ukraine (Kostikov et al., 2001; Algae of Ukraine…, 2006, 2009, 2011, 2014). Thus, *Cyanopokaryota* and *Bacillariophyta* occupy an important place among the leading orders. Leading orders from *Chlorophyta* united the largest number of species – 48 (35.8%). *Cyanoprokaryotes* occupy the first place in the list of leading orders – 44 species (32.8%). A smaller number represents diatoms in this list – 42 species (31.3%). In general, at the level of orders there is a predominance of typical taxa for saline aquatic habitats, with a share of soil and marine ones.

Such features of the studied algal flora are even more visible at the family level. The leading ones included 18 families, which include 97 species of algae. Their basis is formed by representatives of *Oscillatoriaceae* – 13 species, *Nostocaceae*, *Leptolyngbyaceae* and *Naviculaceae* – 8 each, *Microcoleaceae*, *Bacillariaceae* – 7 each (Table 3).

These families are leading in the soil of the steppe zone of Ukraine. They were registered in substrates with different salinity (Solonenko, 1999, 2015; Maltseva, 2000, 2002, 2004; Solonenko et al., 2004, 2005, 2006a, b, 2008, 2009a, b, 2010, 2011, 2020; Kostikov et al., 2001; Yarovoy, 2007, 2009; Yarovy et al., 2007, 2013, 2014, 2016, 2017; Bren et al., 2009, 2019; Yarova et al., 2008, 2012; Arabadzhi, 2016a, b; Arabadzhi et al., 2016, 2017, 2019; Maltseva et al., 2019).

TABLE 3: Leading families of algae in the saline coastal reservoirs of PNNP

Position (place)	Family	Number of species	Share in the total number of species, %
1	*Oscillatoriaceae*	13	8.5
2	*Nostocaceae, Leptolyngbyaceae, Naviculaceae*	8 each	5.2 each
3	*Microcoleaceae, Bacillariaceae*	7 each	4.6 each
4	*Cladophoraceae*	6	3.9
5	*Fragilariaceae*	5	3.3
6	*Scenedesmaceae, Cocconeidaceae, Surirellaceae, Ulvaceae, Rivulariaceae*	4 each	2.6
7	*Spirulinaceae, Merismopediaceae, Pseudanabaenaceae, Chlorellaceae, Stichococcaceae*	3 each	2.0
Totally species in the leading families		97	63.4
Totally species		153	–

There were 28 leading genera found in our research. The basis of these genera are cyanoprokaryotes and diatoms. A smaller number of species represented the genera of *Chlorophyta* (Table 4).

TABLE 4: Leading genera of algae in the saline coastal reservoirs of PNNP

Position place	Genera	Number of species
1	*Leptolyngbya*	6
2	*Lyngbya, Nostoc*, *Phormidium*, *Nitzschia*	5 each
3	*Calothrix*, *Kamptonema*, *Cocconeis*, *Navicula*	4 each
4	*Pseudanabaena*, *Spirulina*, *Fragilaria*, *Gyrosigma*, *Surirella*, *Cladophora. Stichococcus*	3 each
5	*Chroococcus*, *Trichormus*, *Oscillatoria*, *Merismopedia*, *Jaaginema*, *Schizothrix*, *Halamphora*, *Luticola*, *Amphora*, *Desmodesmus*, *Ulva*, *Chaetomorpha*	2 each

Analysis of the leading genera indicates that algal representatives of different habitats form the flora in the studied reservoirs. Representatives of the genera *Nitzschia*, *Cocconeis*, *Navicula*, and *Spirulina* are represented mainly by aquatic species. Other genera in the list of leading ones include amphibious species (for example, *Leptolyngbya*, *Phormidium*, *Lyngbya*). The genera *Cladophora*, *Ulva*, *Chaetomorpha* represents the organisms that are typical for marine ecosystems, however, a small number of species represents such genera. The genus *Nostoc* shares the second place with the genera *Phormidium* and *Nitzschia* (five species each), and includes terrestrial and amphibian species.

