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Diversity of Cyanoprokaryota in sandy habitats in Pryazov National Natural Park (Ukraine)

S.O. Yarovyi[1,2], L.I. Arabadzhi[1], A.M. Solonenko[1], O.G. Bren[1,2], E.I. Maltsev[1], A.V. Matsyura[3]

[1]Bogdan Chmelnitskiy Melitopol State Pedagogical University, Melitopol, Ukraine
[2]Pryazov National Natural Park, Ukraine
[3]Altai State University, Barnaul, Russia
E-mail: dilabif@ukr.net, luidmila108@ukr.net, anatol8@ukr.net, ocillat@mail.ru, mz_5@ukr.net, amatsyura@gmail.com
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Data on abundance and distribution on Cyanoprokaryota of alluvial soil of the Pryazov National Natural Park (PNNP) are presented. The PNNP is situated in the south part of Zaporizhzhya region near the Azov Sea. Sandy soils of the PNNP are suitable habitats for biodiversity conservation. Nevertheless. Cyanoprokaryota algae have been studying insufficiently and unevenly. 16 soil samples were sampled from the sandy habitats in the PNPP to study the Cyanoprokaryota. The sampling was carried out on the sample areas during 2014-2015 in various locations on Stepanivka Spit (Azov Sea), Fedotova Spit (Utlyutskyi Estuary), Tubalskyy estuary at the mouth Korsak, Taschenakskyi hearth (mouth of the river Tashchenak), Berdyansk Spit near the Krasne lake, Samples were sampled by a conventional algological method, treatment and identification of sampled material was performed in the Laboratory of Botany and Gardening of the Bogdan Chmelnitskiy Melitopol State Pedagogical University.
Laboratory processing of the material was carried with culturing methods in two types of cultures: soil cultures with glasses of growth and Bold's nutrient agar with normal and triple quantity of nitrogen (1N BBM and 3 NBBM). Identification were performed with the light binocular microscope "MICROmed XS-5520" using 40x and 100x objective lenses.
Here we registered 23 cyanoprokaryota species from 3 orders (*Chroococcales, Oscillatoriales,* and *Nostocales*), 10 families (*Merismopediaceae*, *Gomphosphaeriaceae*, *Microcystaceae, Chroococcaceae, Oscillatoriaceae, Phormidiaceae, Schizotrichaceae, Pseudanabaenaceae, Nostocaceae, Rivulariaceae*) and 11 genera. The dominant species were *Merismopedia elegans*, *M. glauca*, *Chroococcus minutus*, *Calothrix parietina*, *Leptolyngbya notata*, *Nostoc microscopicum*, and *Phormidium* (*Komvophoron*) *mucicola.* Such species like *Merismopedia elegans*, *M. glauca*, *Chroococcus minutus*, and *Calothrix parietina* were found in all studied park plots with sandy soils that confirming algae wide ecological tolerance. We also discovered strong domination of aquatic species at studied habitats.
Key words: *Cyanoprokaryota, Pryazov National Natural Park, algae flora.*

Cyanoprokaryota is the ancient group of organisms, which still retains a dominant position in some biocenoses. This is morphologically and physiologically unique group of organisms that is widespread in the plankton of stagnant and slowly flowing waters, in the coastal benthos as epiphytes and as a growth on various solid substrates, in hot springs, on the snow surface and even on ice, on the wet rocks, on the surface, and deep in the ground.
Despite the intensive researches of algae in PNNP by the scientists of Melitopol State Pedagogical University and PNNP researchers (Solonenko et al., 2006; Yaroviy et al., 2007; Yaroviy et al., 2008; Solonenko et al., 2008; Yarova et al., 2012; Yaroviy, 2012; Yaroviy et al., 2013; Scherbina et al., 2014; Shekhovtseva, Mal'tseva, 2015; Maltsev, 2015; Maltsev et al., 2017) there were no special investigations of the cyanoprocaryota in sandy alluvial soil habitats, that' why there is no data regards their species composition and taxonomic structure.
Pryazov Park is situated in the south part of Zaporizhzhya region. It is very special area due to coastal location, wild steppe plots, aquatic and ecotonic biocenoses. Great landscape variety is caused by coastal location and dynamics of marine shoreline. Sandy soil habitats of the PNPP are of great importance for many rare species of flora and fauna (Barabokha et al, 2012). However, the data on Cyanoprokaryota of these unique habitats are still fragmentary, that was a ground to study the cyanoprokaryota of this habitat in PNNP and to identify the environmental features of certain species. We supposed that the ecological features of cyanoprokaryota can be used in the analysis and forecasting of the environmental changes.

