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SMALL WATER BODIES IN AGRICULTURAL AREAS AS IMPORTANT HABITATS FOR EUGLENOIDS IN POLAND

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Abstract. Temporary water bodies of glacial origin, known as kettle holes, are typical elements of the young moraine landscape in many countries. Unfortunately, they are very exposed to effects of anthropogenic changes, especially in agricultural areas. Due to their small area and depth, as well as to the great fluctuations in water level, they create specific conditions for organisms that inhabit them. Consequently, kettle holes are unique biodiversity hotspots in landscape, rich in some microalgal species, particularly euglenoids (euglenophytes). In this study, the taxonomic composition of euglenoids was studied in three temporary water bodies in an agricultural landscape of Wielkopolska Province (western Poland). In total, 65 euglenoid taxa were identified there during one year. Euglenoids in the investigated field ponds were the most species-rich group of microalgae. They accounted for 26% of the total number of phytoplankton taxa. According to the constancy (frequency) of occurrence most of the species were incidental. The most common taxa were: *Trachelomonas volvocina*, *Euglenaformis proxima*, *Trachelomonas intermedia*, *Lepocinclis tripteris*, and *Lepocinclis acus*. The high species richness of euglenoids in aquatic ecosystems of agricultural areas shows how valuable ponds are for preserving local biodiversity and for aquatic food webs. The small water bodies in farmlands should be protected against progressive anthropogenic eutrophication and degradation.

Keywords: field ponds, phytoplankton, species diversity, biodiversity conservation, eutrophication

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INTRODUCTION

In intensively used farmlands in Poland small water bodies are particularly important elements of the heavily transformed landscape. Ponds in such areas are considered to be major hotspots of biodiversity, hosting populations of interesting and rare algae, higher plants, and animals (Boix et al. 2012; Gołdyn et al. 2015 a, b). Most of the animal and plant species occurring in farmlands gather around and directly depend on functioning of small wetlands. Moreover, ponds play a crucial role in increasing connectivity between freshwater habitats, as stepping-stone ecosystems. They are important also because of their ecosystem services and high economic value because they play crucial roles in the rural landscape, such as flood control, groundwater recharge, toxicant removal, and recycling of nutrients (Koc et al. 2001; Waterkeyn et al. 2008). Moreover, species of animals connected with ponds play a significant role in pest control in surrounding agricultural areas (Williams 2006).

Climate change (increase in average temperatures, decrease in the amount or even long-term lack of regular snowfall or rainfall), together with the progressive anthropogenic transformations of landscape, lead to changes in species composition and to degradation of the sensitive small water bodies. Until recently, water management in Poland was focused on intensive drainage of agricultural land in order to increase the acreage of crops. Moreover, some activities indirectly affected their rapid degradation, *e.g.* drainage works in areas adjacent to ponds, which caused them to dry out, or intensive fertilization of agricultural fields, which led to overfertilization of water in the kettle holes and, consequently, to their shallowing and disappearance of the water bodies. Field ponds were treated as useless elements of landscape, so their area and number were reduced in an uncontrolled way (Juszczak & Arczyńska-Chudy 2003; Dudzińska et al. 2020). In recent decades, they have disappeared rapidly also in other parts of Europe and are known to be one of the most endangered ecosystems on this continent (Waldon 2012).

Small water bodies are typical elements of agricultural landscapes in the regions that were covered by the last glaciation. Many of them are of natural post-glacial origin. According to a Polish classification, they are up to 1 ha in area, usually have an oval shape, diameter up to 100 m, and depth not exceeding 2–3 m (Koc et al. 2001). They fill depressions left by the glaciers and are the most numerous type of aquatic ecosystems in Poland. These water bodies are often astatic, characterized by irregular, but usually very large fluctuations of water level, leading to periodic or even complete drying out, as opposed to permanent ponds (Gołdyn & Kuczyńska-Kippen 2012). They create specific habitats for the species inhabiting them, because of the great fluctuations of physical-chemical parameters of water (*e.g.,* water temperature, pH, conductivity, and nutrient concentrations). Organisms in astatic ponds develop specific adaptations, which allow them to survive drought periods in habitats of this type. As a result of the instability of environmental conditions and the frequent drying out of small water bodies, they are usually devoid of fish. However, this allows their colonization by many other vertebrates (*e.g.,* specialized amphibians) or large aquatic invertebrates. Very important components of these habitats include planktonic algae, which are primary producers. Thus the structure and function of algal communities markedly influence the functioning of the whole aquatic ecosystem. The phytoplankton of small water bodies is highly specific (Celewicz & Gołdyn 2021). They are dominated by species that tolerate variable or even extreme environmental conditions, also by some rare species. After every drought period, phytoplankton communities in temporary water bodies are restored mainly thanks to resting stages preserved in bottom sediments. The colonization of the aquatic ecosystem by various algae after their filling with water is caused by secondary succession. The phytoplankton of astatic water bodies in rural areas is still poorly studied. Preliminary research shows that such ecosystems are rich in species that are rare in lakes (Celewicz, unpublished data).

Euglenoids (also known as euglenids or euglenophytes) are a characteristic group of pond phytoplankton and usually prefer shallow and freshwater habitats rich in dissolved organic matter, which are rapidly warming, even with poor light conditions (Messyasz 1996; Reynolds et al. 2002; Wołowski & Grabowska 2007; Poniewozik & Wołowski 2017). According to Wołowski (2003), there are about 650 taxa of euglenoids in Poland. They are mixotrophic organisms, capable of both photosynthesis and using organic carbon from the environment as a source of energy. They are regarded as good indicators of organic pollution of water and used for trophic state assessment (Wołowski & Grabowska 2007; Czerwik-Marcinkowska 2019). Euglenoids are able to form resting stages (cysts) to survive unfavourable conditions in bottom sediments (Poniewozik & Juráň 2018). Species of this group are often present in broad belts of littoral vegetation of shallow water bodies (where intensive processes of decomposition of macrophytes take place), in inlets or in the whole permanent water bodies polluted by organic wastewater as well as in astatic water bodies (which dry out periodically), peatlands, and pools. Considering their specific habitat preferences, their species diversity is usually high also in astatic field ponds.

The aim of the study was to assess the species composition of euglenoids and their share compared to other phytoplankton groups in astatic water bodies, which could serve as a basis for future tracking of algal diversity in this type of aquatic ecosystems. Moreover, the acquired knowledge about the qualitative structure of microalgae will help us understand better the functioning of field ponds, but also will raise awareness of their ecological importance and of the need to protect them against drying out and degradation.

MATERIAL AND METHODS

Euglenoids were studied in three small water bodies located at the outskirts of Poznań, within Wielkopolska Province, western Poland (52°27'N, 16°57'E). The ponds represented the post-glacial type and were located in an agricultural landscape. Their maximum depths and surface areas were as follows: 1.2 m and 1171 m^2; 1 m and 1100 m^2; 0,7 m and 371 m^2, respectively.

Samples for phycological analyses were taken from the surface layers of water (from the central part of each pond), by using a plankton net (mesh size: 25 µm) and then fixed with Lugol solution. Phytoplankton samples were collected every two weeks from 11.02.2008 to 02.03.2009, and 89 samples were taken in total. Algal taxa were determined with a light microscope (magnification 200x, 400x, and 1000x). Publications of the following authors were used for the taxonomic identification of euglenoids: Starmach (1983), Wołowski (1998), and Wołowski & Hindak (2005). Microalgal taxa names were given in accordance with classifications used in Algaebase (Guiry & Guiry 2021). Photographic documentation of algae was made using an Olympus BX43 microscope with an SC30 camera.

The constancy (frequency) of the phytoplankton taxa in the investigated ponds was estimated, and species were classified according to the Tichler scale (Trojan 1975): incidental (1–25%), accessory (26–50%), permanent (51–75%), and absolutely permanent (76–100%).

RESULTS AND DISCUSSION

In the investigated ponds, 254 phytoplankton taxa have been identified, representing 8 systematic groups: Euglenophyta (65), Bacillariophyceae (64), Chlorophyta (54), Cyanoprokaryota/Cyanobacteria (36), Cryptophyta (21), Dinophyceae (9), Xanthophyceae (3), and Chrysophyceae (2).

Euglenoids had the largest share in the total number of taxa (26%), compared to the other phytoplankton groups (**Fig. 1**). Some of the species are illustrated in **Fig. 2**. Similar results were found in two temporary small water bodies in the farmlands of the southern edge of Wysoczyzna Świecka (Paczuska et al. 2002), where also euglenoids and diatoms dominated in the phytoplankton communities. The large share of diatom taxa in microalgae assemblages is probably connected with the fact that phytoplankton communities in ponds are enriched also by tychoplanktonic organisms (of epiphytic or benthic origin), due to their small area and depth. This was consistent with results of other studies concerning field ponds (Paczuska et al. 2002; Kuczyńska-Kippen 2009; Celewicz-Gołdyn & Kuczyńska-Kippen 2017; Celewicz & Gołdyn 2021).

The results of taxonomic identification of the euglenoids in all the studied ponds are summarized in **Table 1**. The listed taxa belong to 11 genera (*Astasia*, *Colacium, Discoplastis, Euglena, Euglenaformis, Euglenaria, Lepocinclis, Mono*

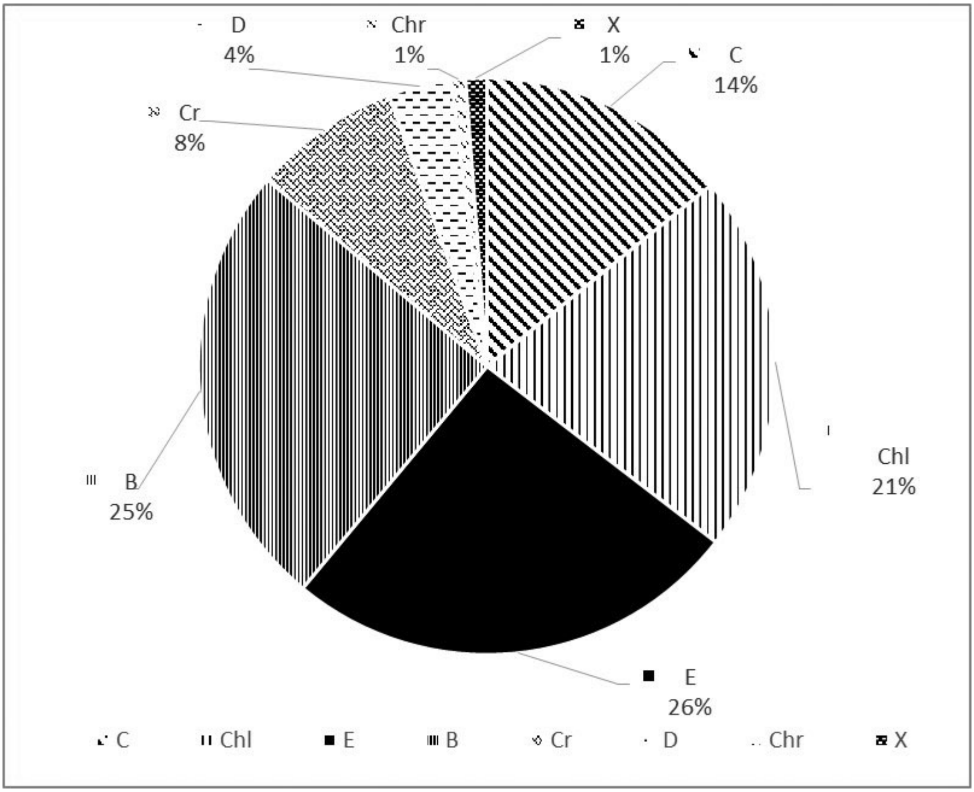

Fig. 1. Percentage contributions of major systematic groups – Cyanobacteria (C), Chl – Chlorophyta (Chl), Euglenophyta (E), Bacillariophyceae (B), Cryptophyta (Cr), D – Dinophyceae (D), Chrysophyceae (Chr), and Xanthophyceae (X) – to the total number of phytoplankton taxa in the investigated ponds.

morphina, Phacus, Strombomonas, and *Trachelomonas*). Among them, the most species-rich was the genus *Trachelomonas* (25 taxa). Many species of this genus are considered cosmopolitan, ubiquitous, and are often present in small water bodies polluted with mineral fertilizers, puddles, peatlands, lakes, and in slow-flowing waters (Czerwik-Marcinkowska 2019). Additionally, Grabowska & Wołowski (2014) stated that euglenoids of the genus *Trachelomonas* prefer eutrophic warm waters with a high oxygen content. According to Poniewozik & Juráň (2018), they are observed in waters with a very high concentration of ammonium nitrogen. Similarly, Stević et al. (2013) recorded a high diversity of *Trachelomonas* species in waters with large amounts of organic matter and, consequently, high concentrations of phosphorus and nitrogen.

In respect of constancy, most of the euglenoids (47 taxa) were classified as incidental in the investigated field ponds, because they were found in up to 25% of the analysed samples (**Table 1**). A large group of species (15) occurred in 26–50%

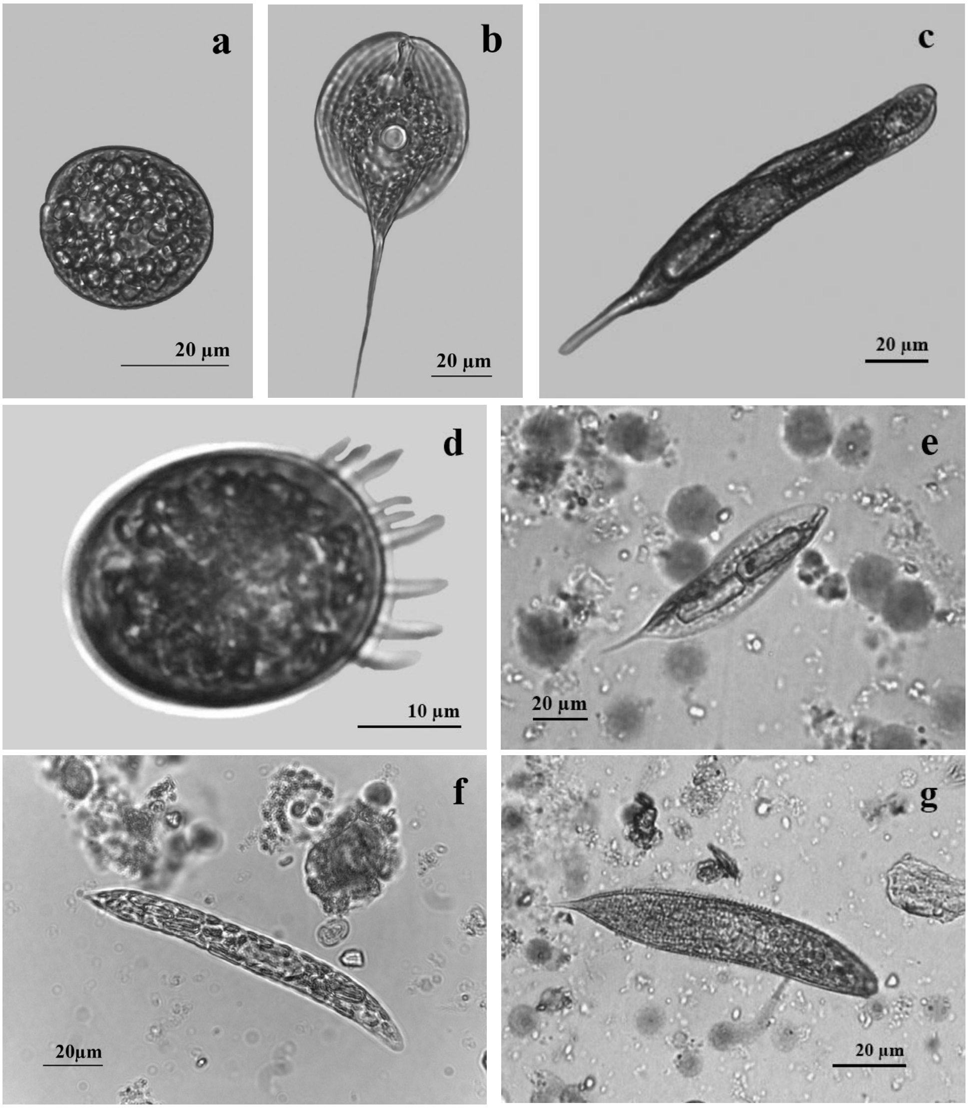

Fig. 2. Examples of euglenoids from the examined ponds: a - *Euglena texta*; b - *Phacus longicauda*; c - *Lepocinclis oxyuris*; d - *Trachelomonas armata*; e - *Lepocinclis tripteris*; f - *Euglena deses*; g - *Lepocinclis spirogyroides*.

of the analysed samples and most of them belong to the genera *Lepocinclis* and *Phacus*. The most frequently noted (absolutely permanent) species was *Trachelomonas volvocina*. According to Wołowski (1998), it is a very common species in Poland and can occur in various types of water bodies with various levels of saprobity. *T. volvocina* reached the highest frequency also in field ponds of the southern edge of Wysoczyzna Świecka in Poland (Paczuska et al. 2002). Permanent species included *Euglenaformis proxima* and *T. hispida*.