The distribution of representatives of different phyla of algae shows the highest species diversity in the beds of dried up reservoirs (114 species). Majority of species is formed here by cyanoprokaryotes, diatoms and green algae (57, 35 and 20 species, respectively). *Rhodophyta* and *Xanthophyta* are represented here by single species (*Vertebrata subulifera* and *Heterococcus akinetus*), and the representatives of *Cryptophyta* are absent (Table 5).

The second and third places by species richness are occupied by ephemeral reservoirs and lake-like estuaries (60 and 51 species, respectively). *Cyanopokaryota*, *Bacillariophyta* and *Chlorophyta* (28, 22, 8 species, respectively) predominate in ephemeral reservoirs, as well as in beds of dried up reservoirs. In the same reservoirs, representatives of *Rhodophyta* and *Cryptophyta* are represented by *Polysiphonia opaca* and *Cryptomonas* cf. *ovata* respectively (Table 5).

TABLE 5: Distribution of phyla of algae in different saline coastal reservoirs of PNNP*

Phyla	Bay	Lagoon-like estuary	Lagoon-like estuary	Ephemeral reservoir	Bed of the dried up reservoir
Cyanoprokaryota	6 (15.8)	10 (33.3)	18 (35.3)	28 (46.7)	57 (50)
Bacillariophyta	22 (57.9)	7 (23.3)	21 (41.2)	22 (36.6)	35 (30.7)
Chlorophyta	8 (21.0)	11 (36.7)	12 (23.5)	8 (13.3)	20 (17.5)
Rhodophyta	2 (5.3)	2 (6.7)	0 (0)	1 (1.7)	1 (0.9)
Cryptophyta	0 (0)	0 (0)	0 (0)	1 (1.7)	0 (0)
Xanthophyta	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.9)
Total	38 (100)	30 (100)	51 (100)	60 (100)	114 (100)

* In parentheses – share (%) of the total number of species.

A similar situation is observed with the dominant phyla in lake-like estuaries. The only difference is set in the dominance of *Bacillariophyta* but not is not *Cyanoprokaryota* representatives. *Chlorophyta* remained the last of the three dominant phyla (21, 18 and 12 species). Species of other phyla were not found in lake-like estuaries (Table 5).

The smallest number of species were found in bays and lagoon-like estuaries – 38 and 30, respectively. However, the general features of the leading phyla proportion here are changing. The bays have a relatively small share of cyanoprokaryotic species (6 species – 15.8% of the total number of species) and a significant increase in *Bacillariophyta* (22 – 57.9%). Green algae occupy second place (8–21.0%). Among other phyla, only *Rhodophyta* (*Ceramium diaphanum* and *Vertebrata subulifera*) were noted. Algae plankton is represented by 23 species, benthos – 15, and on the on the water's edge 16 species were registered.

The situation remains the same in lagoon-like estuaries –the dominant are green algae, cyanoprokaryotes and diatoms (11, 10 and 7 species, respectively) (Table 5).

The highest values of the Sörensen-Chekanovsky floristic similarity coefficient were observed in a pairwise comparison of species found in bays and lagoon-like estuaries (K = 0.41), as well as in ephemeral reservoirs and beds of dried-up reservoirs. Slightly lower values of the coefficient were observed between the species composition of algae in lake-like estuaries and beds of dried-up reservoirs (K = 0.39), as well as ephemeral reservoirs in pairs with lagoon-like and lake-like estuaries (K = 0.38). Pairwise comparisons of the species composition of other saline coastal reservoirs have lower values of the coefficient (0.22–0.35) (Table 6).