Materials and Methods

In total, 16 soil samples were sampled from the sandy ecotopes in the PNPP (78,126,92 ha, 46°24'00" N 35°25'00" E) to study the cyanoprokaryota. The sampling was carried during 2014-2015 in plots located on the Stepanivka Spit (Azov Sea), Fedotova Spit (Utlyutskyi Estuary) natural boundary Tubalskyy estuary at the mouth Korsak, Taschenakskyi hearth (mouth of the river Tashchenak), and on the Berdyansk Spit near the Krasne lake (Fig. 1).

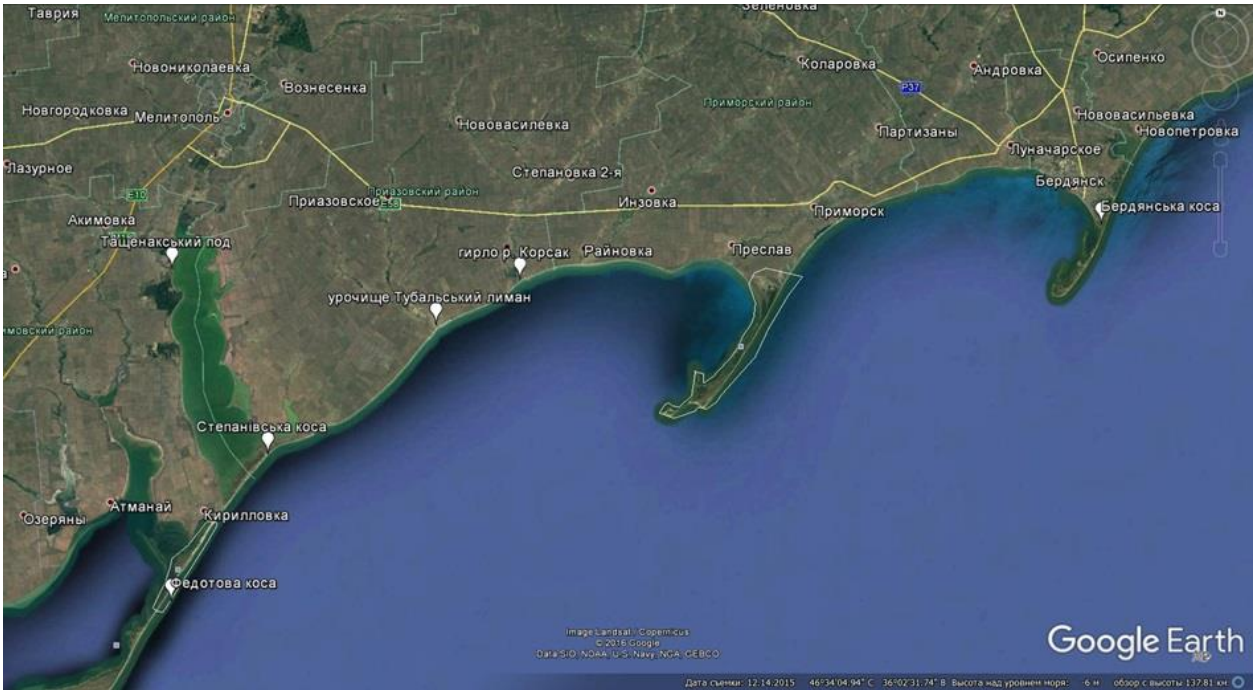

Fig. 1. Location of soil sampling plots within the Pryazov National Natural Park.

Samples were sampled by a conventional algological method (Gollerbakh, Shtina, 1969; Wasser, Tsarenko, 1989). The treatment and identification of sampled material was performed in the laboratory of Botany and Gardening of the Bogdan Chmelnitskiy Melitopol State Pedagogical University (www.mdpu.org.ua).

We used culturing methods in two types of cultures in lab processing of the material: soil cultures with glasses of growth and Bold's nutrient agar with normal and triple quantity of nitrogen (1N BBM and 3 NBBM) (Arce, Bold, 1958). Researches were conducted by the light binocular microscope "MICROmed XS-5520" using 40x and 100x objective lenses.