Most of the taxa recorded in the investigated ponds are cosmopolitan and widespread, usually inhabiting ponds and swamps. However, some interesting, rare species, such as *Trachelomonas sydneyensis*, were also observed. According to Poniewozik & Juráň (2018), this alga was found in nutrient-rich, temporary clay-pit ponds (especially rich in ammonium salts), located in eastern Poland near Lublin city.

Table 1. Taxonomic composition of euglenoids and type of constancy of species occurrence in the examined ponds.

Taxa	Type of constancy			
	absolutely permanent	permanent	accessory	incidental
Astasia sp.				+
Colacium mucronatum Bourrelly & Chadefaud				+
Colacium sp.				+
Colacium vesiculosum Ehrenberg				+
Discoplastis angusta (C. Bernard) Zakryś & Łukomska				+
Euglena clara Skuja				+
Euglena deses (O. F. Müller) Ehrenberg			+	
Euglena hemichromata Skuja				+
Euglena texta (Dujardin) Hübner			+	
Euglena truncata L. B. Walton				+
Euglena viridis (O. F. Müller) Ehrenberg				+
Euglenaformis proxima (P. A. Dangeard) M. S. Bennett & Triemer		+		
Euglenaria caudata (E. F. W. Hübner) Karnkowska -Ishikawa & E. W. Linton				+
Euglenaria clavata (Skuja) Karnkowska & E. W. Linton				+
Lepocinclis acicularis Francè				+
Lepocinclis acus (O. F. Müller) B. Marin & Melkonian			+	
Lepocinclis fusiformis (H. J. Carter) Lemmermann			+	
Lepocinclis globulus Perty				+
Lepocinclis hispidula (Eichwald) Daday				+

Taxa	Type of constancy			
	absolutely permanent	**permanent**	**accessory**	**incidental**
Lepocinclis ovum (Ehrenberg) Lemmermann				+
Lepocinclis oxyuris (Schmarda) B. Marin & Melkonian				+
Lepocinclis spirogyroides B. Marin & Melkonian			+	
Lepocinclis steinii (Lemmermann) Lemmermann			+	
Lepocinclis tripteris (Dujardin) B. Marin & M. Melkonian			+	
Lepocinclis sp.				+
Monomorphina pyrum (Ehrenberg) Mereschkowsky				+
Phacus acuminatus A. Stokes			+	
Phacus alatus G. A. Klebs			+	
Phacus caudatus Hübner			+	
Phacus clavatus P. A. Dangeard				+
Phacus curvicauda Svirenko				+
Phacus limnophilus (Lemmermann) E. W. Linton & Karnkowska				+
Phacus longicauda (Ehrenberg) Dujardin			+	
Phacus onyx Pochmann				+
Phacus orbicularis Hübner			+	
Phacus parvulus G. A. Klebs				+
Phacus pusillus Lemmermann				+
Phacus sp.				+
Strombomonas acuminata (Schmarda) Deflandre				+
Strombomonas sp.				+
Trachelomonas armata (Ehrenberg) F. Stein				+
Trachelomonas caudata (Ehrenberg) F. Stein			+	
Trachelomonas cylindrica Ehrenberg				+
Trachelomonas dubia Svirenko				+
Trachelomonas duplex (Deflandre) Couté & Tell				+

Taxa	Type of constancy			
	absolutely permanent	**permanent**	**accessory**	**incidental**
Trachelomonas globularis (Averintsev) Lemmermann				+
Trachelomonas globularis f. *crenulato-collis* (Szabados) T. G. Popova				+
Trachelomonas hispida (Perty) F. Stein		+		
Trachelomonas hispida var. *coronata* Lemmermann				+
Trachelomonas hispida var. *crenulato-collis* (Maskell) Lemmermann				+
Trachelomonas hispida var. *volicensis* Drężepolski				+
Trachelomonas intermedia P. A. Dangeard			+	
Trachelomonas manginii Deflandre				+
Trachelomonas oblonga Lemmermann			+	
Trachelomonas oblonga var. *pulcherrima* (Playfair) T. G. Popova				+
Trachelomonas pseudobulla Svirenko				+
Trachelomonas pusilla Playfair				+
Trachelomonas rugulosa F. Stein				+
Trachelomonas sp.				+
Trachelomonas sydneyensis Playfair				+
Trachelomonas verrucosa A. Stokes				+
Trachelomonas volvocina (Ehrenberg) Ehrenberg	+			
Trachelomonas volvocina var. *derephora* W. Conrad				+
Trachelomonas volvocinopsis Svirenko				+
Trachelomonas woycickii Koczwara				+

CONCLUSIONS

The results showed that small water bodies in the agricultural landscape in Wielkopolska Province in Poland are important habitats of interesting and often unique euglenoids. Their high contribution to the qualitative structure of phytoplankton is probably associated with a high organic matter content and high concentrations of nutrients in ponds (Celewicz, unpublished data) as well as with the fast changes in water temperature. These observations are confirmed by results of phycological studies of other authors, cited in this article. Research on algae living in these interesting ecosystems should be continued, contributing to their better understanding.

Aquatic ecosystems fulfil numerous functions in the usually monotonous agricultural landscapes (simplified structurally) but are subject to strong human impact, which threatens their existence. Thus, it is necessary to study their flora and fauna, and to assess their environmental value, in order to optimize protection measures. Protection of such ponds aims to preserve many rare and valuable species of algae, higher plants, and animals linked with aquatic habitats, and thus to maintain or increase biodiversity.

CONFLICT OF INTERESTS

The author declare that there is no conflict of interests regarding the publication of this article.

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FIRST DATA ON THE SUMMER PHYTOPLANKTON COMPOSITION OF 21 MICRORESERVOIRS IN BULGARIA AND THEIR FLORISTIC SIMILARITY

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Abstract. The present paper provides first detailed data on the phytoplankton species composition collected during two summer campaigns (2019 and 2021) from 21 Bulgarian microreservoirs (<100 ha). By conventional light microscopy (LM) 414 algae from seven phyla were identified, among which Chlorophyta were the taxonomically richest group (143 taxa). The recorded high algal biodiversity corresponded to the average species contribution of 36 taxa per site. It was associated with a significant variability between the phytoplankton composition in different microreservoirs: the total number of species ranged from 9 to 97. The dominant/co-dominant and sub-dominant phytoplankton composition comprised 46 algae from six phyla, most of which were cyanoprokaryotes (26 species, out of which 17 dominated in 12 microreservoirs and 11 sub-dominated in seven microreservoirs). The floristic similarity estimated through Sørensen's Correlation Index (SCI) was quite low (0-43%) corresponding to the high number of species (256, or 61%) found in a single waterbody. We strongly believe that the obtained results will stimulate further investigations of such small waterbodies as unexplored genetic reservoirs of algae.

Keywords: cyanobacteria, cyanoprokaryotes, drone, green algae, Sørensen's correlation index

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INTRODUCTION

Bulgaria is a country well-known for its significant contribution to the biodiversity of the Balkan Peninsula, considered as a hot-spot of the European biodiversity (Griffits et al. 2004). The algal diversity, despite not thoroughly studied, has been recognized as notable, comprising more than 5,500 taxa (Stoyneva 2014). Most of these algae have been found in the wetlands, the number of which exceeds 10,000 (Michev & Stoyneva 2007). In a more than a century, the largest and most significant of them have been sampled with different regularity (Michev & Stoyneva 2007, Stoyneva et al. 2017, Descy et al. 2018). However, much less phycological attention has been paid to the shallow small waterbodies (<100 ha), which serve as microreservoirs for irrigation, as fish-breeding ponds or as sport-fishing recreational sites, and are of great importance for the local people, especially in the lowlands, plains and kettles with small summer precipitation (Michev & Stoyneva 2007). In addition, it has to be noted that many of these waterbodies serve as resting, nesting or over-wintering places for waterfowl and currently are of nature conservational interest (Michev & Stoyneva 2007). The number of such waterbodies in the country exceeds 2484 and the vulnerability of their water quality has been stressed (Michev & Stoyneva 2007). Therefore, considering the ongoing climatic global change combined with anthropogenically speeded-up eutrophication, which result in increasing threats from harmful algal blooms (*e.g.*, Delpla et al. 2009, Whitehead et al. 2009, Ahmed et al. 2020, Meerhoff et al. 2022, WHO 2022, Zeppernick et al. 2023), we decided to investigate 21 microreservoirs in the country, which have never been studied in relation to phytoplankton.

The work was done in the frames of three complementary projects, oriented towards harmful algal blooms in relation to public health and national security in the country, during which the summer phytoplankton of 43 different waterbodies has been studied (Stoyneva-Gärtner et al. 2023). Some data on their general diversity with details on the main toxin producers, as well as on their quantitative structure, have been published in a set of papers (Stoyneva-Gärtner et al. 2019, 2021, 2022, 2023; Radkova et al. 2020; Stefanova et al. 2020; Uzunov et al. 2021a, b).

The present paper provides the first detailed data on the species composition of the summer phytoplankton of 21 small waterbodies from different parts of the country, selected according to their vulnerability, significant local importance and lack of previous algological studies. The only exception is the reservoir Mechka, from which ten cyanoprokaryotes were published in 2022 (Dochin 2022). Although based on single samplings, our results demonstrate the great biodiversity of the phytoplankton in all these waterbodies with strong variability from site to site and low floristic similarity of the studied microreservoirs. We strongly believe that the obtained results will stimulate further investigations of such small waterbodies as unexplored genetic reservoirs of algae.

MATERIALS AND METHODS

Sampling sites

The paper is based on phytoplankton samples from 21 selected microreservoirs in Bulgaria collected during two summer campaigns in August 2019 and August 2021 (**Table 1**). In regard to the sampling periods, we would like to recall that there was no sampling campaign in the year 2020 because of the travelling restrictions during Covid-19 pandemics (Stoyneva-Gärtner et al. 2021, 2023).

For most of the studied microreservoirs, except Hadzhidimovo, Byalata Prust-Mezek and Yunets, data on location, morphometry, usage, etc. are available in the Database of the Inventory of Bulgarian wetlands (IBW - Michev & Stoyneva 2007)

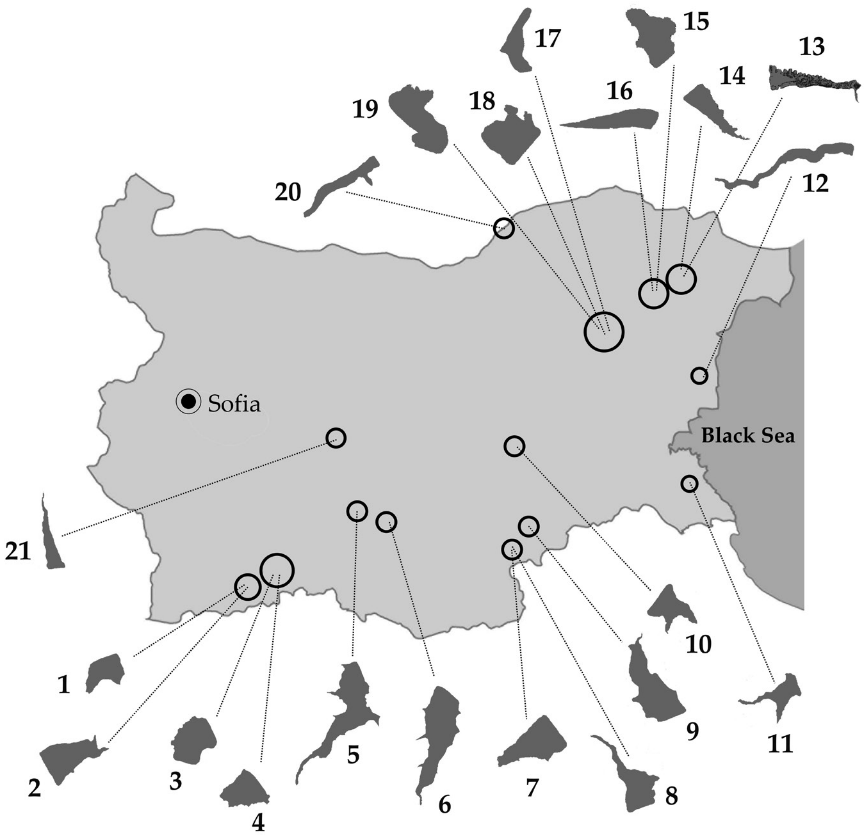


Fig. 1. Map of Bulgaria with location of the studied waterbodies. The waterbodies are represented by numbers that follow Table 1 (modified after Google Earth and Ginkgo maps).

Table 1. Sampling sites in Bulgarian waterbodies and their environmental parameters during summer sampling campaigns in years 2019 and 2021. Legend: WBN – name of the waterbody, IBW – identification number in Inventory of Bulgarian Wetlands (Michev & Stoyneva 2007), Abbr – abbreviation of the name, Alt – altitude above the sea level [m], WT – water temperature [° C], CN - conductivity [S m^{-1}], TDS – total dissolve solids [µg L^{-1}], DO – oxygen concentration [mg L^{-1}], TP - total phosphorus [µg L^{-1}], TN – total nitrogen [mg L^{-1}].

