

Diversity and Ecology of the Phytoplankton of Filamentous Blue-Green Algae (Cyanoprokaryota, Nostocales) in Bulgarian Standing Waters

*Plamen Stoyanov**, *Ivanka Teneva*, *Rumen Mladenov*, *Detelina Belkinova*

University of Plovdiv "Paisii Hilendarski", Faculty of Biology, Department of Botany,
24 Tzar Assen Str., Plovdiv, BULGARIA

* Corresponding author: pstoyanov@uni-plovdiv.bg

Abstract. The current study presents data about the diversity and ecology of filamentous blue-green algae, found in the phytoplankton of 42 standing water basins in Bulgaria. We identified 9 species from *Cyanoprokaryota*, which belong to 5 genera from order *Nostocales*. Ecological characterization of the identified species has been performed. Data about the physicochemical parameters of the water basins are also provided.

Key words: filamentous blue-green algae, standing water basins, morphology, ecology, distribution, Bulgaria.

Abbreviations used in the text:

- L3 - Mountain lakes in Pontic province
- L4 - Lowland or semi-mountain natural lakes end swamps in Pontic province
- L7 - Black Sea freshwater coastal lakes
- L11 - Large deep reservoirs
- L12 - Small and medium-size semi-mountain reservoirs in Pontic province
- L13 - Small and medium-size semi-mountain reservoirs in Eastern Balkans
- L14 - Large lowland reservoirs with medium depth in Pontic province
- L15 - Large lowland reservoirs with medium depth in Eastern Balkans
- L16 - Small and medium-size lowland reservoirs in Pontic province

Introduction

The blue-green algae are characterized with high adaptive plasticity and quick adaptation to light, temperature or other physical and chemical changes in the environment. This is supported by their wide distribution (ANAGNOSTIDIS & DANIELIDIS, 1982; ECONOMOU-AMILLI *et al.*, 1984; HALLFORS, 1984; KOMAREK, 1985; ANAGNOSTIDIS *et al.*, 1985; SKULBERG &

SKULBERG, 1985; KOMÁREK & KOVÁČIK, 1987).

TEMNISKOVA *et al.* (2005) summarized the studies of the algal flora in Bulgaria. Another synopsis on the phytoplankton in the Bulgarian reservoirs was done by STOYNEVA & MICHEV (2007) and BESHKOVA *et al.* (2007).

So far, the studies describing the hydrophilic blue-green algae and their

distribution in Bulgaria are limited. Some contemporary studies on this subject are done by TSANEV & BELKINOVA (2009) and TENEVA *et al.* (2010a, 2010 b, 2011).

The aim of the study was to identify the filamentous blue-green algae from different standing water basins in Bulgaria.

Material and Methods

For species identification of the filamentous blue-green algae 42 natural samples were collected from 42 Bulgarian freshwater basins in 2009. The typology of the water basins (dams, lakes and swamps) was defined according to System B (BELKINOVA *et al.*, 2013).

The physicochemical parameters (temperature, oxygen saturation, pH and conductivity) in the water basins were measured *in situ* with calibrated field devices. Additionally, NH₄N, NO₂N, NO₃N, PO₄P, total phosphorus and nitrogen were analyzed by using a NOVA 60 spectrophotometer (MERCK) following adopted standards: ammonium nitrogen (ISO 7150/1), nitrite and nitrate nitrogen (EN 26777 and ISO 7890-1), total nitrogen (EN ISO 11905-1), phosphate phosphorus (EN ISO 6878) and total phosphorus (EN ISO 6878).

The taxonomic composition was determined by using a light microscope MAGNUM-T, with 10x40 magnification, equipped with 3Mpx digital camera and the guide of JOHN *et al.* (2003).

For each taxon the frequency of occurrence (FQ) was calculated (TEMNISKOVA & STOYNEVA, 2011).

Results and Discussion

The ecological analysis of the species includes total distribution of the identified species and information about their habitats in Bulgaria. The physicochemical parameters of the water basins and the range of their variability (for species, occurring in more than one water basin) are presented.

We have identified the following species from order Nostocales:

FAMILY NOSTOCACEAE

Anabaena affinis LEMMERMANN



Habitat: occurs in the plankton of standing water bodies, sometimes causing "blooming" of the water.

Distribution in Bulgaria: large, deep reservoirs (type L11). In the current study it was found and documented in reservoir Studen Kladenets.