TABLE 6: Matrix of floristic similarity of algae species diversity of different saline coastal reservoirs of PNNP

Reservoir	**Bay**	**Lagoon-like estuary**	**Lagoon-like estuary**	**Ephemeral reservoir**	**Bed of the dried-up reservoir**
Bay	1	0.41	0.29	0.35	0.32
Lagoon-like estuary		1	0.22	0.38	0.28
Lake-like estuary			1	0.38	0.39
Ephemeral reservoir				1	0.41
Bed of the dried-up reservoir					1

The dendrogram of the floristic similarity of algae species diversity in the different saline coastal reservoirs of PNNP shows the separation in two clusters (Fig. 2). The first one included bays and estuaries, the second one – lake-like estuaries, ephemeral reservoirs and beds of dried-up reservoirs. The last two are grouped at a distance of 0.012, and their

linkage distance to the lake-like estuaries in this cluster is 0.024. This amalgamation can be explained by similar living conditions in bays and lagoon-like estuaries, where there is a relatively constant hydrological regime and low salinity due to the connection with the sea. Ephemeral reservoirs and beds of dried-up reservoirs also acquire similar conditions as a result of their isolation, resulting in high salinity and unstable hydrological regime. Lake-like estuaries entered the second cluster for the same reasons. However, this type of reservoir is more sustainable compared toephemeral reservoirs. This is reflected in the species composition of algae.

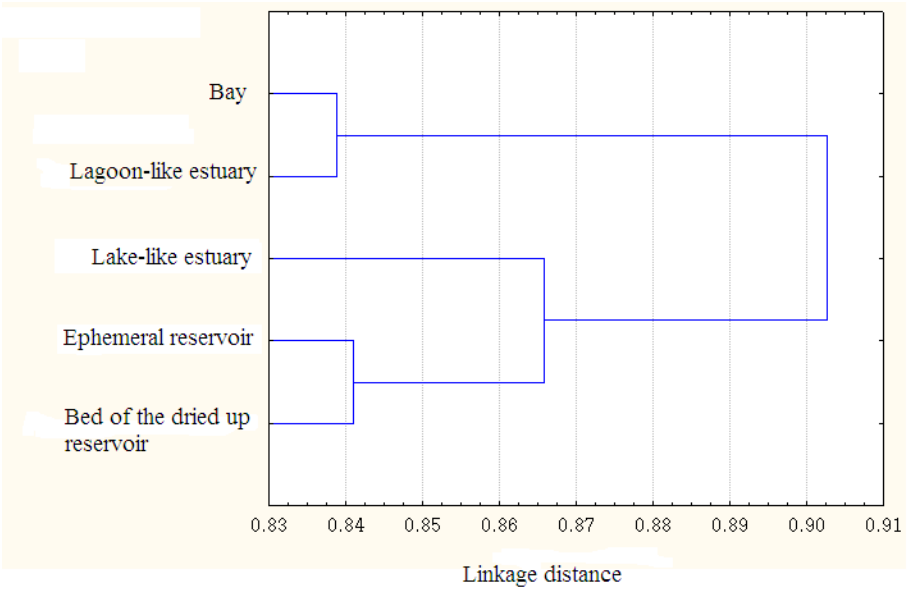

FIG. 2: Dendrogram of floristic similarity of algae species diversity indifferent types of coastal reservoirs on the PNNP territory

Thus, the largest number of species is represented by three phyla of algae: *Cyanoprokaryota*, *Bacillariophyta* and *Chlorophyta*, according to the distribution of occurrence in the studied reservoirs. In the inverse chain of transformations from the bed of the dried up reservoir (extreme drying and salinization of water bodies) to bays (reservoirs with relatively constant hydrological and salt regime) there is a decrease in species richness at the level of all phyla. The proportions between leading phyla vary from absolute predominance of the cyanoprokaryotes (50% of the number of detected algae species in the beds of dried ponds) to their replacement by the diatoms (from 30.7 to 57.9%) with an increase in the proportion of green algae (from 17.5 to 36.7%).