	WBN and IBW	Abbr	Year	Alt	Latitude	Longitude	WT	pH	CN	TDS	DO	TP	TN
1	Hadzhidimovo	Hd	2021	156	41º29.8933'	23º50.1890'	29.1	9.5	300	192	17.00	0.1	0.1
2	Dubnitsa (IBW3698)	Db	2021	600	41º33.8500'	23º50.7500'	25.2	9.6	246	159	9.21	0.1	0.1
3	Ablanitsa (IBW6013)	Ab	2021	682	41º32.8594'	23º55.5869'	27.2	8.8	242	157	8.54	1.0	0.5
4	Satovcha 2 (IBW1197)	Sv	2021	1017	41º36.8222'	23º58.1446'	27.4	8.70	272	176	9.00	0.5	0.1
5	Chetiridesette Izvora (IBW1523)	CI	2021	246	42º00.5510'	24º56.2819'	28.7	7.5	402	263	8.66	1.0	0.5
6	Mechka (IBW1584)	Mc	2021	319	41º55.8970'	25º06.1595'	27.1	9.0	241	154	8.50	1.5	1.0
7	Byalata Prust-Mezek	BP	2021	167	41º45.1080'	26º05.2403'	29.7	8.5	291	188	9.37	2.0	1.0
8	Birgo (Shtit)	Br	2021	215	41º49.7743'	26º22.1889'	27.3	8.0	594	385	8.75	1.5	1.8
9	Studena (Fishera) (IBW2421)	Sd	2021	282	41º54.2136'	26º24.5964'	29.3	9.0	652	423	3.35	1.0	0.3
10	Mogila (Kaynaka) (IBW2626)	Mg	2021	166	42º29.8310'	26º36.1043'	29.2	9.5	682	442	15.75	4.0	1.0
11	Hadzhi Yani (Lozenets) (IBW2893)	HY	2021	12	42º12.0333'	27º47.3000'	26.1	7.5	751	488	8.42	1.5	0.8
12	Yunets	Yn	2021	79	42º55.6700'	27º45.3074'	27.4	8.5	965	765	11.00	2.5	1.8
13	Plachidol 2 (IBW5073)	Plc	2019	220	43º33.3504'	27º52.6338'	24.6	9.0	1225	793	9.13	0.2	0.4
14	Yazovir Malka Smolnitsa (IBW3107)	MS	2019	211	43º36.2606'	27º44.5367'	25.2	9.1	755	490	7.05	0.6	0.6
15	Preselka (IBW3078)	Pr	2019	281	43º25.3767'	27º16.6214'	24.1	9.0	138	282	10.05	0.6	2.8
16	Izvornik 2 (IBW3082)	Iz	2019	255	43º27.3838'	27º21.1110'	24.5	9.4	389	253	13.26	9.0	4.8
17	Fisek (IBW2674)	Fs	2019	182	43º18.8453'	26º44.3765'	27.2	8.7	690	397	7.52	0.2	0.1
18	Shumensko Ezero (IBW2754)	SE	2019	152	43º14.8140'	26º57.5675'	25.2	8.5	471	445	6.32	0.2	0.5
19	Kriva Reka (IBW3071)	KR	2019	133	43º22.6573'	27º10.9807'	23.7	8.4	662	428	6.24	1.0	9.0
20	Nikolovo (IBW3176)	Nk	2021	89	43º50.9768'	26º05.1796'	26.0	9.8	2156	1400	11.88	11	2.0
21	Duvanli (IBW1483)	Dv	2019	250	42º23.1851'	24º43.1000'	26.3	8.8	4050	291	7.09	0.1	0.3

and, therefore, their identification numbers are provided in **Table 1**. We would like to note, that after our visit the unidentified waterbody near to village Vulkosel ("Vodoem do Vulkosel" in Bulgarian language), provided by IBW number 6013, has to be renamed as reservoir of Ablanitsa ("Yazovir Ablanitsa" in Bulgarian language), used mainly for local irrigation.

Aquameter AM-200 and Aquaprobe AP-2000 from Aquaread water monitoring instruments, 2012 Aquaread Ltd were used to prove the geographical coordinates and altitude, as well as for the *in situ* measurements of the physical and chemical water parameters (water temperature, pH, water hardness expressed by total dissolved solids, oxygen concentration, chlorophyll *a* and conductivity). The *ex situ* measurements of the total nitrogen (TN) and total phosphorus (TP) were done using Aqualytic AL410 Photometer from AQUALYTIC®, Dortmund, Germany - **Table 1**.

Regarding the sampling sites, it has to be boldly underlined that they were selected according to the identification of algal blooms as one of the main targets of the projects, and, therefore, the collection of water from inflatable boats was preceded by drone observations Methodological details and advantages of drone application have been provided in a set of our papers (Stoyneva-Gärtner et al. 2019, 2021, 2022, 2023; Radkova et al. 2020; Stefanova et al. 2020; Uzunov et al. 2021a, b; Valskys et al. 2022), but for the completeness of the methods description here, we recall that two types of drones (each supplied by a photo camera) have been used: DJI Mavic Pro, Model: M1P GL200A (SZ DJI Technology Co., LTD, Shenzhen, China) in 2018 and DJI Mavic 2 Enterprise Dual Pro (DJI Technolo-gy Co, LTD, Shenzhen, China) in 2019, 2021, which can measure the surface water temperature.

Algal identification and counting by light microscopy

At each site, a surface water sample (0.5-1.5 L) was collected for algal determination and counting by light microscopy (LM). These samples were immediately fixed with 2-4% formalin and transported in a dark box to the lab, where they were sedimented to 30 ml for at least 48 hours (Stoyneva-Gärtner et al. 2019, 2021, 2022, 2023; Radkova et al. 2020; Uzunov et al. 2021a, b). The taxonomic LM work was performed twice: 1) almost immediately after the collection on a Motic BA microscope with a Moticam 2000 camera, supported by Motic Images 2 Plus software program; 2) some months later, all samples were processed in a repetitive and comparative way on a Motic B1 microscopes supplied by a Moticam 2.0 mp camera with Motic Images 3 Plus software program. To ensure the consistency of LM data, the identification and counting was done by one and the same person (MPSG) (Stoyneva-Gärtner et al. 2023).

The algal identification was done on non-permanent slides under magnification 100x with application of immersion oil and was based on standard European taxonomic literature consulted with recent data in AlgaeBase (Guiry & Guiry

2023). The floristic similarity was based on Sørensen Correlation Index (SCI) with considering the presence/absence of the species (Sørensen 1948).

Algae were counted on a Thoma blood-counting chamber, in minimum four reiterations for each sample with the cell taken as the main counting unit and further estimation of the biomass (Stoyneva et al. 2015; Stoyneva-Gärtner et al. 2019, 2021, 2022, 2023; Radkova et al. 2020; Uzunov et al. 2021a). Likewise in our former article (Stoyneva-Gärtner et al. 2023), here the relative abundance of species is expressed using the modification of the Starmach's scale (Starmach 1955) according to the species contribution to the biomass Stoyneva 2000): "rare species" were those seen as single specimens in the whole microscopic slide (<0.5% of the biomass), "occasional species" – those represented by up to five specimens (<5% of the biomass), "common, or abundant species"– those seen with six to 30 specimens in a slide (5-20% of the biomass), whereas dominants and sub-dominants were evaluated among the most numerous species which contributed with >20 and >25% of the biomass, respectfully.

RESULTS

Total biodiversity of the phytoplankton

Total biodiversity of the phytoplankton comprises 414 species, varieties and forms from seven phyla (**Fig. 2**). Green algae were represented by the highest number of taxa (164), comprising 40% of the total biodiversity, with predominance of the phylum Chlorophyta (143, or 34%) over the second green phylum – Streptophyta (17, or 4%). Cyanoprokaryota, represented with 110 species, occupied the second place in the total taxonomic structure (27%), followed by Ochrophyta (70, or 17%, mainly diatoms – 55 taxa), Euglenophyta, Pyrrhophyta and Cryptophyta (**Fig. 2**).

Likewise in the total phytoplankton diversity, in almost all microreservoirs, chlorophytes were the main contributors to the phytoplankton structure: if the average number of species per waterbody was 36, about half of them (15) were green algae (14 chlorophytes and one streptophyte). The second position belonged to the blue-green algae (9 species per site), followed by yellow-brown algae (5, mainly diatoms - 4) and euglenophytes (4), with very low contribution of pyrrhophytes and cryptophytes - two and one species per site, respectively (**Fig. 3**).

Seven, or almost one third of the sampled microreservoirs, had total number of species over the calculated average per site, with the highest number (97) detected in Duvanli – **Fig. 3**. Only in Shumensko Ezero, commonly used for sport fishing, quite low number of species (9) was identified.

The number of widespread algae was very low: only 18 (or 4% from all) were found in more than 5 waterbodies. They belonged to Chlorophyta (8), Cyanoprokaryota (3), Pyrrhophyta (2), Euglenophyta (1) and Cryptophyta (1). The most widely spread chlorophytes were: *Tetraedron minimum* (16 sites), followed by *Coelastrum astroideum* and *Nephrochlamys subsolitaria* (each in 9 sites), *Golenkinia radiata* (8 sites) and *Oocystis lacustris* (7 sites), *Monactinus simplex*, *Monactinus simplex* var. *echinulatum* and *Tetradesmus lagerheimii* (each in 6 sites). The most widespread algae from other taxonomic groups in descending order of findings were: the pyrrhophytes *Parvodinium elpatiewskyi* (9 sites) and *Parvodinium goslaviense* (7 sites), the cyanoprokaryote *Planktolyngbya limnetica* and *Microcystis wesenbergii* (each in 7 sites), *Aphanizomenon klebahnii, Coelomoron pusilum, Microcystis aeruginosa* and *Pseudoanabaena limnetica* (each in 6 sites), as well as the cryptophyte *Cryptomonas erosa* (7 sites) and by the euglenophyte *Trachelomonas volvocina* (6 sites). No algal species was found as spread in all sampled microreservoirs, despite of their similar morphometry.

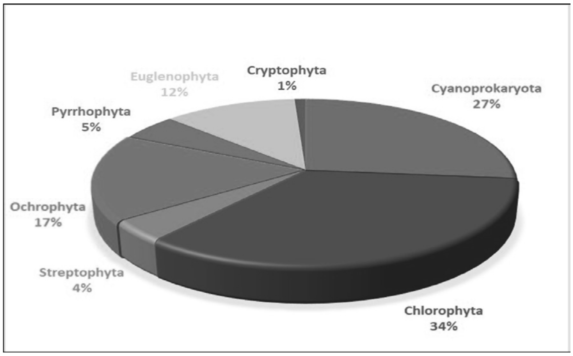


Fig. 2. Total biodiversity of the summer phytoplankton of 21 Bulgarian microreservoirs colected in the years 2019 and 2021.

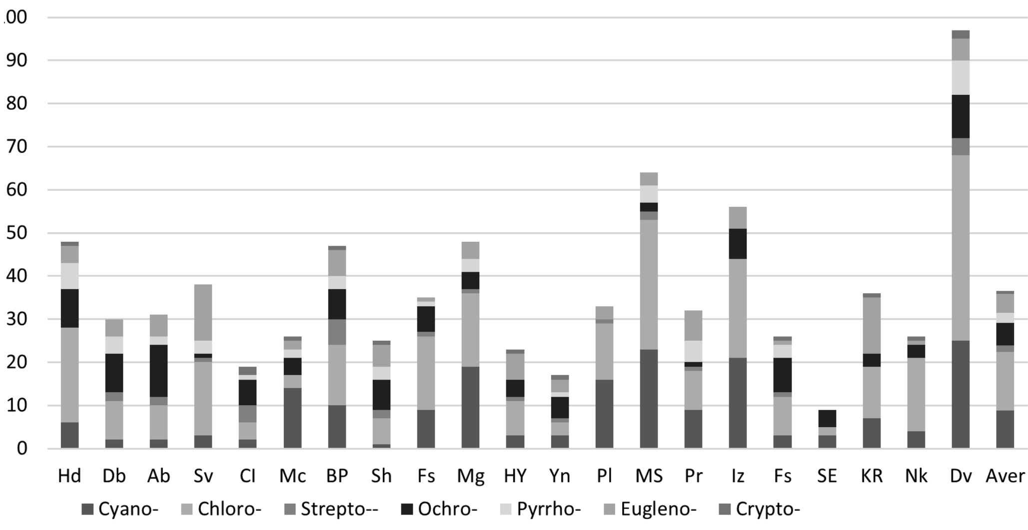


Fig. 3. Number of species in the main taxonomic phyla in the summer phytoplankton of 21 Bulgarian microreservoirs (abbreviations of their names follow those in **Table 1**) in comparison with their average number (Aver): Cyano – Cyanoprokaryota, Chloro – Chlorophyta, Strepto – Streptohyta, Pyrrho - Pyrrhophyta, Eugleno – Euglenophyta, Ochro - Ochrophyta, and Crypto – Cryptophyta.