Abiotic parameters: t° - 25.2°C; %pO₂ - 109; pH - 8.5; ε - 253; NH₄N -0.092; NO₂N - 0.002; NO₃N <0.20; PO₄P <0.010; total P - 0.029; total N - 1.9.

Anabaena scheremetievi ELENK.



Habitat: occurs in the plankton of lakes, reservoirs and rivers. Widely distributed species.

Distribution in Bulgaria: middle and small semi-mountain reservoirs in Pontic province; big large lowland medium deep reservoirs in Pontic province; small and medium lowland reservoirs in Pontic province (L12, L14, L16). In the current study it was found and documented in reservoirs Kula, Ogosta, Enitsa, Yastrebino, Krapets, Antimovo, Aheloy, Poroy, Daskal Atanasovo, Ovchi kladenets and Ovcharitsa.

Abiotic parameters: t° - 9.2÷29.2°C; %pO₂ - 44÷98.23; pH - 7.92÷9.5; ε - 201÷863; NH₄N <0.010÷1.55; NO₂N - 0.002÷0.052; NO₃N - 0.08÷0.28; PO₄P <0.010÷0.223; total P - 0.015÷0.246; total N <0.5÷2.1.



Anabaena spiroides KLEBAHN

Habitat: occurs in the plankton of standing freshwater basins. Widely distributed species.

Distribution in Bulgaria: Black Sea freshwater lakes and marshes, semi-mountain reservoirs in Pontic province, small and medium-sized lowland reservoirs in Pontic province (L7, L12, L16). In the current study it was found and

documented in reservoirs Enitsa, Poroy, Daskal Atanasovo, Ovchi kladenets, Ovcharitsa and in Durankulak swamp.

Abiotic parameters: t° - $9.2 \div 29.2^{\circ}\text{C}$; %pO₂ - $28.9 \div 95$; pH - $8.02 \div 9.5$; ε - $522 \div 1210$; NH₄N - $0.019 \div 1.55$; NO₂N - $0.005 \div 0.052$; NO₃N <0.20; PO₄P <0.010÷0.223; total P - $0.044 \div 0.246$; total N - $0.5 \div 2.1$.

Anabaena variabilis (KÜTZING) BORNET ET FLAHAULT



Habitat: occurs in standing freshwater and marine basins and sometimes

even on wet soils.

Distribution in Bulgaria: middle-sized and small semi-mountain reservoirs in Pontic province; small and medium-sized lowland reservoirs in Pontic province (L12, L16). In the current study it was found and documented in reservoirs Antimovo and Ovchi kladenets.

Abiotic parameters: t° - $24.9 \div 27.9^{\circ}\text{C}$; %pO₂ - $95 \div 98.23$; pH - $9 \div 9.5$; ε - $536 \div 690$; NH₄N - $0.016 \div 0.05$; NO₂N - $0.002 \div 0.006$; NO₃N <0.20; PO₄P <0.010÷0.034; total P - $0.062 \div 0.082$; total N <0.5÷1.6.

Anabaenopsis arnoldii APTEK.



Habitat: Occurs in standing waters and rivers.

Distribution in Bulgaria: small and medium-sized

lowland reservoirs in Pontic province (L16). In the current study it was found and documented in reservoirs Tri kladentsi, Enitsa and Krushovitsa.

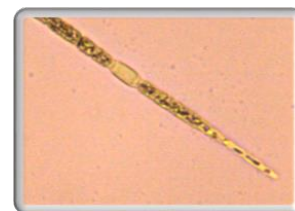
Abiotic parameters: t° - $9.2 \div 23.9^{\circ}\text{C}$; %pO₂ - $44 \div 111$; pH - $8 \div 9.29$; ε - $378 \div 609$; NH₄N - $0.054 \div 1.55$; NO₂N - $0.013 \div 0.052$; NO₃N $0.16 \div 0.43$; PO₄P - $0.009 \div 0.025$; total P - $0.112 \div 0.195$; total N - $0.8 \div 2.1$.

Aphanizomenon elenkinii KISSEL.

Habitat: occurs in the plankton of standing water basins.