We identified the algae according to Komárek & Anagnostidis (1998, 2005). Analysis of the revealed species in relation to some geographical confinement was done regards Barinova (2006).

Results and Discussion

We registered some 23 species of cyanoprokaryota on sandy soil habitats of PNNP. These species belong to 3 orders, 10 families, and 11 genera (Table. 1).

The dominant species were *Merismopedia elegans*, *M. glauca*, *Chroococcus minutus*, *Calothrix parietina*, *Leptolyngbya notata*, *Nostoc microscopicum*, *Phormidium mucicola*. The largest number of cyanoprokaryota (14 species) was found on the Stepanivka Spit, namely *Leptolyngbya nostocorum, Gomphosphaeria aponina*, *Lyngbya lutea*, *Microcystis litoralis*, *Merismopedia glauca*, *Microcoleus vaginatus*, *Merismopedia elegans*, *Merismopedia glauca, Merismopedia punctata, Chroococcus minutus, Nostoc microscopicum*, *Leptolyngbya notata*, *Schizothrix coriacea.*

The next important plot with high algae diversity was mouth of river Korsak where we registered 12 species: *Oscillatoria lloyadiana, Phormidium paulsenianum, Merismopedia elegans, Merismopedia glauca, Merismopedia punctata*, *Chroococcus minutus*, *Phormidium mucicola*, *Calothrix parietina*, *Nostoc microscopicum*, *Leptolyngbya notata*, *Oscillatoria tenuis*, *Lyngbya semiplena*.

The third plot along the diversity gradient of cyanoprokaryota was mouth of river Tashchenak with 11 species: *Calothrix aeruginosa, Calothrix parietina, Gomphosphaeria aponina, Lyngbya lutea, Merismopedia elegans, Merismopedia glauca, Chroococcus minutus, Phormidium mucicola, Nostoc microscopicum*, *Leptolyngbya notata*, *Schizothrix coriacea.*

We discovered the lowest number of cyanoprokaryota species in the natural boundary of Tubalskyy estuary (8 species: *Merismopedia elegans, Merismopedia glauca, Calothrix parietina*, *Leptolyngbya notata*, *Oscillatoria tenuis, Lyngbya semiplena, Oscillatoria geminata, Phormidium autumnale*); on the Fedotova Spit (7 species: *Merismopedia elegans, Schizothrix coriacea, Merismopedia glauca, Chroococcus minutus*, *Calothrix parietina*, *Nostoc microscopicum, Microcoleus vaginatus*), and on the Berdyansk Spit (near the Krasne lake) where we founded seven species: *Merismopedia glauca, Merismopedia punctata, Chroococcus minutus*, *Phormidium mucicola, Calothrix parietina*, *Leptolyngbya notata*, *Microcoleus vaginatus*.

Table 1 Systematic structure of cyanoprokaryota from sandy alluvial soils, Pryazov National Natural Park