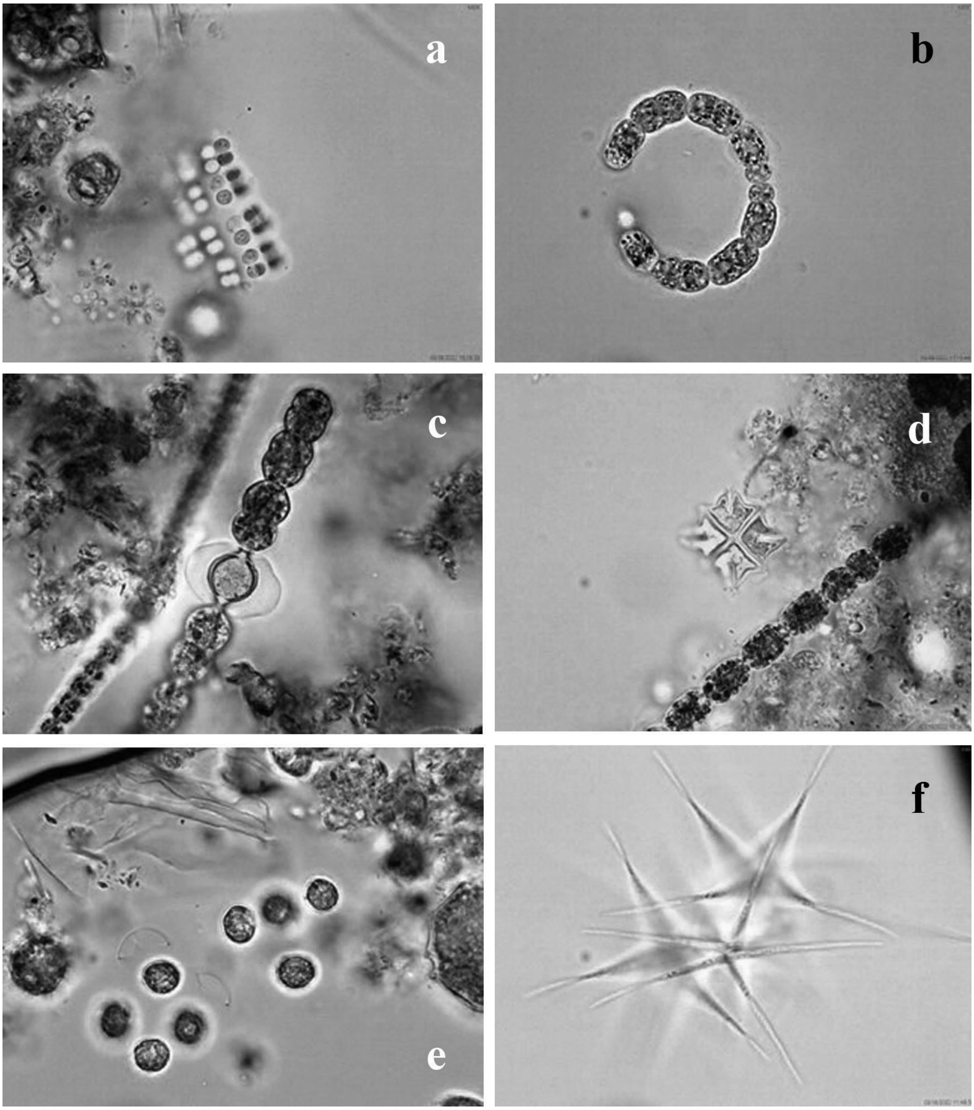
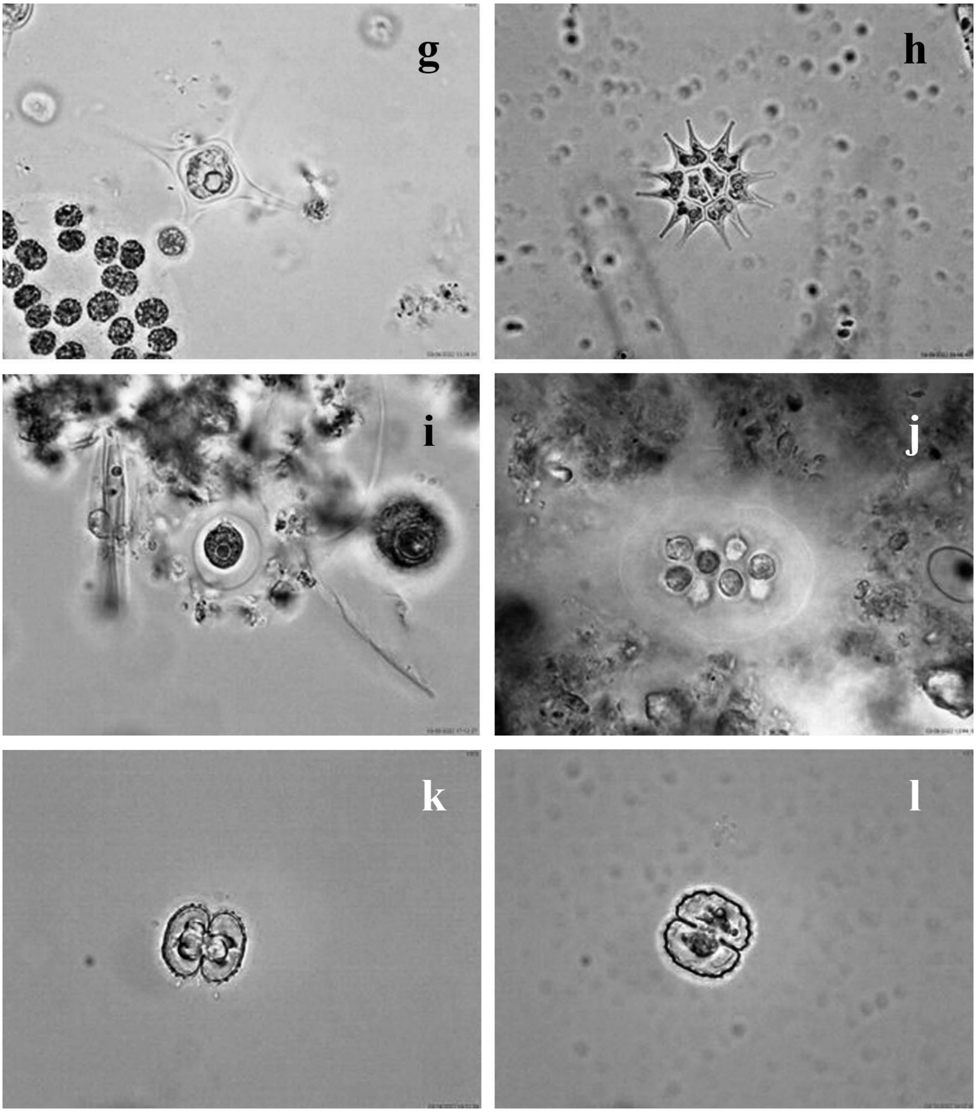
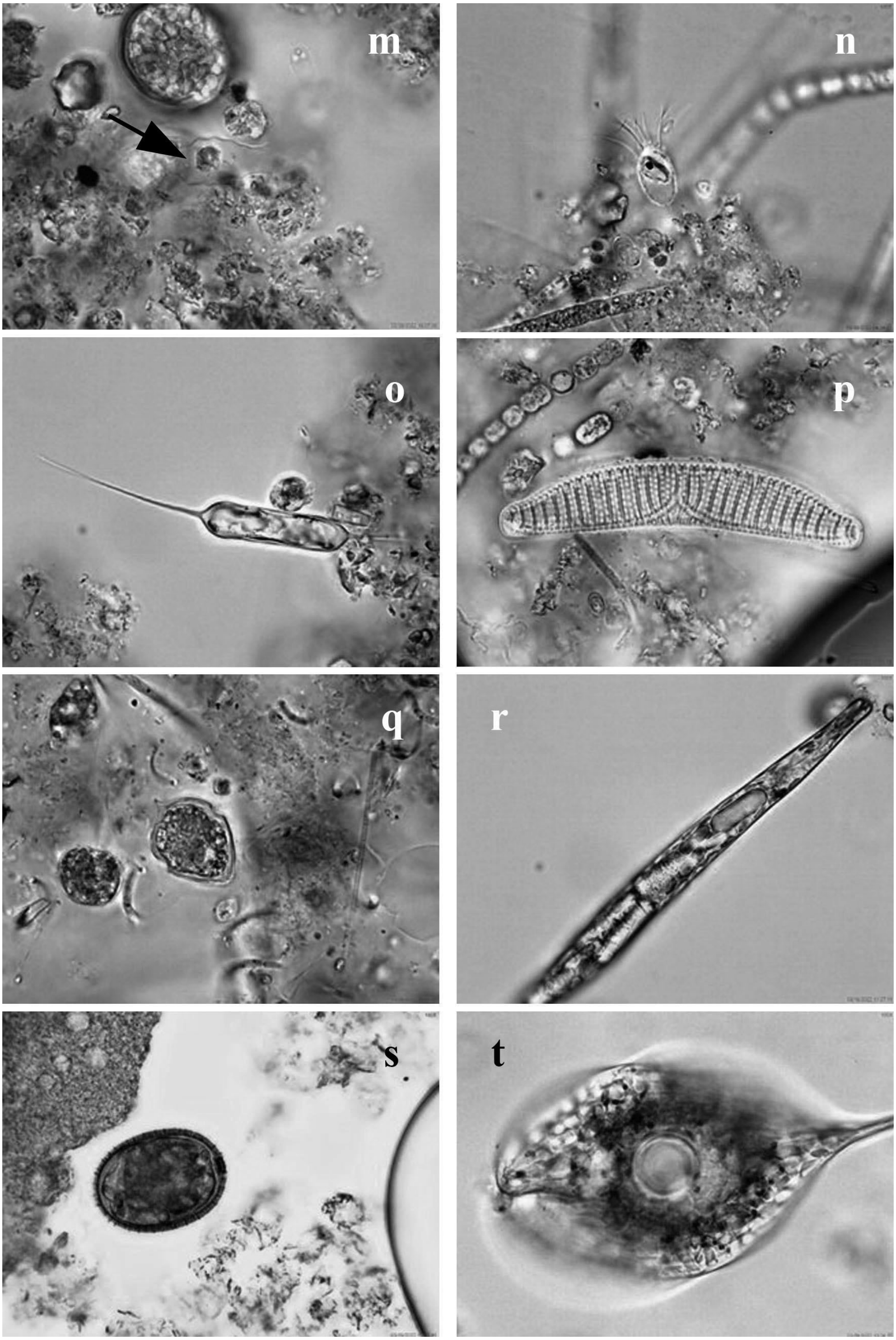


Fig. 4. Microphotos of algae from the phytoplankton samples of 21 microreservoirs in Bulgaria, organized by taxonomic groups*:* **a** - *Merismopedia tranquilla* (Ehrenberg) Trevisan 1845 in reservoir Mogila*;* **b** - *Anabaenopsis elenkinii* V. V. Miller 1923 in reservoir Mogila*;* **c** - *Dolichospermum scheremetieviae* (Elenkin) Wacklin, L. Hoffmann & Komárek 2013 in reservoir Yunets*;* **d** - *Stauridium tetras* (Ehrenberg) E. Hegewald 2005 and *Dolichospermum planctonicum* (Brunnthaler) Wacklin, L. Hoffmann & Komárek 2009 in reservoir Ablanitsa; **e** - *Neocystis ovalis* (Korshikov) Hindák 1988 in reservoir Hadzhidimovo; **f** - *Ankistrodesmus fusiformis* Corda 1838 in reservoir Satovcha 2; **g** - *Treubaria schmidlei* (Schröder) Fott & Kovácik 1975 in reservoir Nikolovo; **h** - *Pseudopediastrum boryanum* var. *longicorne* (Reinsch) P. M. Tsarenko 2011 in reservoir Studena; **i** - *Vitreochlamys fluviatilis* (F. Stein) Batko 1970 in reservoir Yunets; **j** - *Eudorina cylindrica* Korshikov 1938 in reservoir Hadzi Yani; **k** - *Cosmarium phaseolus*



var. *elevatum* Nordstedt 1873 in reservoir Dubnitsa; **l** - *Cosmarium subcostatum* Nordstedt in reservoir Chetiridesette Izvora; **m** - *Dinobryon sertularia* var. *annulatum* Z. X. Shi et Y. X. Wei (arrow) in reservoir Birgo; **n** - *Mallomonas* cf. *tonsurata* Teiling 1912 in reservoir Studena; **o** - *Centritractus belenophorus* (Schmidle) Lemmermann 1900 in reservoir Byalata Prust-Mezek; **p** - *Epithemia adnata* (Kützing) Brébisson 1838 in reservoir Yunets; **q** - *Parvodinium goslaviense* (Wołoszyńska) Carty 2008 - in reservoir Mechka; **r** - *Lepocinclis longissima* (Deflandre) Zakryś & Chaber – in reservoir Satovcha 2; **s** - *Trachelomonas hispida* (Perty) F. Stein 1878 in reservoir Birgo; **t** - *Phacus convexus* Zakryś & Łukomska 2020 in reservoir Hadzhi Yani.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Most the algal taxa (256, or 61%) were found in a single waterbody, and most of them were with very low abundance, found as single specimens (**Table 2**). In the same time, altogether 46 algae were identified as dominants, co-dominants or sub-dominants (**Table 2**). Among them the most significant were cyanoprokaryotes (25 species, out of which 17 dominated/co-dominated in 12 waterbodies and 11 were sub-dominants in seven microreservoirs), followed by Euglenophyta (seven species: three dominants in two microreservoirs and four sub-dominants in three microreservoirs), Pyrrhophyta (five species, out of which four dominants in five microreservoirs and two were sub-dominants in three microreservoirs), Chlorophyta (four species: one dominant and three sub-dominants in one and two microreservoirs, respectively), Ochrophyta (two species dominating, each in a single microreservoir) and Streptophyta (two varieties, dominat-ing and sub—dominating, each in a single microreservoir) – **Table 2**.

Florisric similarity of the studied sites

The floristic similarity between the microreservoirs was quite low, with values of SCI varying between 0 and 43%, and being mostly between 1-20%: 50% of the microreservoirs were with similarity between 1 and 10%, 35% were with similarity between 11 and 20%. Only three sites (1%) showed similarity between 21 and 30% - Mogila, Duvanli and Malka Smolnitsa (**Table 3**), and the highest similarity (43%) was estimated for Mogila and Preselka. It has to be noted that 9% of the estimated SCI values were 0, or that 18 pairs of sites had no similarity with each other. Among them the most striking was the lack of similarity between Shumensko Ezero and 13 other microreservoirs. Detaileded checking of the common species between each pair of microreservoirs revealed that in most of the cases, the similarity was due to species with low abundance in the studied microreservoirs.

DISCUSSION

Results from the present study demonstrated high phytoplankton diversity in the sampled microreservoirs, in which 414 taxa (species, varieties and forms) from seven phyla were identified. The green algae, represented by 160 species (39% from all identified taxa) comprised the taxonomically richest group and were followed by Cyanoprokaryota (110 species). Although occupying the second place in the taxonomical structure, cyanoprokaryotes comprised the highest number of species in dominant and sub-dominant complexes: 23 species out of the totally 46 algae with such significant quantitative role. This is consistent with our previous results obtained on the quantitative phytoplankton structure, according to which blue-greens dominated in 13 of the discussed in this paper microreservoirs (*i.e.*, Chetiridesette Izvora, Duvanli, Fisek, Hadzhi Yani, Izvornik 2, Mogila, Kriva Reka, Malka Smolnitsa, Nikolovo, Plachidol 2, Preselka, Satovcha 2, Yunets) and with the well-known summer dominance of cyanoprokaryotes in nutrient-rich waters in lowlands, plains and kettles (for details see Stoyneva-Gärtner et al. 2023).

Table 2. Species composition of the summer phytoplankton in 21 microreservoirs in Bulgaria, organized by A-Z order in each taxonomic group. Abbreviations of the waterbodies names follow those in **Table 1; d** - dominant/co-dominant, **s** - subdominant; **f** - frequent; **c** - common; **r** - rare/very rare

Taxa/Sample	**Hd**	**Db**	**Ab**	**Sv**	**CI**	**Mc**	**BP**	**Br**	**Sd**	**Mg**	**HY**	**Yn**	**Pl**	**MS**	**Pr**	**Iz**	**Fs**	**SE**	**KR**	**Nk**	**Dv**
Cyanoprokaryota																					
Anabaena minderi Huber-Pestalozzi 1938												r									
Anabaena sp. ster.						r															
Anabaenopsis arnoldii Aptekar 1926														f							
Anabaenopsis circularis (G. S. West) Wołoszyńska et V. V. Miller 1923																			c		r
Anabaenopsis cunningtonii W. R. Taylor 1932														r							
Anabaenopsis elenkinii V. V. Miller 1923										d											r
Anabaenopsis milleri Woronichin 1929																s					
Anagnostidinema acutissimum (Kufferath) Strunecký, Bohunická, J. R. Johansen et J. Komárek 2017										c											
Anagnostidinema amphibium (C. Agardh ex Gomont) Strunecký, Bohunická, J. R. Johansen et J. Komárek 2017		r	r		r		r						f								
Anagnostidinema pseudacutissimum (Geitler) Strunecký, Bohunická, J. R. Johansen & J. Komárek 2017																					r
Anathece smithii (Komárková-Legnerová et Cronberg) Komárek, Kastovsky et Jezberová 2011																			r		
Aphanizomenon gracile Lemmermann 1907				r			r														
Aphanizomenon klebahnii (Elenkin) Pechar et Kalina ex Komárek et Komárková 2006						c	c			r	s		f								

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Aphanizomenon cf. *manguinii* Bourrelly 1952									c												
Aphanizomenon yezoense M. Watanabe 1991							r		d												
Aphanocapsa conferta (West et G. S. West) Komárková-Legnerová et Cronberg 1994								c	r												f
Aphanocapsa delicatissima West et G. S. West 1912						r											r	s			
Aphanocapsa fusco-lutea Hansgirg 1893																			f		
Aphanocapsa holsatica (Lemmermann) G. Cronberg et Komárek 1994											s					f					
Aphanocapsa nubila Komárek et H. J. Kling 1991													r								
Aphanocapsa planctonica (G. M. Smith) Komárek & Anagnostidis 1995																r					
Aphanothece elabens (Meneghini) Elenkin 1936																					c
Chroococcus distans (G. M. Smith) Komárková-Legnerová & Cronberg 1994													r								
Chroococcus limneticus var. *elegans* G. M. Smith 1918													r								
Chroococcus minimus (Keissler) Lemmer-mann 1904				r																	
Chroococcus minutus (Kützing) Nägeli 1849			c								r							c			
Chrysosporum minus (Kisselev) Komárek 2012													d								
Chrysosporum sp. ster.														f							
Coelomoron pusillum (Van Goor) Komárek 1988							c			r					c	r			s		c
Coelomoron sp.							r														

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Coelosphaerium aerugineum Lemmermann 1898																					c
Cronbergia planctonica Komárek, Zapomelová & Hindák 2010													r								
Cuspidothrix elenkinii (I. A. Kisselev) P. Rajaniem, J. Komárek, R. Willame, P. Hrouzek, K. Kastovská, L. Hoffmann et K. Sivonen 2005						r	c			c											
Cuspidothrix issatschenkoi (Usachev) P. Rajaniemi, Komárek, R. Willame, P. Hrouzek, K. Kastovská, L. Hoffmann et K. Sivonen 2005										d			r			r					r
Cuspidothrix tropicalis (Horecká et Komárek) Rajaniem et al. 2005							c		c	c	r										
Cuspidothrix cf. *tropicalis* (Horecká et Komárek) Rajaniem et al. 2005/? *Umezakia* sp.(fig 979 in Komarek 2013)									c		r										
Dolichospermum cf. *affine*																r					
Dolichospermum compactum (Nygaard) P. Wacklin, L. Hoffmann et J. Komárek 2009										f						d					
Dolichospermum flos-aquae (Bornet et Flahault) P. Wacklin, L. Hoffmann et Komárek 2009										c											
Dolichospermum mucosum (Komárková-Legnerová & Eloranta) Wacklin, L. Hoffmann & Komárek 2009																r					
Dolichospermum perturbatum (H. Hill) Wacklin, L. Hoffmann et Komárek 2009																s					
Dolichospermum planctonicum (Brunnthaler) Wacklin, L. Hoffmann et Komárek 2009			d			c															
Dolichospermum scheremetieviae (Elenkin) Wacklin, L. Hoffmann et Komárek 2013												d									