The top five species with the highest frequency of occurrencein the studied reservoirs were: *Halamphora coffeiformis* (share of occurrence – 5.26%), *Lyngbya aestuarii* (4.21%), *Cladophora siwaschensis* (3.51%), *Hantzschia amphioxys* (3.33%)), *Nodularia harveyana* (2.98%).

Thus, algae species compositionof the saline coastal reservoirs of the PNNP lies in the impoverishment of the species number and superspecies taxa in comparison with terrestrial, freshwater and marine habitats of Ukraine. The taxonomic spectrum demonstrates a specific combination of freshwater, marine and terrestrial organisms, with a predominance of cyanoprokaryotes, diatoms and a significant proportion of green algae at all taxonomic levels.

CONCLUSIONS

1. The species composition of algae in saline coastal reservoirs of PNNP under modern conditions is represented by 153 species belonging to 6 orders, 11 classes, 32 orders, 61 families, 92 genera.
2. Cyanoprokaryota (67 species – 43.8% of the total number of detected species), *Bacillariophyta* (49 – 32.0%), *Chlorophyta* (32 – 20.9%) are predominant by their species richness. A similar predominance of these phyla representatives is observed at all taxonomic levels.
3. The highest frequency of occurrence among the identified species had: *Halamphora coffeiformis* (5.26%), *Lyngbya aestuarii* (4.21%), *Cladophora siwaschensis* (3.51%), *Hantzschia amphioxys* (3.33%), *Nodularia harveyana* (2.98%).
4. The leading orders of algae by the species richness in the researched reservoirs were *Oscillatoriales* and *Synechococcales* (23 and 20 species, respectively). The top three families by this parameter – *Oscillatoriaceae* (13 species), *Nostocaceae*, *Leptolyngbyaceae*, *Naviculaceae* (8 each), *Microcoleaceae*, *Bacillariaceae* (7 each). The most diversely represented genera are *Leptolyngbya* (6 species), *Lyngbya*, *Nostoc*, *Phormidium*, *Nitzschia* (5 each), and *Calothrix*, *Kamptonema*, *Cocconeis*, *Navicula* (4 each).
5. The identified species composition of algae of saline coastal reservoirs PNNP is quite impoverished in comparison with the partial soil algae flora, as well as the algae population of freshwater and seas that wash the territory of Ukraine. Specific features of the taxonomic composition of the saline coastal reservoirs are manifested in the association of organisms of fresh, marine and terrestrial habitats.
6. The highest species diversity of algae was found in the beds of dried up reservoirs (114 species). Ephemeral reservoirs and lake-like estuaries (60 and 51 species, respectively) occupy the second and third places by the species richness. The basis of species composition in these water bodies consists of cyanoprokaryotes, diatoms and green algae.

There were 38 and 30 algae species found in bays and lagoon-like estuaries. The first place here by the quantity of species is occupied by representatives of *Chlorophyta*.

7. The values of the Sörensen-Chekanovsky coefficients and the dendrogram of the floristic similarity of species diversity of algae in saline coastal water bodies on the PNNP territory demonstrate the separation in two clusters. The first one included bays and estuaries lagoon-like ($K = 0.41$), the second one – lake-like estuaries, ephemeral reservoirs and beds of dried-up reservoirs. The main reasons for this grouping may be the peculiarities of the hydrological regime and salinity of water bodies.

REFERENCES

Abakumov V.A. 1983. *Guidelines for methods of hydrobiological analysis of surface waters and bottom sediments*. Leningrad: Gidrometeoizdat. 240 p. [Rus.]

Andreieva V.M. 1998. *Soil and aerophilic green algae* (*Chlorophyta: Tetrasporales, Chlorococcales, Chlorosarcinales*). SPb.: Nauka. 351 p. [Rus.]

Arabadzhi L.I. 2016a. Diversity of cyanoprokaryotes in several water bodies of the Pryazov National Natural Park. *Biol. Res.*: 82–84.