Distribution in Bulgaria: lowland and semi-mountain natural lakes and swamps in

Pontic province; large deep reservoirs; middle-sized and small semi-mountain



reservoirs in Pontic province; middle and small semi-mountain reservoirs in Eastern Balkans; small and medium-sized lowland reservoirs in Pontic province (L4, L11, L12, L13, L16). In the current study it was found and documented in reservoirs Rabisha, Rasovo, Dabnika, Devets, Telish, Valchovets, Yastrebino, Boyka, Antimovo, Aheloy, Poroy, Ovchi kladenets and Koprinka.

Abiotic parameters: t° - $10.2 \div 27.9^{\circ}\text{C}$; %pO₂ - $48.3 \div 121.4$; pH - $7.92 \div 9.5$; ε - $195 \div 822$; NH₄N - $0.019 \div 0.334$; NO₂N - $0.002 \div 0.029$; NO₃N - $<0.20 \div 0.89$; PO₄P <0.010÷0.044; total P - $0.017 \div 0.218$; total N <0.5÷2.1.

Aphanizomenon flos-aquae [(LINNAEUS) RALFS] BORNET ET FLAHAULT

Habitat: occurs in the plankton of eutrophic freshwater and brackish basins. Causes "blooming" of the water. Widely distributed species. Toxin-producing populations are known to exist.



Distribution in Bulgaria: mountain type lakes in Eastern Balkans; lowland and semi-mountain natural lakes and swamps in Pontic province; Black sea freshwater lakes and swamps; large deep reservoirs; middle-sized and small semi-mountain reservoirs in Pontic province; middle and small semi-mountain reservoirs in Eastern Balkans; large lowland reservoirs in Eastern Balkans; small and middle lowland reservoirs in Pontic province (L3, L4, L7, L11, L12, L15, L16). In the current study it was found and documented in reservoirs Kula, Rabisha, Kovachitsa, Dabnika, Tri kladentsi, Barzina, Pancharevo, Krushovitsa, Telish, Valchovets, Kamenets, Yastrebino, Krapets, Beli Lom, Lomtsi, Kavatsite, Boyka, Antimovo, Aheloy, Mandra, Yasna polyana, Batak, Vacha, Pyasachnik, Daskal

Atanasovo, Ovchi kladenets, Ovcharitsa, Koprinka, Borovitsa, Studena, Pchelina and Durankulak swamp.

Abiotic parameters: t° - $10.2 \pm 29.2^{\circ}\text{C}$; %pO₂ - 28.9 ± 214 ; pH - 6.66 ± 9.55 ; ε - -62 ± 1210 ; NH₄N - 0.008 ± 0.39 ; NO₂N < 0.002 ± 0.067 ; NO₃N < 0.20 ± 0.89 ; PO₄P < 0.010 ± 0.317 ; total P - < 0.010 ± 0.364 ; total N < 0.5 ± 4.1 .

Cylindrospermopsis raciborskii

(WOLOSZYNSKA) SEENAYYA & SUBB RAJU

[Syn.: *Anabaenopsis raciborskii*

WOLOSZYNSKA]



Habitat:

occurs in the plankton of eutrophic lakes and reservoirs.

Toxin-

producing populations are known to exist.

Distribution in Bulgaria: middle and small semi-mountain reservoirs in Pontic province; middle and small semi-mountain reservoirs in Eastern Balkans; small and middle lowland reservoirs in Pontic province (L12, L13, L16). In the current study it was found and documented in reservoirs Drenovets, Smirnenski (Lomtsi), Kovachitsa, Telish, Valchovets, Kamenets, Boyka, Aheloy and Ovchi kladenets.

Abiotic parameters: t° - $10.2 \pm 27.9^{\circ}\text{C}$; %pO₂ - 48.3 ± 123.3 ; pH - 8.1 ± 9.5 ; ε - 241 ± 813 ; NH₄N - 0.01 ± 0.39 ; NO₂N - 0.002 ± 0.02 ; NO₃N < 0.20 ± 0.28 ; PO₄P < 0.010 ± 0.044 ; total P - 0.047 ± 0.116 ; total N < 0.5 ± 2.84 .

Raphidiopsis mediterranea SKUJA



Habitat: occurs in the plankton of standing water basins.

Distribution in Bulgaria: lowland and semi-mountain

natural lakes and swamps in Pontic province; middle and small semi-mountains reservoirs in Pontic province; middle and small semi-mountain reservoirs in Eastern Balkans; small and middle lowland reservoirs in Pontic province (L4, L12, L13,

L16). In the current study it was found and documented in reservoirs Rabisha, Kovachitsa, Barzina, Asparuhov val, Enitsa, Krushovitsa, Valchovets, Kavatsite, Boyka, Baniska, Daskal Atanasovo, Ovchi kladenets and Pchelina.