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Dolichospermum cf. *tenericaule* (Nygaard) E. Zapomelová, O. Skácelová, P. Pumann, R. Kopp & E. Janecek 2012										c											
Dolichospermum sp. ster. 1							r														
Dolichospermum sp. ster. 2																c					
Geitlerinema sp.							r														
Glaucospira laxissima (G. S. West) Simic, Komárek & Dordevic 2014													f	c	f						d
Gloeocapsa sp.																r					
Jaaginema geminatum (Schwabe ex Gomont) Anagnostidis et Komárek 1988																					r
Jaaginema gracile Anagnostidis et Komárek 1988																c					
Jaaginema metaphyticum Komárek 1988														r							
Lemmermanniella pallida (Lemmermann) Geitler 1942																					r
Limnococcus limneticus (Lemmermann) Komárková, Jezberová, O. Komárek et Zapomelová 2010							r		r								r			r	c
Limnothrix planctonica (Wołoszyńska) Meffert 1988												r									
Limnothrix redekei (Goor) Meffert 1988														f	d						
Limnothrix sp. 1								r													
Limnothrix sp. 2											r										
Merismopedia glauca (Ehrenberg) Kützing 1845																r					
Merismopedia tenuissima Lemmermann 1898																			f		

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Merismopedia tranquilla (Ehrenberg) Trevisan 1845	r									r				c		c					
Merismopedia warmingiana (Lagerheim) Forti 1907														f	r						
Microcystis aeruginosa (Kützing) Kützing 1846										c			c	r	r	r					r
Microcystis comperei Komárek 1984																c					r
Microcystis flos-aquae (Wittrock) Kirchner 1898	r									c						c					
Microcystis microcystiformis (Hindák) Joosten 2006																r					
Microcystis natans Lemmermann ex Skuja 1934																c					f
Microcystis cf. *natans* Lemmermann ex Skuja 1934																					r
Microcystis pseudofilamentosa Crow 1923										r			r	r							r
Microcystis smithii Komárek et Anagnostidis 1995									r					c							
Microcystis cf. *viridis* (A. Braun) Lemmermann 1903														r	r						r
Microcystis wesenbergii (Komárek) Komárek ex Komárek 2006													c	c	r	c			d	d	r
Microcystis cf. *wesenbergii* (Komárek) Komárek ex Komárek 2006														r					f		
Microcystis sp. juv.															r						
Microcystis spp. - separate cells													r	r	r	c	r	r			s
Myxobactron sp.	r																				
Oscillatoria sancta Kützing ex Gomont 1892										r											
Oscillatoria simplicissima Gomont 1892						r															
Oscillatoria tenuis C. Agardh ex Gomont 1892		r																		r	

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Oscillatoria sp.																r					
Phormidium terebriforme (C. Agardh ex Gomont) Anagnostidis & Komárek 1988																r					
Phormidium sp.																					r
Planktolyngbya limnetica (Lemmermann) Komárková-Legnerová et Cronberg 1992	r				r	r	c		f				r	r							c
Planktolyngbya spp.	r					r	r														
Planktothrix isothrix (Skuja) Komárek et Komárková 2004														c	r						
Planktothrix suspensa (Pringsheim) Anagnostidis & Komárek 1988				f																	
Pseudanabaena articulata Sjuka 1948										r			r								r
Pseudanabaena catenata Lauterborn 1915						r															
Pseudanabaena galeata Böcher 1949												r				c					
Pseudanabaena limnetica (Lemmermann) Komárek 1974						r						r	r	d	s						d
Pseudanabaena mucicola (Naumann et Huber-Pestalozzi) Schwabe 1964	r																			s	
Raphidiopsis acuminato-crispa (Couvy et Bouvy) Aguilera, Berrendero Gómez, Kastovsky, Echeniqe et Salerno 2018						s															
Raphidiopsis africana (Komárek et H. Kling) Aguilera et al. 2018						c															
Raphidiopsis cuspis (Komárek & Kling) Aguilera, Berrendero Gómez, Kastovsky, Echenique & Salerno 2018						s															
Raphidiopsis gangetica (G. U. Nair) Aguilera, Berrendero Gómez, Kastovsky, Echenique et Salerno 2018						d															

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Raphidiopsis mediterranea Skuja 1937										f			f	f							
Raphidiopsis philippinensis (W. R. Taylor) Aguilera, Berrendero Gómez, Kastovsky, Echenique et Salerno 2018														r							
Raphidiopsis raciborskii (Woloszynska) Aguilera et al. 2018						d	s			f				d	s						
Raphidiopsis setigera (Aptekarj) Eberly 1966										f											
Raphidiopsis turcomanica Kogan 1967						c															
Romeria simplex (Hindák) Hindák 1988																f					d
Snowella lacustris (Chodat) Komárek et Hindák 1988														r		c					c
Snowella litoralis (Häyrén) Komárek et Hindák 1988													r								c
Snowella sp.				r																	
Sphaerospermopsis aphanizomenoides (Forti) Zapomelová, Jezberová, Hrouzek, Hisem, Reháková et Komárková 2010							c		d	f				f							
Sphaerospermopsis cf. *reniformis* (Lemmermann) Zapomelová, Jezberová, Hrouzek, Hisem, Reháková et Komárková 2010									c												
Synechococcus endogloeicus Hindák 1996													r								
Synechococcus epigloeicus Hindák 1996													c								
Synechocystis endobiotica (Elenkin et Hollerbach) Elenkin 1938													c								
Trichodesmium iwanoffianum Nygaard 1926												r									
Wollea sp.									r												

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Chlorophyta																					
Acanthosphaera zachariasii Lemmermann 1899														r							c
Actinastrum hantzschii Lagerheim 1882									c												
Actinastrum hantzschii var. *subtile* Woloszynska 1911																					r
Amphikrikos buderi (Heynig) Hindák 1977																					c
Amphikrikos hexacosta (R. H. Thompson) Hindák 1977															r						
Ankistrodesmus fusiformis Corda 1838				f			c														
Ankistrodesmus tortus Komárek et Comas González 1982		r																			
Ankyra judayi (G. M. Smith) Fott 1957																c					r
Binuclearia lauterbornii (Schmidle) Proshkina-Lavrenko 1966																	r				
Botryococcus braunii Kützing 1849											r										
Carteria sp.				r																	
Chlamydomonas sp.											r			c		r				f	
Chlorella elongata (Hindák) C. Bock, Krienitz et Pröschold 2011																					r
Chlorogonium sp.																r					
Choricystis sp.																		r			
Closteriopsis longissima (Lemmermann) Lemmermann 1899							c														
Coelastrum astroideum De Notaris 1867	s			c	c		r	r	r					f	r						r
Coelastrum microporum Nägeli 1855												r									

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Coelastrum microporum var. *octaëdricum* (Skuja) Sodomková 1972																	f				
Coelastrum pseudomicroporum Korshikov 1953										f				r							
Coelastrum pulchrum Schmidle 1892																					c
Coelastrum reticulatum (P. A. Dangeard) Senn 1899	f							r													
Coelastrum reticulatum var. *cubanum* Komárek 1975									f												
Coelastrum sphaericum Nägeli 1849																					r
Coenochloris fottii (Hindák) P. M. Tsarenko 1990		c																		f	
Desmodesmus abundans (Kirchner) E. H. Hegewald 2000	c			r						r										r	
Desmodesmus armatus (Chodat) E. H. Hegewald 2000									r												
Desmodesmus bicaudatus (Dedusenko) P. M. Tsarenko 2000																r					
Desmodesmus bicellularis (Chodat) S. S. An, T. Friedl et E. Hegewald 1999	r	c	r																		
Desmodesmus communis (E. Hegewald) E. Hegewald 2000									r				r	r							c
Desmodesmus denticulatus (Lagerheim) S. S. An, T. Friedl et E. Hegewald 1999																r					
Desmodesmus granulatus (West et G. S. West) P. M. Tsarenko 2000																r				f	
Desmodesmus hystrix (Lagerheim) E. Hegewald 2000																				r	
Desmodesmus intermedius (Chodat) E. Hegewald 2000	r																		r		

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Desmodesmus insignis (West et G. S. West) E. Hegewald 2000			r																		
Desmodesmus magnus (Meyen) P. M. Tsarenko 2000															r						
Desmodesmus opoliensis (P. G. Richter) E. Hegewald 2000									r												r
Desmodesmus opoliensis var. *carinatus* (Lemmermann) E. Hegewald 2000	f																				
Desmodesmus opoliensis var. *mononensis* (Chodat) E. Hegewald 2000	r			r										r		c					f
Desmodesmus pannonicus (Hortobágyi) E. Hegewald 2000														c							
Desmodesmus pleiomorphus (Hindák) E. Hegewald 2000														r							
Scenedesmus praetervisus Chodat 1926									r												
Desmodesmus protuberans (F. E. Fritsch et M. F. Rich) E. Hegewald 2000																			r		
Desmodesmus spinosus (Chodat) E. Hegewald 2000				r												r					c
Desmodesmus subspicatus (Chodat) E. Hegewald et A. W. F. Schmidt 2000														r							
Dictyosphaerium granulatum Hindák 1977														r							
Dictyosphaerium simplex Korshikov 1953																			f		
Didymocystis comasii Komárek 1983	c																r				r
Diplochloris sp.														c							
Echinosphaeridium quadrisetum Behre 1956																					c
Echinosphaeridium nordstedtii Lemmermann 1904													c			r					c

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Echinosphaeridium sp.	r																				
Elakatothrix inflexa Hindák 1966			c																		
Elakatothrix lacustris Korshikov 1953														r							
Eudorina cylindrica Korshikov 1938											r										r
Eudorina elegans Ehrenberg 1832																				r	
Franceia javanica (C. Bernard) Hortobágyi 1962																				r	
Golenkinia radiata Chodat 1894	f			f				r					s	f	r	c					r
Hegewaldia parvula (Woronichin) Pröschold, C. Bock, W. Luo et L. Krienitz 2010										c											
Hindakia tetrachotoma (Printz) C. Bock, Pröschold et Krienitz 2010																					c
Granulocystis chlamydomonadoides Hindak 1980										c											r
Granulocystis helenae Hindák 1977				r																	
Granulocystopsis decorata (Svirenko) P. M. Tsarenko 2000																r					r
Juranyiella javorkae (Hortobágyi) Hortobágyi 1962																					r
Komarekia appendiculata (Chodat) Fott 1981									r												
Korshikoviella limnetica (Lemmermann) P. C. Silva 1959										f											
Korshikoviella mystacina (Hortobágyi et Németh) Philipose 1967														r							
Lacunastrum gracillimum (West et G. S. West) H. McManus in McManus et al. 2011				c						r					r						r
Lagerheimia ciliata (Lagerheim) Chodat 1895														r			r				

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Lemmermannia komarekii (Hindák) C. Bock et Krienitz 2013										r										r	
Lemmermannia tetrapedia (Kirchner) Lemmermann 1904				r	r														c		
Lemmermannia triangularis (Chodat) C. Bock et Krienitz 2013		r																			
Lobocystis sp.													r		r						
Lobomonas ampla Pascher 1927																r					
Messastrum gracile (Reinsch) T. S. Garcia 2016																					r
Micractinium crassisetum Hortobágyi 1973													r								
Micractinium pusillum Fresenius 1858	c												r								
Monactinus simplex (Meyen) Corda 1839	r	f							c		d									c	c
Monactinus simplex var. *echinulatum* (Wittrock) Pérez, Maidana et Comas 2009		r							c		c			f						c	c
Monactinus simplex var. *sturmii* (Reinsch) Pérez, Maidana et Comas 2009																					
Monoraphidium griffithii (Berkeley) Komárková-Legnerová 1969				r																	
Monoraphidium komarkovae Nygaard 1979													r								
Mucidosphaerium pulchellum (H. C. Wood) C. Bock, Proschold et Krienitz 2011										r											
Mychonastes fluviatilis (Hindák) Krienitz, C. Bock, Dadheech et Proschold 2011							f									c					f
Nephrochlamys subsolitaria (G. S. West) Korshikov 1953				c						f				c	r	r	r		r	r	r
Neocystis ovalis (Korshikov) Hindák 1988	f																				

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Oocystis lacustris Chodat 1897			c						f		c			r		f			r	c	
Oocystis parva West et G. S. West 1898				c																	
Oocystis sp. 1					r																
Oocystis sp. 2						r	r	r													
Oocystella sp.																					f
Oonephris obesa (West et G. S. West) Fott 1964																	f				
Pachycladella sp.																					r
Pandorina morum (O. F. Müller) Bory 1826										r						f					
Pediastrum duplex Meyen 1829																r					
Polyedriopsis spinulosa (Schmidle) Schmidle 1899				f						f			r								f
Pseudocharacium acuminatum Korshikov 1953								r													
Pseudodidymocystis lineata (Korshikov) Hindák 1990																			r		
Pseudopediastrum boryanum (Turpin) E. Hegewald 2005									r											r	
Pseudopediastrum boryanum var. *longicorne* (Reinsch) P. M. Tsarenko 2011									r				c								
Quadricoccus ellipticus Hortobágyi 1973							r														
Radiococcus sp.																	r				
Scenedesmus acuminatus var. *elongatus* G. M. Smith 1926														c							r
Scenedesmus acunae Comas Gonzáles 1980																				f	
Scenedesmus apiculatus var. *indicus* Hortobágyi 1969																c					

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Scenedesmus ecornis (Ehrenberg) Chodat 1926		r	c				c												r		
Scenedesmus ecornis var. *concavus* Hortobágyi 1969														r							
Scenedesmus ellipticus Corda 1835 (= *Scenedesmus linearis* Komárek 1974)		f	r											r							
Scenedesmus nanus var. *spinosus* Chodat 1913													r	r						r	r
Scenedesmus cf. *nanus* var. *spinosus* Hortobágyi 1969	c																				
Scenedesmus obtusus Meyen 1829	r							r									r				r
Scenedesmus obtusus f. *disciformis* (Chodat) Compère 1977																r					
Scenedesmus quadricauda (Turpin) Brébisson 1835	c									c				r							
Scenedesmus quadrispina Chodat 1913							r														
Scenedesmus semipulcher Hortobágyi 1960																					r
Scenedesmus cf. *soli* Hortobágyi 1960	r													r							
Scenedesmus subspicatus Chodat 1926																			c		
Scenedesmus sp.																					r
Schroederia setigera (Schröder) Lemmermann 1898				c		r			c										r		
Siderocelis kolkwitzii (Naumann) Fott 1934																			r		
Siderocystopsis pseudoblonga (Hindák) Hindák 1984														f							
Stauridium tetras (Ehrenberg) E. Hegewald 2005			c				r											r			
Tetradesmus cumbricus var. *apiculatus* Korshikov 1953																r					

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Tetraëdron caudatum (Corda) Hansgirg 1888													r								
Tetraëdron minimum (A. Braun) Hansgirg 1889	f	r	f	f	r	f	c		r	f		r	r	f	c	c	c				c
Tetraëdron punctulatum (Reinsch) Hansgirg 1889											r										
Tetraëdron triangulare Korshikov 1953														f							
Tetradesmus dimorphus (Turpin) M. J. Wynne 2016	f									c					c						r
Tetradesmus lagerheimii M. J. Wynne et Guiry 2016	r						r			c				r					c		r
Tetradesmus lagerheimii var. *tetradesmoides* (G. M. Smith) Taşkin et Alp 2019										r											r
Tetradesmus obliquus (Turpin) M. J. Wynne 2016																					r
Tetrallantos lagerheimii Teiling 1916	s			r			f														
Tetrastrum glabrum (Y. V. Roll) Ahlstrom et Tiffany 1934							f			r											
Tetrastrum heteracanthum (Nordstedt) Chodat 1895																				r	
Tetrastrum staurogeniaeforme f. *brasiliense* C.E.M.Bicudo et Ventrice 1968													r	r							
Thelesphaera alpina Pascher 1943									f												
Thoracomonas sp.											c					r					
Treubaria planctonica (G. M. Smith) Korshikov 1953									r							r					r
Treubaria schmidlei (Schröder) Fott et Kovácik 1975														r						r	
Treubaria sp.																					c