Arabadzhi L.I. 2016b. In: *Fundamental and applied research in biology and ecology*: Mat. IV Int. Sci. Conf. Pp. 22–24. [Ukr.]

Arabadzhi-Tipenko L.I., Solonenko A.N., Bren O.G. 2019a. Cyanoprokaryota of the salt marshes of the Pryazov National Natural Park, Ukraine. *Algologia*. 29(4): 447–477.

Arabadzhi-Tipenko L.I., Solonenko A.M., Bren O.G. 2019b. Cyanoprokaryota of the salt marshes at the Pryazov National Natural Park, Ukraine. *Int. J. Algae.* 21(4): 299–310.

Arabadzhi L.I., Solonenko A.M., Bren O.G., Holubev M.I. 2016. Cyanoprocaryota of Tubalskyi Estuary (Azov Sea basin). *Biol. Bull. Bogdan Chmelnitskiy Melitopol State Ped. Univ.* 3(6): 414–418.

Arabadzhi L.I., Solonenko A.M., Yarovy S.O., Bren O.G., Maltsev E.I. 2017. *Diversity of Cyanoprocaryota of the sand coastal soils of the Priazov National Natural Park*: Mat. 14th *Congress Ukr. Bot. Assoc*. Kyiv. 82 p. [Ukr.]

Barabokha N.M., Barabokha O.P., Bren O.G., Vovk O.A., Golod G.V., Demchenko V.O., Dyadicheva O.A., Suchkov S.I., Yarova T.A., Yarovy S.O., Antonovsky O.G., Mykytynets G.I. 2012. *Chronicle of Nature of the Pryazov National Natural Park.* Vol. I. Melitopol: Azov Nat. Nat. Park. 761 p. [Ukr.]

Bren O.G., Solonenko A.M. 2019. In: *Advances in Modern Phycology*: Abstr. VI Int. Conf. Kyiv. Pp. 20–21.

Bren O.G., Yarovy S.O., Sholukh O.O. 2009. In: *Fundamental and applied research in biology*: Mat. Int. Conf. Donetsk: Weber. Pp. 20–21. [Ukr.]

Dedusenko-Shchegoleva N.T., Hollerbakh M.M. 1962. *Keys to freshwater algae of the USSR*. Issue 5. Moscow, Leningrad: USSR Acad. Sci. 138 p. [Rus.]

Didukh Y.P., Shelyag-Sosonko Y.R. 2003. Geobotanical zoning of Ukraine and adjacent territories. *Ukr. Bot. J.* 60(1): 6–17.

Ettl H., Gärtner G. 1988. In: *Süßwasserflora von Mitteleuropa.* Bd 10. Jena: G. Fischer Verlag. 437 p.

Ettl H. 1978. In: *Süßwasserflora von Mitteleuropa.* Bd 3. Stuttgart, New York: G. Fischer Verlag. 530 p.

Garkusha O.P. 2016. *Formation of groups of microalgae on different substrates of the coastal zone of the Black and Azov Seas.* PhD Diss. Abstract. Odesa. 21 p. [Ukr.]

Generalova V.N. 1951. Aquatic vegetation of the Utlyuk estuary and the Arabat arrow in the Azov Sea. *Proc. AzCherNIIRO*: 331–340.

Gromov V.V. 2012. Aquatic and coastal-aquatic vegetation of the northern and western coasts of the Azov Sea. *J. Sib. Federal Univ.* 5(2): 121–137.

Hollerbakh M.M., Shtina E.A. 1969. *Soil algae*. Leningrad: Science. 228 p. [Rus.]

Huber-Pestalozzi G. 1962. *Das phytoplankton des Susswassers: Systematik und biologie. Die Binnengewasser*. Bd 16/3. Stuttgart: E. Schweizerbart'sche. 606 p.

Ivanov O.I. 1960. In: *Biological substantiation of development of mullet economy of eastern Sivash and the Molochnyi estuary*. Kyiv. Pp. 123–130. [Ukr.]