Abiotic parameters: t° - $9.2 \pm 27.9^{\circ}\text{C}$; %pO₂ - $44. \pm 214$; pH - 8 ± 9.55 ; ε - 202 ± 1044 ; NH₄N - 0.019 ± 1.55 ; NO₂N - 0.002 ± 0.067 ; NO₃N < 0.20 ± 0.81 ; PO₄P < 0.010 ± 0.039 ; total P - 0.017 ± 0.202 ; total N < 0.5 ± 4.1

The analysis of the results showed that most common taxa from the *Nostocaceae* family are genus *Aphanizomenon* (FQ=55%), followed by genus *Anabaena* (FQ=25%), *Raphidiopsis* (FQ=20%), *Cylindrospermopsis* (FQ=14%) and *Anabaenopsis* (FQ=13%).

The frequency of occurrence of the species is presented in Fig. 1. As can be seen from the figure, the species with the highest frequency of occurrence is *Aphanizomenon flos-aquae*, followed by *Aphanizomenon elenkinii* and *Raphidiopsis mediterranea*. The rarest species was *Anabaena affinis*, found only in reservoir Studen kladenets.

The species *Aphanizomenon elenkinii*, *Aphanizomenon flos-aquae*, *Anabaena spiroides* and *Anabaena scheremetievi* were found in water basins, which are included in protected territories. Thus, this study fulfills one of the 10 directions of the Bulgarian algological studies, suggested by TEMNISKOVA et al. (2005).

With the established in the current study 9 species from order *Nostocales* belonging to 5 genera, we enrich the existing information about the distribution of the filamentous blue-green algae in the standing waters in Bulgaria.

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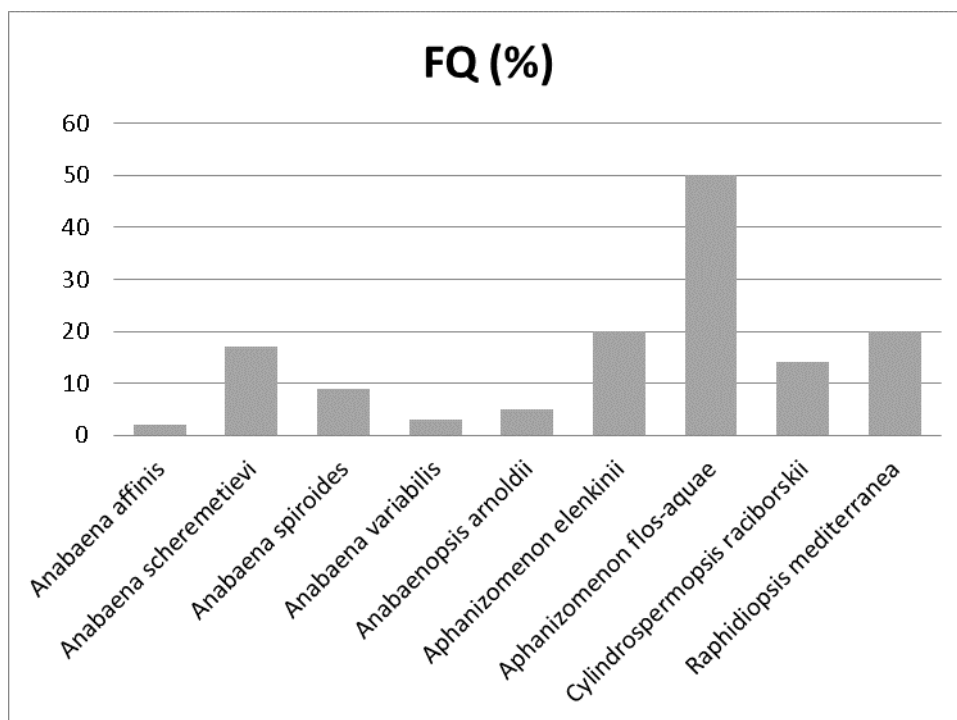


Fig. 1. Frequency of occurrence of filamentous blue-green algae from order *Nostocales* in Bulgarian standing water basins.

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