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Vitreochlamys fluviatilis (F. Stein) Batko 1970												c									
Vitreochlamys gloeosphaera (Pascher et Jahoda) Masjuk 2003																					f
Willea apiculata (Lemmermann) D. M. John, M. J. Wynne et P. M. Tsarenko 2014							c														
Streptophyta																					
Closterium aciculare T. West 1860								c													
Closterium limneticum Lemmermann 1899							c		r	r	c										r
Closterium venus Kützing ex Ralfs 1848			r																		
Cosmarium contractum O. Kirchner 1878													r								
Cosmarium depressum var. *planctonicum* Reverdin 1919							c							c			d				r
Cosmarium laeve Rabenhorst 1868			c	r																	
Cosmarium phaseolus Brébisson ex Ralfs 1848							r														
Cosmarium phaseolus var. *elevatum* Nordstedt 1873		s			c																
Cosmarium porteanum f. *extensum* G. W. Prescott 1981								r													
Cosmarium regnellii var. *minimum* Eichler et Gutwinski 1894														r							
Cosmarium subcostatum Nordstedt 1876					r																
Gonatozygon kinahanii (W. Archer) Rabenhorst 1868					r										f						c
Hyalotheca sp.							r														
Mougeotia sp.							r					c									

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Staurastrum anatinum Cooke et Wills 1881					r		r														
Staurastrum chaetoceras (Schröder) G. M. Smith 1924																					c
Staurodesmus cuspidatus (Brébisson) Teiling 1967		r																			
Pyrrhophyta																					
Biecheleria pseudopalustris (J. Schiller) Moestrup, K. Lindberg et Daugbjerg 2009														c							
Ceratium furcoides (Levander) Langhans 1925	r													r	c						r
Ceratium rhomvoides B. Hickel 1988																					r
Ceratium hirundinella (O. F. Müller) Dujardin 1841									r												
Glenodiniopsis uliginosa (A. J. Schilling) Wołoszyńska 1928								f		c		f									
Gymnodinium saginatum T. M. Harris 1940				c																	
Gymnodinium schuettii J. Schiller 1955						r															
Gymnodinium schuettii J. Schiller 1955																	r				
Gymnodinium wawrikae J. Schiller 1955		r	c																		
Kolkwitziella acuta (Apstein) Elbrächter 1993					r																
Parvodinium cunningtonii (Lemmermann) Pandeirada, Craveiro, Daugbjerg, Moestrup et A. J. Calado 2022	r	r	d												f						c
Parvodinium elpatiewskyi (Ostenfeld) Kretschmann, Zerdoner et Gottschling 2019		d		s			r	d		c				r	c		f				r
Parvodinium goslaviense (Wołoszyńska) Carty 2008	r			r		s	r			s/r					c						r

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Parvodinium umbonatum (F. Stein) Carty 2008	d						r	c													
Parvodinium umbonatum var. *spiniferum* (M. Lefèvre) Moestrup 2018	r																r				
Peridinium bipes F. Stein 1883	r																				
Peridiniopsis borgei Lemmermann 1904		r																			
Peridiniopsis cunningtonii var. *excavata* (M. Lefèvre) Moestrup 2018																					r
Sphaerodinium polonicum Wołoszyńska 1916																					d
Sphaerodinium sp.															r						
Tovellia apiculata (Stosch) Moestrup, K. Lindberg et Daugbjerg 2005																					r
Tyrannodinium edax (A.J.Schilling) Calado 2011														r							
Euglenophyta																					
Anisonema sp.																f					
Colacium sp.		c																			
Discoplastis gasterosteus (Skuja) Zakryś et Łukomska 2021	c																				
Discoplastis spathirhyncha (Skuja) Triemer 2006															r	f			s		r
Euglena hemichromata Skuja 1948										f	c	c							r		
Euglena pavlovskoënsis (Elenkin et Poljanski) T. G. Popova 1951																			s		
Euglena texta (Dujardin) Hübner 1886																					r
Euglena sp. 1																			r		
Euglena sp. 2															c				c		

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Euglena sp. 3															c						
Euglena sp. 4																r					
Euglena sp. 5																					r
Euglenaformis proxima (P. A. Dangeard) M. S. Bennett et Triemer 2014		c	c			r								f							
Euglenaria clavata (Skuja) Karnkowska et E. W. Linton 2010				d						c			c								
Lepocinclis acicularis Francè 1894				r																	
Lepocinclis acus (O. F. Müller) B. Marin et Melkonian 2000	r						r				r		r								
Lepocinclis globulus Perty 1849							r														
Lepocinclis fominii (Y. V. Roll) Zakryś et Łukomska 2019												r									
Lepocinclis fusiformis var. *amphirhynchus* Nygaard 1950																					r
Lepocinclis longissima (Deflandre) Zakryś et Chaber 2022				r								r									
Lepocinclis sp.			r																r		
Monomorphina nordstedtii (Lemmermann) T. G. Popova 1955				f																	
Monomorphina pyrum (Ehrenberg) Mereschkowsky 1877				c			r			c				f	r						
Phacus acuminatus A. Stokes 1885							r														
Phacus caudatus Hübner 1886													r						r		
Phacus convexus Zakryś et Łukomska 2020															r				c		
Phacus curvicauda Svirenko 1915											d										
Phacus tortus (Lemmermann) Skvortzov 1928		r					r				f										

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Phacus onyx Pochmann 1942																			r		
Phacus orbicularis Hübner 1886											r								r		
Phacus pleuronectes (O. F. Müller) Nitzsch ex Dujardin 1841																			r		
Phacus textus Pochmann 1942											f										
Strombomonas australica var. *fusiformis* T. Yamagishi 2016				r																	
Strombomonas fluviatilis (Lemmermann) Deflandre 1930																			c		
Strombomonas planctonica (Wołoszyńska) T. G. Popova 1955							r														
Strombomonas urceolata (A. Stokes) Deflandre 1930				r																	
Trachelomonas dybowskii Drežepolski 1923				c																	
Trachelomonas hispida (Perty) F. Stein 1878				f				s							r					c	r
Trachelomonas hispida var. *crenulatocollis* (Maskell) Lemmermann 1910				c																	
Trachelomonas intermedia P. A. Dangeard 1902				s				r	r												
Trachelomonas intermedia f. *papillata* (Skuja) T. G. Popova 1966								r													
Trachelomonas pavlovskoensis (Poljanskij) Popova 1955										r											
Trachelomonas planctonica Svirenko 1914				r																	
Trachelomonas volvocina (Ehrenberg) Ehrenberg 1834	r		c	d				f							f				r		
Trachelomonas volvocina var. *subglobosa* Lemmermann 1913	r		c					f								f					
Trachelomonas sp.		f	c			r															

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Urceolus cyclostomus (F. Stein) Mereschkowsky 1879																r					
Unidentified euglenophytes														r			r				
Bacillariophyceae																					
Achnanthes sp.																	r				
Amphora ovalis (Kützing) Kützing 1844			r																		
Aulacoseira distans (Ehrenberg) Simonsen 1979											r										
Aulacoseira granulata (Ehrenberg) Simonsen 1979																c			r	r	c
Aulacoseira italica (Ehrenberg) Simonsen 1979																r				r	
Brebissonia lanceolata (C. Agardh) R.K.Mahoney et Reimer 1986			r																		
Caloneis bacillum (Grunow) Cleve 1894	r																				
Ctenophora pulchella var. *lanceolata* (O'Meara) Bukhtiyarova 1995		r																			
Ctenophora pulchella (Ralfs ex Kützing) D. M. Williams et Round 1986												c						d			
Cymbella affinis Kützing 1844																	r				
Cymbella tumida (Brébisson) Van Heurck 1880									r												
aff. *Diploneis* sp.														r							
Discostella stelligera (Cleve et Grunow) Houk et Klee 2004			f								f				r	r					
Encyonema elginense (Krammer) D. G. Mann 1990					r																
Epithemia adnata (Kützing) Brébisson 1838												c									

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Epithemia operculata (C. Agardh) Ruck et Nakov 2016					c																
Epithemia sorex Kützing 1844		r	r						c												
Eunotia exigua (Brébisson ex Kützing) Rabenhorst 1864			r																		
Fragilaria intermedia (Grunow) Grunow 1881																	r				
Fragilaria montana (Krasske ex Hustedt) Lange-Bertalot 1981						f															
Fragilaria sp.			r																		
Gomphonema constrictum Ehrenberg 1844			r																		
Gomphonema sp.																r					
Gyrosigma acuminatum (Kützing) Rabenhorst 1853	r																				
Hippodonta capitata (Ehrenberg) Lange-Bertalot, Metzeltin et Witkowski 1996		r																			
Iconella biseriata (Brébisson) Ruck & Nakov 2016	r		r																		
Iconella linearis (W. Smith) Ruck et Nakov 2016	r		r				r	r													
Lacustriella lacustris (W. Gregory) Lange-Bertalot et Kulikovskiy 2012			r																		
Lindavia comta (Kützing) T. Nakov et al. 2015					d											f					c
Navicula cf. *minima* Grunow 1880					r																
Navicula cf. *platystoma* Ehrenberg 1838							r	c													
Navicula sp.																		r			
Nitzschia sp.								r													

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Pantocsekiella ocellata (Pantocsek) K. T. Kiss et Ács 2016		c						f													
Paraplaconeis placentula (Ehrenberg) Kulikovskiy et Lange-Bertalot 2012									f												
Pinnularia cocconeis (Ehrenberg) Ehrenberg 1854																	r				
Placoneis dicephala (Ehrenberg) Mereschkowsky 1903	r				r	r													c		r
Pleurosigma sp.	r																				
Pseudostaurosira brevistriata var. *inflata* (Pantocsek) M. B. Edlund 1994							c														
Rhopalodia gibba (Ehrenberg) O. Müller 1895		r										c									
Skeletonema subsalsum (A. Cleve) Bethge 1928																					r
Staurosira construens Ehrenberg 1843		r	c																		
Staurosirella martyi (Héribaud) Morales et Manoylov 2006																					r
Stephanodiscus astraea (Kützing) Grunow 1880						c			r												
Stephanodiscus hantzschii Grunow 1880											r										
Stephanocyclus meneghinianus (Kützing) Kulikovskiy, Genkal et Kociolek 2022										c				r			r				
Surirella robusta Ehrenberg 1841 - broken		r																			
Synedra sp. s.l.	r					r						r									
Tabularia tabulata (C. Agardh) Snoeijs 1992								r		r									c		
Ulnaria acus (Kützing) Aboal 2003									r	r											
Ulnaria ulna (Nitzsch) Compère 2001	c			r																	f

Taxa/Sample	**Hd**	**Db**	**Ab**	**Sv**	**CI**	**Mc**	**BP**	**Br**	**Sd**	**Mg**	**HY**	**Yn**	**Pl**	**MS**	**Pr**	**Iz**	**Fs**	**SE**	**KR**	**Nk**	**Dv**
Ulnaria oxyrhynchus (Kützing) Aboal 2003			c																		
Urosolenia sp.																					r
Unidentified diatoms (broken frustules)							r				r					r					
Chrysophyceae																					
Dinobryon sertularia var. *annulatum* Z. X. Shi et Y. X. Wei								r													
Dinobryon bavaricum Imhof 1890																		r			
Dinobryon sertularia Ehrenberg 1834							r														
Ochromonas sp.																		r			
Unidentified chrysophycean flagellate																	r				
Synurophyceae																					
Mallomonas cf. *horrida* J. Schiller 1929		r																			
Mallomonas intermedia Kisselev 1931					f																
Mallomonas cf. *tonsurata* Teiling 1912								c	c												
Xanthophyceae																					
Centritractus belenophorus (Schmidle) Lemmermann 1900	c						r														
Dichotomococcus curvatus Korshikov 1939																r					
Nephrodiella cf. *acuta* Pascher 1938																	r				
Ophiocytium parvulum (Perty) A. Braun 1855							r														
cf. *Peroniella* sp.																	r				
Tribonema sp.												r									

Taxa/Sample	Hd	Db	Ab	Sv	CI	Mc	BP	Br	Sd	Mg	HY	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Eustigmatophyceae																					
Goniochloris cf. *ivengari* (Ramanathan) Ettl 1977																					r
Goniochloris cf. *mutica* (A. Braun) Fott 1960										r											r
Goniochloris pulchra Pascher 1938																				r	
Pseudostaurastrum hastatum (Reinsch) Chodat 1921		r																			
Cryptophyta																					
Chroomonas sp.					r																
Cryptomonas erosa Ehrenberg 1832					c	f	r	c									r			f	r
Cryptomonas sp. 1	r										f	r									c
Cryptomonas sp. 2																			r		

Table 3. Floristic similarity between the studied 21 microreservoirs, shown in the blue horizontal and vertical headings (abbreviations of the names follow those in **Table 1**). Diagonal boxes (brown colour) show the total number of phytoplankton species in each of the microreservoirs, numbers above the diagonal reflect the number of common species between the sites, and numbers below the diagonal show the percentage values of the Sørensen Similarity Index (SCI). Colour below the diagonal indicate different classes of SCI values: white – 0%, grey – 1-10%, green – 11-20%; bright yellow – 21-30%, bright brown – 31-40%, and brown – 41-50%.

	Hd	Db	Ab	Sv	Cl	Mc	BP	Br	Sd	Mg	Hy	Yn	Pl	MS	Pr	Iz	Fs	SE	KR	Nk	Dv
Hd	48	4	5	9	1	4	7	7	1	8	4	2	2	9	6	6	3	1	4	2	14
Db	10	30	11	1	2	2	5	2	4	2	3	2	1	5	3	1	2	0	1	4	5
Ab	13	3	31	3	2	4	5	3	3	1	2	1	1	4	4	4	1	1	4	1	2
Sv	21	3	12	38	1	4	7	4	4	7	2	2	5	7	10	5	1	0	3	1	10
Cl	3	8	8	4	19	2	6	2	1	1	0	1	2	3	3	2	2	0	1	1	5
Mc	11	7	14	13	9	26	7	2	3	5	1	2	4	5	4	1	3	1	2	1	6
BP	15	13	13	16	18	19	47	7	5	8	5	2	4	7	5	2	5	1	2	2	11
Br	19	7	11	13	9	8	19	25	3	3	0	1	1	3	3	2	3	0	2	2	7
Sd	2	12	9	11	4	10	12	10	35	4	5	1	4	8	2	3	1	0	2	4	10
Mg	17	5	3	16	3	14	17	8	10	48	3	1	6	12	9	9	3	0	3	2	17
Hy	11	11	7	7	0	4	14	0	17	8	23	2	2	1	1	5	0	0	2	5	5
Yn	6	9	4	7	6	9	6	5	4	8	10	17	1	1	1	2	0	0	1	0	1
Pl	9	3	3	14	8	14	10	3	12	28	7	4	33	12	7	5	2	0	2	2	13
MS	16	11	8	14	7	11	13	7	16	33	2	2	25	64	14	10	7	0	5	7	24
Pr	15	10	13	29	12	14	13	11	6	43	4	4	22	29	32	7	3	0	8	3	18
Iz	12	2	9	11	5	2	4	5	7	27	13	5	11	17	16	56	2	1	6	6	20
Fs	8	7	4	3	9	12	14	12	3	17	0	0	7	16	10	5	26	2	1	3	9
SE	4	0	5	0	0	6	4	0	0	0	0	0	0	0	0	3	11	9	0	0	1
KR	10	3	12	8	4	6	5	7	6	13	7	4	6	10	24	13	3	0	36	4	6
Nk	5	14	4	3	4	4	14	8	13	11	20	0	7	16	10	15	12	0	13	26	9
Dv	19	8	3	15	9	10	15	11	15	32	8	2	20	30	28	26	15	2	9	15	97

The high general phytoplankton biodiversity with the relatively high average number of 36 taxa per site was associated with a great variability from site to site: from 9 species in Shumensko Ezero to 97 in Duvanli. In this regard, the recorded high number of rarely spread species (256) correlates well with the low estimated floristic similarity (SCI ranging from 0 to 43%) between the studied microreservoirs. Since this similarity was mostly based on the algae found in a low abundance (**Table 2**), we would like to point on the necessity to investigate the whole species composition in limnological studies. Moreover, the notable recorded general biodiversity shows the great potential of the small waterbodies as unexplored genetic pool of algae.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this article.