Komárek J. 2013. In: *Süswasserflora von Mitteleuropa/Freshwater Flora of Central Europe.* Berlin, Heidelberg: Springer Spektr. 1130 p.

Komárek J., Anagnostidis K. 1998. In: *Süßwasserflora von Mitteleuropa.* Bd 19/1. Jena, etc.: G. Fischer Verlag. 548 p.

Komárek J., Anagnostidis K. 2005. In: *Susswasserflora von Mitteleuropa.* Bd 19/2. Munchen: Elsevier Spectr. 759 p.

Kondratyeva N.V. 1984. *Identification guide for the freshwater algae of the Ukrainian SSR.* Kyiv: Naukova Dumka. 388 p. [Ukr.]

Kostikov I.Yu., Romanenko P.O., Demchenko E.M., Darienko T.M., Mykhailyuk T.I., Rybchynsky O.V., Solonenko A.M. 2001. *Aalgae of soils of Ukraine: history and research methods, system, summary of flora*. Kyiv: Fitocociocenter. 300 p. [Ukr.]

Krammer K., Lange-Bertalot H. 1986. In: *Süßwasserflora von Mitteleuropa.* Bd 2/1. Jena: Gustav Fischer Verlag. 876 p.

Krammer K., Lange-Bertalot H. 1988. In: *Süßwasserflora von Mitteleuropa.* Bd 2/2. Jena: Gustav Fischer. 596 p.

Krammer K., Lange-Bertalot H. 1991. In: *Süßwasserflora von Mitteleuropa* Bd 2/3. Stuttgart: Gustav Fischer Verlag. 576 p.

Maltseva I.A. 2000. Soil algae of some saline soils of the North-Western Pryazov region. *Ecol. Noospher.* 9(1–2): 15–19.

Maltseva I.A. 2002. Diversity of soil algae and higher salt marsh plants of the Northern Pryazov and Prysyvash. *Sci. Bull. Chernivtsi Univ.*(145): 15–18.

Maltseva I.A. 2004. *Algae of the Pryazov soils* (Zaporozhye region, Ukraine). *Algologia.* 14(3): 246–255.

Maltseva I.A., Maltsev Y.I., Bren O.G., Yarova T.A., Pavlenko O.M., Yakoviichuk O.V. 2019. In: *Advances in Modern Phycology:* Abstr. VI Int. Conf. Kyiv. Pp. 65–67.

Matvienko O.M., Dogadina T.V. 1978. *Identification guide of freshwater algae of the Ukrainian SSR. Yellow-green algae*. Vol. 1. Kyiv: Nauk. Dumka. 511 p. [Ukr.]

Merezhkovsky K.S. 1902. Note about Henichesk diatoms (Azov Sea). *Not. Novoros. Soc. Nat. Hist*. 24(2): 33–72.

Moshkova N.A., Hollerbach M.M. 1986. *Identification guide of freshwater algae of the USSR.* Issue 10. Leningrad: Nauka. 182 p. [Rus.]

Palamar-Mordvintseva G.M., Tsarenko P.M. 2015. Algofloristic zoning of Ukraine. *Algologia*. 25(4): 355–395.

Prikhodkova L.P. 1969. Blue-green algae of some soils of the Left Bank of the Lower Dnieper. *Ukr Bot. J.* 26(1): 36–41.

Prikhodkova L.P. 1992. *Blue-green algae of the soils of the steppe zone of Ukraine*. Kyiv: Naukova Dumka. 218 p. [Rus.]

Proshkina-Lavrenko A.I. 1950. Algae of the Molochnyi estuary. *Bot. Mat. Dep. Spore Plants BIN AS USSR*. 6(7–12): 134–147.

Proshkina-Lavrenko A.I. 1951. Botanical materials of the department of spore plants. *BIN AS USSR*. 7: 69–75.