№	Taxon
Order	*Cyanophyta* Schussnig, 1925
Class	*Cyanophyceae* Sachs 1874
Order	*Chroococcales* Caval.-Sm., 2002
Family	*Merismopediaceae* Elenkin, 1933
Genus	*Merismopedia* Meyen, 1839
1.	*Merismopedia elegans* A. Braun in Kützing, 1849
2.	*Merismopedia glauca* Kützing, 1845
3.	*Merismopedia punctate* Meyen, 1839
Family	*Gomphosphaeriaceae* Elenkin, 1933
Genus	*Gomphosphaeria* Kützing, 1836
4.	*Gomphosphaeria aponina* Kützing, 1836
Family	*Microcystaceae* Elenkin, 1933
Genus	*Microcystis* Kützing, 1907
5.	*Microcystis pulverea* (H.C. Wood) Forti emend Elenkin, 1933
6.	*Microcystis litoralis* Elenkin, 1933
Family	*Chroococcaceae* Nägeli, 1849
Genus	*Chroococcus* Nägeli, 1849
7.	*Chroococcus minutus* (Kützing) Nägeli 1849
Order	*Oscillatoriales* Elenkin, 1934
Family	*Oscillatoriaceae* Engl., 1898
Genus	*Lyngbya* C. Agardh ex Gomont, 1892
8.	*Lyngbya lutea* Gomont, 1892
9.	*Lyngbya semiplena* J. Agardh ex Gomont, 1892
Genus	*Oscillatoria* Vaucher, 1892
10.	*Oscillatoria tenuis* C. Agardh ex Gomont, 1892
11.	*Oscillatoria geminata* Menegh., 1892
12.	*Oscillatoria lloyadiana* Gomont, 1899
Family	*Phormidiaceae* Anagn. et Komárek, 1988
Genus	*Phormidium* Kützing, 1892
13.	*Phormidium (Komvophoron) mucicola* Hub.-Pest. et Naumann, 1929
14.	*Phormidium autumnale* Gomont, 1892
15.	*Phormidium paulsenianum* Boye-Petersen, 1930
16.	*Phormidium paulsenianum f. takyricum* Novichk., 1960
рід	*Microcoleus* Desm., 1892
17.	*Microcoleus vaginatus* Gomont, 1890
Family	*Schizotrichaceae* Elenkin, 1934
Genus	*Schizothrix* Kützing, 1892
18.	*Schizothrix coriacea* Kützing ex Gomont 1892
Family	*Pseudanabaenaceae* Anagn. et Komárek, 1988
Genus	*Leptolyngbya* Anagn. et Komárek, 1988
19.	*Leptolyngbya notata* (Schmidle) Anagn. et Komárek 1988
20.	*Leptolyngbya nostocorum* Anagn. et Komárek, 1988
Order	*Nostocales* Caval.-Sm., 2002
Family	*Nostocaceae* Eichler, 1886
Genus	*Nostoc* Vaucher, 1886
21.	*Nostoc microscopicum* Carmich. sensu Elenkin 1949
Family	*Rivulariaceae* Kützing, 1843
Genus	*Calothrix* C. Agardh ex Bornet & Flahault, 1886
22.	*Calothrix parietina* Thuret, 1886
23.	*Calothrix aeruginosa* Thuret, 1886

We need to mention that some cyanoprokaryota species were sampled in sandy soil plots within the PNNP: *Merismopedia elegans*, *Merismopedia glauca*, *Chroococcus minutus*, *Calothrix parietina*. Such species like *Merismopedia punctata*, *Gomphosphaeria aponina, Microcystis pulverea, Microcystis litoralis, Chroococcus minutes, Lyngbya lutea, Lyngbya semiplena, Oscillatoria tenuis, Oscillatoria lloyadiana, Oscillatoria geminata, Phormidium mucicola, Phormidium paulsenianum, Phormidium paulsenianum (f. takyricum), Phormidium autumnale, Microcoleus vaginatus, Schizothrix coriacea, Leptolyngbya notata, Leptolyngbya nostocorum, Nostoc microscopicum, Calothrix parietina,* and *Calothrix aeruginosa* are cosmopolitans and were found in all soil types of Ukraine: Ukrainian Polissya, Steppe, Lisosteppe, Ukrainian Carpathians, and Crimean Mountains, that is confirmed their wide ecological tolerance (Kostikov, 2001; Tsarenko, 2006). *Merismopedia elegans* and *Merismopedia glauca* can be considered as psamophytic because they were founded only in the algal cenoses on the bare sand biotopes and sand-shell beaches in the Steppe zone of Ukraine.

We proposed to divide the registered species divided by their habitat selectivity: soil - 6 species, planktonic-benthic – 2, planktonic - 8, benthic - 4, and 1 epiphytic species. The water habitat was the limited factor in distribution for 14 identified algae species.

Conclusions

We registered 23 species of cyanoprocaryota in sandy habitats of PNNP. These species belong to 3 orders: *Chroococcales, Oscillatoriales, and Nostocales;* 10 families: *Merismopediaceae*, *Gomphosphaeriaceae*, *Microcystaceae, Chroococcaceae, Oscillatoriaceae, Phormidiaceae, Schizotrichaceae, Pseudanabaenaceae, Nostocaceae, Rivulariaceae* and 11 genera.

The dominant species were *Merismopedia elegans*, *M. glauca*, *Chroococcus minutus*, *Calothrix parietina*, *Leptolyngbya notata*, *Nostoc microscopicum*, *Phormidium* (*Komvophoron*) *mucicola.* Such species like *Merismopedia elegans*, *M. glauca*, *Chroococcus minutus*, and *Calothrix parietina* were found in all the studied park plots with sandy soils that contributed to algae wide ecological tolerance.

We suggested that water habitats limited the distribution of the majority of algae species in the condition of sandy alluvial soils in Pryazov National Natural Park.

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