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AUTHORS CONTRIBUTION

Conceptualization and supervision - MSG; writing—original draft preparation, MSG, MA, KI; writing—review and editing, MSG, GG, BA; visualization - BA, MSG, GG; field sampling – BA, GG, MSG, MA; project administration - BU; funding acquisition – MSG, BU. All authors have read and agreed to the published version of the manuscript.

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SPECIES COMPOSITION OF CYANOPROKARYOTA IN THE SUMMER PHYTOPLANKTON OF 55 SELECTED LAKES AND RESERVOIRS, SAMPLED IN BULGARIA IN THE YEARS 2018, 2019, 2021 AND 2023

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Abstract. The paper presents detailed results on cyanoprokaryote diversity in the summer phytoplankton of 55 lakes, small and large reservoirs sampled in Bulgaria in the frame of three joined projects related to algal blooms threat to human health and national security. The phytoplankton of twenty from these selected waterbodies was sampled for first time. In total, 185 species and one variety from 55 genera have been identified, 54 of which (29%) were novel for the country. The average contribution of cyanophytes to the phytoplankton per site was 8 species (or 44% of the total biodiversity), reaching in some sites 80%. According to the morphology, the recorded algae were distributed as follows: 83 coccal, 52 non-heterocytous filamentous and 51 heterocytous filamentous cyanoprokaryotes. Their average contribution to the phytoplankton diversity was estimated as 4 coccal, 2 non-heterocytous and 2 heterocytous species per site. Most of the cyanoprokaryote species (94, or 51%) were recorded only once, even in the case of wetlands and sites which have been repeatedly visited during all sampling campaigns. These 96 species embrace 39 coccal, 23 non-heteroctous and 32 heterocytous forms. No species was found in all studied waterbodies. The most widely spread species were *Microcystis aeruginosa* (19 records), *Planktolyngbya limnetica* (17 records), *Aphanizomenon klebahnii* (16 records), *Microcystis wesenbergii* (16 records), *Aphanocapsa delicatissima* (13 records), *Cuspidothrix issatschenkoi* (12 records), *Coelomoron pusillum* (11 records), *Pseudanabaena limnetica* (11 records), *Anagnostidinema amphibium* (10 records), *Raphidiopsis raciborskii* (10

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records), *Limnococcus limneticus* (10 records), and separate cells of *Microcystis* as well (15 records). The record of the chytrid parasite *Rhizosiphon anabaenae* on separate trichomes of *Sphaerospermopsis aphanizomenoides* is described.

Key words: algal blooms, biodiversity, chytrids, drone observations, *Rhizosiphon anabaenae*, rare species, zoosporic parasites

INTRODUCTION

Peculiar group of organisms with a prokaryotic cell organization, commonly known as blue-green algae (Cyanophyta) or cyanobacteria (Cyanobacteria), was renamed taxonomically as Cyanoprokaryota about three decades ago with recognition of both the prokaryotic organization of these organisms with algal morphological organization and their physio-ecological function of primary producers capable of photosynthesis with oxygen production (Komárek & Anagnostidis 1999). Cyanoprokaryotes occurred in the Early Archaean and currently are among the most diverse organisms on the Planet (Whitton & Potts 2012). They were the main players in the enrichment of Earth's atmosphere by oxygen that drove to the "Great Oxygen Event" about 2400 mln years ago (Schopf 2012). Moreover, up to now, they are the only phototrophs capable to utilize directly the atmospheric nitrogen in the process commonly known as nitrogen-fixation (Schopf 2012; Stal 2012). In addition, cyanoprokaryotes are proved producers of unique substances important for the modern biotechnology, pharmacology and medicine, some of which are with potent anti-Covid and anti-HIF properties (Teas et al. 2004; Mader et al. 2016; Mitchell et al. 2017; Carpine & Sieber 2021; Mazur-Marzec et al. 2021; Konkel et al. 2023, *etc*.). However, despite these very important and useful features, during the last decades cyanoprokaryotes became more popular and better known from their negative side – the ability to produce great diversity of toxic substances, which can harm both human and ecosystem health (*e.g.*, Merel et al. 2013; Meriluoto et al. 2017). In this respect, a lot of attention of the scientific community was sharpened on their driving factors and their increasing abundance in the waterbodies was proved as related with current global climatic changes and anthropogenically speeded-up eutrophication caused by increased nutrient loading (*e.g.*, Yan et al. 2019, 2020; Xu et al. 2021; Zhang et al. 2023).

Although this all raised the interest of the algologists, ecologists, physiologists, toxicologists and specialists in molecular-genetics, currently there is a decrease of papers which deal with the total phytoplankton species composition identified by conventional light microscopic (LM) studies. The aim of the present paper is to provide detailed data on the biodiversity of cyanoprokaryotes in the summer phytoplankton of different Bulgarian waterbodies determined by standard LM methods. The results are obtained after processing of samples obtained from 55 selected lakes, large and small reservoirs during four sampling campaigns in the frame of three complementary projects related with human health and national security of Bulgaria (*i.e.*, grants DN-13/9 - 15.12.2017, KP-06-OPR 03/18 - 19.12.2018, and KP-06-OPR06/2 - 18.12.2018 funded by the Scientific Research Fund of the Bulgarian Ministry of Education). Up-to now the revealed general phytoplankton biodiversity was discussed only in a paper oriented towards possibilities to identify algal indicators for water quality assessment (Stoyneva et al. 2023), the detailed species composition is currently published only for 21 small reservoirs, sampled for first time (Stoyneva et al. this volume) and some important species involved in potential toxin production have been discussed in a set of papers based on a polyphasic approach (Radkova et al. 2020; Stefanova et al. 2020; Stoyneva-Gärtner et al. 2021, 2022, 2023; Uzunov et al. 2021a, b). In these papers some genetically proved species were outlined as novel for the country, but here they are notified again with providing the relevant references in order to obtain a generalized summary on all data obtained by us on phytoplanktonic cyanoprokaryotes during the period 2018-2023. The potential alien character and possible transporting vectors of the species recorded for first time in the country, will be discussed elsewhere.

It has to be mentioned that there are some small differences in the number of cyanoprokaryote species in comparison with our previous paper (Stoyneva et al. 2023). They appear due to four main reasons: 1) this paper is based on samplings from four years (2018, 2019, 2021, 2023), while the former one is based on samplings from three years (2018, 2019, 2021); 2) for the purposes of the present paper all samples were once more processed taxonomically; 3) some taxonomic changes in names and synonymy currently included in Algaebase (Guiry & Guiry 2023) have been considered; 4) the average numbers for this paper were calculated separately for each sampling year, while in the paper of Stoyneva et al. (2023) the average values are calculated in a generalized way for each waterbody. After these notes, it is possible to state that all obtained data revealed significant biodiversity of Cyanoprokaryota in the sampled waterbodies (182 species) on the background of their already noticed high contribution to the biomass (Stoyneva et al. 2023).

MATERIAL AND METHODS

Sampling sites and periods

The paper is based on phytoplankton samples from 55 selected lakes, large reservoirs and microreservoirs in Bulgaria collected during three summer campaigns in June 2018, August 2019, August 2021 and July 2023 (**Table 1**, **Fig. 1**). These 55 waterbodies were sampled simultaneously for phytoplankton species composition identification and for assessment of algal biomass through HPLC (Stoyneva-Gärtner et al. 2019, 2021, 2022, 2023, this volume; Radkova et al. 2020; Stefanova et al. 2020; Uzunov et al. 2021a, b; Valskys et al. 2022). Although the sampling details and periods have been explained in the forementioned papers for completeness of the present publication we recall that: 1) the sampling campaign

Table 1. Sampling sites in Bulgarian waterbodies and their environmental parameters during summer sampling campaigns in years 2018, 2019, 2021 and 2023. Legend: Type – Type of waterbody: M (small reservoir / ”microreservoir”, <100 ha), R (large reservoir, >100 ha) and L (lake), Alt – altitude above the sea level [m], WT – water temperature [º C], CN- conductivity [S m^{-1}], TDS – total dissolve solids [µg L^{-1}], DO – oxygen concentration [mg L^{-1}], TP - total phosphorus [mg L^{-1}], TN – total nitrogen [mg L^{-1}]. Waterbodies are presented according to their geographical location in counter-clockwise order, starting from South-Western Bulgaria. Asterisks indicate the waterbodies which are sampled for first time.

	WBN and IBW	Abbr	Type	Year	Alt	Latitude	Longitude	WT	pH	CN	TDS	DO	TP	TN
1	*Yazovir Hadzhidimovo	Hd	M	2021	156	41º29.8933'	23º50.1890'	29.1	9.5	300	192	17.00	0.1	0.1
2	*Yazovir Dubnitsa (IBW3698)	Db	M	2021	600	41º33.8500'	23º50.7500'	25.2	9.6	246	159	9.21	0.1	0.1
3	*Yazovir Ablanitsa (IBW6013)	Ab	M	2021	682	41º32.8594'	23º55.5869'	27.2	8.8	242	157	8.54	1.0	0.5
4	*Yazovir Satovcha 2 (IBW1197)	St	M	2021	1017	41º36.8222'	23º58.1446'	27.4	8.7	272	176	9.00	0.5	0.1
5	Yazovir Batak (IBW1316)	Bt	R	2023	1115	42º01.2536'	24º12.1739'	26.7	8.9	94	63	9.4	0.1	0.1
6	Yazovir Toshkov Chark (IBW1315)	TC	M	2023	1430	41º48.6333'	24º09.8833'	25.5	8.3	123	81	9.04	0.1	0.1
7	Yazovir Dospat (IBW3155)	Ds	R	2021	1214	41º39.1495'	24º89.5596'	25.9	9.9	81	52	8.73	0.1	0.5
				2021	1212	41º39.1493'	24º89.5918'	25.6	9.5	83	52	8.70	0.3	0.5
				2023	1207	41º39.4268'	24º09.5933'	27.4	8.3	78	49	8.3	0.2	0.3
8	Yazovir Golyam Beglik (IBW1314)	GB	R	2021	1540	41º48.8927'	24º07.8725'	22.0	9.1	99	63	8.92	1.5	1.0
				2023	1546	41º48.9792'	24º07.7179'	24.1	8.1	92	59	8.56	0.5	0.5
9	Yazovir Shiroka Polyana (IBW3144)	SP	R	2021	1550	41º46.1776'	24º08.8201'	25.3	8.9	66	42	8.70	0.5	0.5
				2023	1534	41º46.1722'	24º08.8157'	25.4	7.7	59	38	8.32	0.3	0.1
10	Yazovir Beglika (IBW3141)	Bg	M	2021	1535	41º49.7963'	24º07.8196'	21.7	9.1	242	157	9.11	1.0	0.8
				2023	1515	41º49.8081'	24º07.8460'	19.6	7.9	200	130	9.5	0.5	0.1
	WBN and IBW	**Abbr**	**Type**	**Year**	**Alt**	**Latitude**	**Longitude**	**WT**	**pH**	**CN**	**TDS**	**DO**	**TP**	**TN**

11	Yazovir Vucha (3143)	Vc	R	2023	546	41º54.0874'	24º26.7470'	26.4	8.9	224	144	9.52	0.1	0.1
12	Yazovir Krichim (IBW1366)	Kr	M	2023	425	41º59.5718'	24º28.0848'	23.4	8.9	219	143	10.45	1.0	0.3
13	Yazovir Ivaylovgrad (IBW2271)	Iv	R	2023	135	41º35.0193'	26º06.5330'	29.7	8.7	305	197	8.96	0.1	0.1
14	Yazovir Studen Kladenets (IBW1763)	SK	R	2023	234	41º37.0963'	25º38.4232'	31	8.8	284	183	8.94	0.1	0.1
15	Yazovir Kurdzhali (IBW1668)	Kz	R	2023	333	41º38.3578'	25º19.3461'	29.2	8.2	222	144	8.76	0.3	0.1
16	Yazovir Trakiets (IBW1677)	Tr	R	2023	259	41º52.2592'	25º25.8222'	29	8.9	346	224	9.35	0.3	0.1
17	Yazovir Rozov Kladenets (IBW2209)	RK	R	2023	111	42º08.9716'	25º53.2100'	30	9.1	970	627	11.97	0.8	0.1
18	Yazovir Malko Sharkovo (IBW2481)	MH	R	2023	243	42º06.9834'	26º51.1590'	30.6	8.5	451	293	9.54	0.5	0.3
19	*Yazovir Chetiridesette Izvora (IBW1523)	CI	M	2021	246	42º00.5510'	24º56.2819'	28.7	7.5	402	263	8.66	1.0	0.5
20	Yazovir Mechka (IBW1584)	Mc	M	2021	319	41º55.8970'	25º06.1595'	27.1	9.0	241	154	8.50	1.5	1.0
21	*Yazovir Byalata Prust-Mezek	BP	M	2021	167	41º45.1080'	26º05.2403'	29.7	8.5	291	188	9.37	2.0	1.0
22	*Yazovir Birgo (Shtit)	Br	M	2021	215	41º49.7743'	26º22.1889'	27.3	8.0	594	385	8.75	1.5	1.8
23	*Yazovir Studena (Fishera) (IBW2421)	St	M	2021	282	41º54.2136'	26º24.5964'	29.3	9.0	652	423	3.35	1.0	0.3
24	*Yazovir Mogila (Kaynaka) (IBW2626)	Mg	M	2021	166	42º29.8310'	26º36.1043'	29.2	9.5	682	442	15.75	4.0	1.0
25	*Yazovir Hadzhi Yani (Lozen-ets) (IBW2893)	HY	M	2021	12	42º12.0333'	27º47.3000'	26.1	7.5	751	488	8.42	1.5	0.8
26	Yazovir Mandra (IBW1720)	Mn	R	2018	12	42º24.0643’	27º26.1120’	25.9	8.3	649	421	6.81	3.0	3.0
				2018		42º24.0670’	27º19.1310’	26.2	8.2	663	461	5.89	6.0	4.0
				2018		42º26.1420’	27º26.5860’	24.9	8.5	639	415	7.91	4.0	3.3
	WBN and IBW	**Abbr**	**Type**	**Year**	**Alt**	**Latitude**	**Longitude**	**WT**	**pH**	**CN**	**TDS**	**DO**	**TP**	**TN**

				2019		42º24.0295'	27º19.1194'	25.8	7.9	676	436	7.93	0.7	0.5
				2019		42º25.9303'	27º26.7652'	27.2	8.5	578	375	7.87	1.5	1.8
				2021		42º24.2370'	27º19.1205'	27.3	9.0	513	333	9.32	7.0	4.0
				2021		42º25.9282'	27º26.7675'	27.3	9.0	513	333	10.70	7.5	4.0
				2023		42º24.0854'	27º19.1397'	34.4	9.5	602	391	12.7	3.0	1.0
				2023		42º25.9346'	27º26.7735'	31.6	9.1	582	378	12.66	3.5	1.0
27	Uzungeren (IBW0710)	Uz	L	2018	7	42º26.1782'	27º27.1998'	25.9	8.1	1458	9351	7.83	5.0	2.8
				2019		42º26.1551'	27º27.2235'	27.6	8.5	1748	1132	9.70	0.4	0.3
				2021		42º26.1532'	27º27.2214'	28.1	9.0	18520	12000	11.21	5.5	4.0
28	Burgasko Ezero (Vaya) (IBW0191)	BE	L	2018	0	42º30.5940'	27º22.0750'	26.9	9.7	2588	1682	12.51	13	5.4
				2018		42º28.4540’	27º25.482	28.28	8.9	1183	768	11.94	11	3.7
				2018		42º29.1850’	27º26.5310'	23.7	9.5	1024	665	7.01	12	4.6
				2019		42º30.5940'	27º22.075'	27.9	9.2	490	170	7.69	0.5	0.3
				2021		42º30.7934'	27º24.2425'	26.6	9.0	4421	2873	1.26	12	5.3
				2023	0.2	42º30.6944'	27º25.6881'	32.9	9.7	936	60.95	13.42	10	5
29	Yazovir Poroy (IBW3038)	Pr	M	2018	41	42º43.0190’	27º37.3160’	25.10	8.3	762	495	9.45	1.0	2.8
				2019		42º43.3403'	27º37.5255'	27.5	8.1	644	416	7.60	0.1	0.3
				2021		42º43.4683'	27º36.8757'	26.1	9.0	792	514	11.68	2.1	1.5
				2023		42º43.2500'	27º37.2500'	29.6	8.5	834	544	8.78	1.5	0.5
30	Yazovir Aheloy (IBW3032)	Ah	M	2018	144	42º42.8230’	27º30.9740’	25.4	8.5	614	399	8.92	1	4.1
31	*Yazovir Yunets	Yn	M	2021	79	42º55.6700'	27º45.3074'	27.4	8.5	965	765	11.00	2.5	1.8
32	Yazovir Tsonevo (IBW3022)	Ts	R	2019	75	43º01.8055'	27º24.3965'	24.8	8.8	355	231	8.20	0.1	0.1
				2021		43º01.8278'	27º24.3954'	26.6	8.0	417	272	10.65	0.1	0.1
				2023		43º01.8173'	27º24.3943'	26	8.9	454	295	9.21	0.1	0.1
	WBN and IBW	**Abbr**	**Type**	**Year**	**Alt**	**Latitude**	**Longitude**	**WT**	**pH**	**CN**	**TDS**	**DO**	**TP**	**TN**