Proshkina-Lavrenko A.I. 1963. *Diatoms of plankton of the Azov Sea*. Moscow, Leningrad: AS USSR. [Rus.]

Shmidt W.M. 1984. *Mathematical methods in botany*. Leningrad: LSU Publ. House. 288 p.

Solonenko A.N. 1999. *Algae of cultivated soils of the Black Sea-Azov dry-steppe province of the Steppe zone of Ukraine*: Abstr. II Int. Conf. Kiev. 134 p.

Solonenko A.N. 2013. Fatty acid composition of benthic macroscopic growths of algae and peloids of ephemeral reservoirs. *Algologia.* 23(1): 47–52.

Solonenko A.N. 2014. Some peculiarities of the destruction of *Cladophora siwaschensis* C.Meyer (*Chlorophyta*) organic matter in brine. *Int. J. Algae.* 16(3): 256–262. https://doi.org/10.1615/InterJAlgae.v16.i3.50

Solonenko A.M. 2015. *Algae of hyperhaline reservoirs of the north-western coast of the Sea of Azov and their participation in the formation of silt sulfide peloids*. Dr. Dis. Thesis. Kyiv. 347 p. [Ukr.]

Solonenko A.M., Yaroviy S.O. 2009a. Algae of coastal salt marshes of the Chongar Peninsula (Sivash). *Black Sea Bot. J.* 5(2): 224–230.

Solonenko A.M., Yaroviy S.O. 2009b. Annotated list of algae of Stepanivska spit. *Black Sea Bot. J.* 5(4): 617–628.

Solonenko A.M., Yaroviy S.O. 2011. Algae of salt marshes of Shelyuhy Pod (Zaporizhzhya region). *Ukr. Bot. J.* 68(3): 399–406.

Solonenko A.M., Bren O.G. 2020. Floristic Composition and Taxonomic Structure of Algae in the Hyperhaline Reservoirs of the Northwestern Azov Sea Coast (Ukraine). *Int. J. Algae.* 22(4): 373–382. https://doi.org/10.1615/InterJAlgae.v22.i4.60

Solonenko A.N., Yarovy S.O., Raznopolov O.N. 2004. Soil algae of the salt marshes of the Molochnyi estuary coast in the area of Altagir forestry. *Bull. Zap. State Univ.* (1): 206–212.

Solonenko A.N., Raznopolov O.N., Podorozhny S.N. 2006. Saltwater algae of the floodplain on the right bank of the Molochnyi Estuary. *Bull. Zap. Nat. Univ.* 1(1): 142–148.

Solonenko A.N., Yarovy S.O., Yarova T.A. 2008. Saltwater algae at the mouth of the Korsak River and the Tubal Estuary tract. *Bull. State Nikita Bot. Garden.* (96): 26–29.

Solonenko A.M., Yarovy S.O., Yarova T.A. 2010. Saline algae on the shores of Lake Solone (Zaporozhye region). *Bull. Lviv. Univ.* (52): 13–19.

Solonenko A.N., Yarovy S.O., Raznopolov O.N., Podorozhny S.N. 2005. Saltwater algae of the Sivash Bay coast. *Bull. Zaporizh. Nat. Univ* .(1): 163–167.

Solonenko A.N., Yarovy S.O., Podorozhny S.N., Raznopolov O.N. 2006. Saltwater algae of Stepanovskaya and Fedotova spit of the North-West coast of the Sea of Azov. *Soil Sci.* 7(3–4): 123–127.

Solonenko A.N., Khromyshev V.A., Maltsev E.I., Bren O.G. 2014. Amino acid content of benthic macroscopic growths of algae and sediments in hypersaline water bodies. *Int. J. Algae.* 16(4): 392–401. https://doi.org/10.1615/InterJAlgae.v16.i4.80

Topachevskyi A.V., Masyuk N.P. 1984. *Freshwater algae of the Ukrainian SSR*. Kyiv: Vysshaya Shkola. 336 p. [Rus.]

Tsarenko P.M. 1990. *Short determinant of chlorococcal algae of the Ukrainian SSR*. Kyiv: Naukova Dumka. 208 p. [Ukr.]

Tsarenko P.M., Wasser S.P., Nevo E. 2006. *Algae of Ukraine: diversity, nomenclature, taxonomy, ecology and geography.* Ruggell: A.R.G. Gantner Verlag K.-G. Vol. 1. 713 p.; 2009. Vol. 2. 413 p.; 2011. Vol. 3. 512 p.; 2014. Vol. 4. 703 p.

Vinogradova O.M. 2006. Cyanoprocaryota in hyperhaline habitats and their adaptation strategies. *Ukr. Phytocenol. J.* (24): 33–44.

Vinogradova O.M. 2012. *Cyanoprokaryota of hyperhaline ecosystems of Ukraine*. Kyiv: Alterpress. 200 p. [Ukr.]

Vinogradova K.L., Hollerbach M.M., Sauer L.M., Sdobnikova N.V. 1980. *Identification guide of freshwater algae of the USSR.* Issue 13. Leningrad: Nauka. 126 p. [Rus.]

Vladimirova K.S. 1960. In: *Biological substantiation of development of mullet economy of eastern Sivash and Molochnyi estuary*. Kyiv. Pp. 131–137. [Ukr.]

Volkov L.I. 1927. *Materials for learning of the Azov Sea flora. Collection in honor of N.M. Knipovich*. Moscow: Nauka. Pp. 235–240. [Rus.]

Yarova S.A., Yarova T.A., Solonenko A.N. 2008. To the study of saline algae of the Berdyansk spit in the area of Lake Krasnoye. *Ecol. Noospher.* 19(1–2): 160–162.

Yarova T.A., Yarovy S.O., Bren O.G. 2012. In: *The role of environmental protection institutions in the preservation of biodiversity, ethnocultural heritage and balanced development of territories*. Kosiv. Pp. 309–312. [Ukr.]

Yarovy S.O. 2013. Algae of coastal salt marshes of Prysyvasko-Pryazovska physical-geographical region of Ukraine. *Black Sea Bot. J.* 9(2): 238–256.

Yarovy S.O., Solonenko A.N. 2009. In: *Algae: problems of taxonomy, ecology and use in monitoring:* Proc. II All-Russian Algol. Conf. Syktyvkar. Pp. 249–252. [Rus.]

Yarovy S.O., Arabadzhi L.I. 2016. For the study of Cyanoprokaryota of some reservoirs of the Pryazov National Nature Park. *Ecol. Noospher*. 27(3–4): 110–116.

Yarovy S.O., Solonenko A.M., Kostikov I.Y. 2007a. *Oscillatoria salina* Biswas – a new specie for the flora of Ukraine. *Black Sea Bot. J*. 3(2): 119–123.

Yarovy S.O., Solonenko A.N., Oleynik T.A. 2007b. *Soil algae of coastal salt marshes of the Berdyansk spit near Lake Krasnoye*: Mat. Int. conf. Cherkasy-Kaniv. Pp. 309–312. [Ukr.]

Yarovy S.O., Yarova T.A., Bren O.G., Zavadska O.A. 2014. Research of algae of wetlands of the Pryazov National Natural Park. *All-Ukrainian Sci.-pract. Conf.* Khotyn. Pp. 52–53. [Ukr.]

Yarovy S.O., Arabadzhi L.I., Bren O.G., Maltsev E.I., Matsyura O.V. 2017. Diversity of Cyanoprokaryota in sandy habitats in Pryazov National Natural Park (Ukraine). *Ukr. J. Ecol.* 2(7): 91–95.

Zabelina M.M., Kiselyov I.A., Proshkina-Lavrenko A.I., Sheshukova V.S. 1954. *Determinant of freshwater algae of the USSR*. Issue 4. Moscow: Sov. Nauka. 311 p. [Rus.]