33	Yazovir Eleshnitsa (IBW3023)	El	M	2019	44	43º00.3344'	27º28. 0744'	26.7	8.4	532	347	6.78	0.1	0.3
34	Ezeretsko Ezero (Ezerets, IBW0233)	Ez	L	2018	0	43º35.2770’	28º33.2290’	26.4	8.4	1084	10	9.94	0.5	5.3
				2019	6	43º35.2681'	28º33.2096'	25.9	8.6	1669	1739	8.58	0.1	0.1
35	Shablensko Ezero (Shabla, IBW0219)	Sb	L	2018	0	43º33.8180’	28º34.1860’	27.1	8.5	1087	706	9.97	0.1	5.1
				2019		43º33.8212’	28º34.8204’	25.9	8.7	1842	1196	9.64	0.1	1.0
36	Durankulashko Ezero (Du-rankulak, IBW0216)	Dr	L	2018	4	43º40.3240’	28º32.0470’	24.03	8.5	1111	722	7.35	21	2.8
				2018		43º40.3340’	28º32.0220’	24.7	8.2	1094	711	7.79	20	4.0
				2018		43º40.5300’	28º32.9930’	24.6	8.5	1075	698	6.19	24	3.9
				2018		43º40.6950’	28º32.6000’	26.5	8.5	1087	706	9.60	20	3.2
				2019		43º40.0006'	29º32.6166'	26.5	8.9	974	631	7.86	0.3	0.7
				2019		43º40.5355'	28º33.0806'	26.7	8.9	1048	680	6.04	0.3	0.6
				2021		43º40.6935’	28º32.6000’	25.5	9.0	2960	736	10.70	14	4.5
				2021		43º40.5300'	28º33.0826'	25.5	9.0	3008	1952	7.40	11	2.0
37	*Yazovir Plachidol 2 (IBW5073)	Pl	M	2019	220	43º33.3504'	27º52.6338'	24.6	9.0	1225	793	9.13	0.2	0.4
38	*Yazovir Malka Smolnitsa (IBW3107)	MS	M	2019	211	43º36.2606'	27º44.5367'	25.2	9.1	755	490	7.05	0.6	0.6
39	*Yazovir Preselka (IBW3078)	Ps	M	2019	281	43º25.3767'	27º16.6214'	24.1	9.0	138	282	10.05	0.6	2.8
40	*Yazovir Izvornik 2 (IBW3082)	Iz	M	2019	255	43º27.3838'	27º21.111'	24.5	9.4	389	253	13.26	9.0	4.8
41	*Yazovir Fisek (IBW2674)	Fs	M	2019	182	43º18.8453'	26º44. 3765'	27.2	8.7	690	397	7.52	0.2	0.1
42	*Yazovir Shumensko Ezero (IBW2754)	SE	M	2019	152	43º14.8140'	26º57.5675'	25.2	8.5	471	445	6.32	0.2	0.5
	WBN and IBW	**Abbr**	**Type**	**Year**	**Alt**	**Latitude**	**Longitude**	**WT**	**pH**	**CN**	**TDS**	**DO**	**TP**	**TN**

43	*Yazovir Kriva Reka (IBW3071)	KR	M	2019	133	43º22.6573'	27º10.9807'	23.7	8.4	662	428	6.24	1.0	9.0
44	Yazovir Beli Lom (IBW2810)	BL	R	2023	280	43º24.5966'	26º41.0196'	23	9.2	604	391	9.32	0.1	0.1
45	Yazovir Suedinenie (IBW2642)	Sn	R	2019	133	43º20.0734'	26º33.6368'	28.1	7.6	739	481	6.77	0.1	0.3
				2023	181	43º19.4392'	26º35.9789'	26.6	8.9	928	603	9.17	0.1	0.1
46	Yazovir Yastrebino (IBW2602)	Ys	R	2023	350	43º08.2573'	26º16.7987'	26	8.7	391	252	8.34	1.0	0.5
47	*Yazovir Nikolovo (IBW3176)	Nk	M	2021	89	43º50.9768	26º05.1796	26.0	9.8	2156	1400	11.88	11	2.0
48	Yazovir Shilkovtsi (Iovkovtsi) (IBW2105)	Sh	R	2019	410	42º55.2320'	25º47.6743'	27.2	8.9	746	479	7.48	0.03	0.1
49	Yazovir Koprinka (IBW2062)	Kp	R	2019	450	42º37.0172'	25º19.4795'	27.2	8.2	250	163	7.21	0.1	0.2
50	Yazovir Zhrebchevo (IBW2545)	Zh	R	2019	253	42º36.6024'	25º51.2345'	27.6	7.7	358	233	8.01	0.1	0.2
51	Yazovir Al. Stamboliyski (IBW2056)	AS	R	2019	190	43º07.0000’	25º07.3936’	29.4	8.9	670	433	9.82	1.4	3.5
52	Yazovir Krapets (IBW2000)	Kt	M	2019	410	43º04.0316'	24º52.3835'	28.7	8.3	870	564	7.74	0.1	1.0
53	Yazovir Sopot (IBW1437)	Sp	R	2019	376	40º00.7017'	24º52.6045'	29.0	8.3	779	490	3.44	0.1	0.1
54	*Yazovir Duvanli (IBW1483)	Dv	M	2019	250	42º23.1851'	24º43.1000'	26.3	8.8	4050	291	7.09	0.1	0.3
55	Yazovir Sinyata Reka (IBW1890)	SR	M	2018	317	42º28.1480’	24º42.2170	27.4	9.7	470	305	9.36	25	4.8
				2018		42°28.1473’	24°42.2175	26.7	9.4	468	306	9.21	27	4.3
				2019		42º28.1518'	24º42.0159'	28.2	10.4	490	317	14.76	1.0	0.2

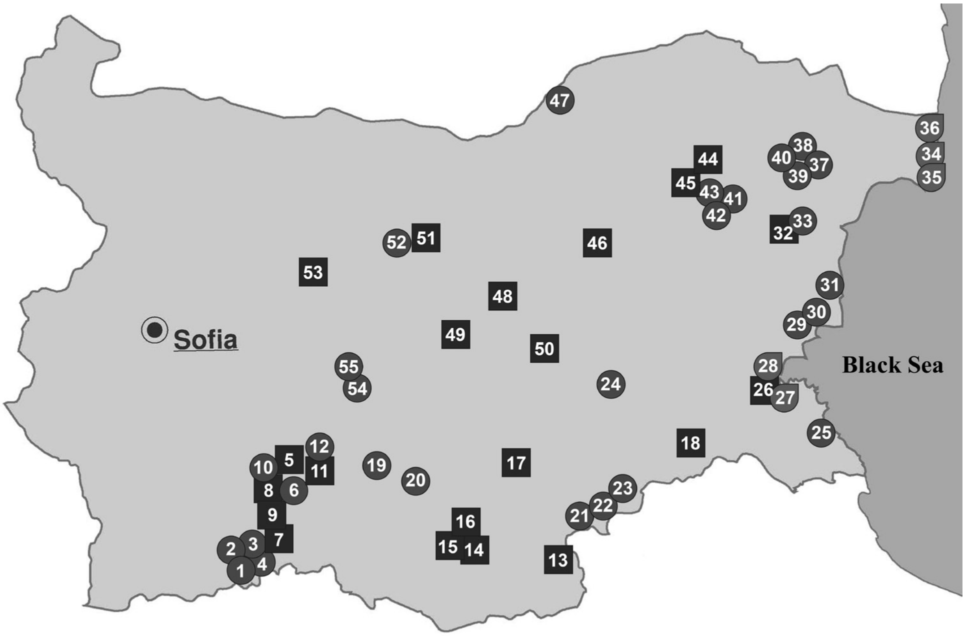


Fig. 1. Map of Bulgaria (modified after Ginkgo maps) with locations of the studied waterbodies and indication of their type. The waterbodies are represented by numbers that follow those in **Table 1**. Type of waterbody: small reservoir / ”microreservoir”, <100 ha - circle, large reservoir, >100 ha - square and lake - teardrop.

in the year 2020 was omitted during Covid-19 pandemics, and in 2020 there was no sampling campaign because of transitional reporting period of the projects; 2) different meteorological conditions led to sampling in different summer months in the years 2018, 2019, 2021 and 2023 (the last one in the end of July after cold and rainy period of April-June); 3) sampling from boats was preceded by sending of a drone for selection of the sampling sites with visible algal blooms; two types of drones have been used, both supplied by photocameras: DJI Mavic Pro, Model: M1P GL200A (SZ DJI Technology Co., LTD, Shenzhen, China) in 2018 and DJI Mavic 2 Enterprise Dual Pro (DJI Technology Co, LTD, Shenzhen, China) in 2019, 2021; 4) detailed data on the waterbodies (except for Hadzhidimovo, Byalata prust and Yunets) are available from the Database of the Inventory of Bulgarian wetlands (IBW - Michev & Stoyneva 2007) using their identification numbers provided in **Table 1**; 5) In July 2023 we visited also the reservoir Tsankov Kamuk, but it did not contain water layer; 6) in situ measurements of the physical and chemical water parameters (water temperature, pH, water hardness expressed by total dissolved solids, oxygen concentration, chlorophyll a and conductivity) were done by using the Aquameter AM-200 and Aquaprobe AP-2000 from Aquaread water monitoring instruments, 2012 Aquaread Ltd, while for the ex situ measurements of the total nitrogen (TN) and total phosphorus (TP) Aqualytic AL410 Photometer from

AQUALYTIC®, Dortmund, Germany was used.

Algal identification and counting by light microscopy

This paper is based on results obtained after processing by light microscopy (LM) only of the fixed by 2-4% formalin phytoplankton samples, collected in a volume of 0.5, 1l or 1.5 L (depending on the visible trophic state) at each site from the surface layer (0-50 cm). All these fixed samples were transported in a dark box to the lab with a subsequent sedimentation to 30 ml for at least 48 hours (Stoyneva-Gärtner et al. 2019, 2021, 2022, 2023; Radkova et al. 2020; Uzunov et al. 2021a, b). The taxonomic LM work was performed three times: 1) almost immediately after the collection on a Motic BA microscope with a Moticam 2000 camera, supported by Motic Images 2 Plus software program; 2) some months later, all samples were processed in a repetitive and comparative way on a Motic B1 microscopes supplied by a Moticam 2.0 mp camera with Motic Images 3 Plus software program; 3) in the months January - July 2023 for the needs of this paper the samples have been processed taxonomically for a third time, while samples from 2023 were looked on in July-October 2023. To ensure the consistency of LM data, the identification and counting was done by one and the same person (MPSG) (Stoyneva-Gärtner et al. 2023, this volume).

The algal identification, based on features used in standard European taxonomic literature (*e.g.*, Geitler 1932; Gollerbakh et al. 1953; Starmach 1966; Komárek & Anagnostidis 1999, 2005; Hindák 2008; Komárek 2013), was done under magnification 100x with application of immersion oil on non-permanent slides and later on was consulted with recent taxonomic changes in AlgaeBase (Guiry & Guiry 2023).

Algae were evaluated by their relative abundance using their frequency of appearance and biomass contribution according to the following relative scale: "rare species" - single specimens in the whole microscopic slide (<0.5% of the biomass), "occasional species" - up to five specimens (<5% of the biomass), "common, or abundant species"– six to 30 specimens in a slide (5-20% of the biomass), and dominants and sub-dominants were evaluated among the most numerous species which contributed with >20 and >25% of the biomass, respectfully (Stoyneva-Gärtner et al. 2023). For this purpose, algae have been counted on a Thoma blood-counting chamber, in minimum four reiterations for each sample with the cell taken as the main counting unit and further estimation of the biomass (*e.g.*, Stoyneva-Gärtner et al. 2023).

Comparison of the biodiversity of the studied reservoirs and lakes with data of other authors

The general knowledge on the aquatic cyanoprokaryote diversity is summarized in the Inventory of Bulgarian Wetlands (Stoyneva & Temniskova-Topalova 2007), in the DrSc thesis of Stoyneva (2014) and in the assessment paper by Stoyneva-

Gärtner et al. (2017). Afterwards, some data on cyanoprokaryotes from the waterbodies included in this study have been published. They concern earlier investigations of the reservoirs Eleshnitsa, Malko Sharkovo and Yasna Polyana (years 2009-2018 – Gecheva et al. 2019), Batak (year 2015 – Dochin et al. 2018), Kurdzhali (years 2015, 2016 – Dochin & Iliev 2019), Koprinka (2017 – Dochin et al. 2017), and Dospat, Studen Kladenets, Kurdzhali and Zhrebchevo (years 2016, 2017 – Dochin 2019), as well as more recent investigations of the reservoirs Mechka (year 2019 – Dochin 2022) and Aheloy (years 2020, 2021 – Dochin 2023). In addition, data on planktonic cyanoprokaryotes from some wetlands in some years, which coincide with some of our samplings were published for the coastal lake Burgasko Ezero (Vaya) (2018 - Teneva et al. 2020) and for the inland reservoirs Sinyata Reka and Koprinka (2019 - Dochin 2021). Therefore, in order to have realistic comparisons concerning diversity in similar periods, the species observed in this study have been compared in the provided taxonomic list with those published by Teneva et al. (2020) and Dochin (2021).

RESULTS AND DISCUSSION

Totally 186 cyanoprokaryotes (185 species and one variety) from 55 genera were identified, 54 of which (29%) were novel for the country. Most of the species (94, or 51%) were recorded only once, even in the case of wetlands and sites which have been repeatedly visited during all sampling campaigns. No species was found in all studied waterbodies. The most widely spread species were *Microcystis aeruginosa* (19 records), *Planktolyngbya limnetica* (17 records), *Aphanizomenon klebahnii* (16 records), *Microcystis wesenbergii* (16 records), *Aphanocapsa delicatissima* (13 records), *Cuspidothrix issatschenkoi* (12 records), *Coelomoron pusillum* (11 records), *Pseudanabaena limnetica* (11 records), *Anagnostidinema amphibium* (10 records), *Limnococcus limneticus* (10 records), *Raphidiopsis raciborskii* (10 records), and separate cells of *Microcystis* as well (15 records).

Species list of cyanoprokaryotes found in the summer phytoplankton of 55 lakes and reservoirs in Bulgaria, sampled in the years 2018. 2019, 2021 and 2023. (The list is organized in alphabetical order of the generic names, for each species the site and year of finding is indicated together with its role in the phytoplankton assemblages, based on relative frequency and biomass: x - rare, xx – common, xxx – abundant/frequent, xxxx - subdominant, xxxxx – dominant/co-dominant (Stoyneva-Gärtner et al. 2023). Taxonomical notes are provided only for species in which some taxonomical peculiarities or deviations from diagnoses have been recorded. For each species our relevant publication is provided, as it is explained in the text of the paper. Published data of other authors concerning the waterbodies sampled in the year/years, which coincide with our sampling of the certain lake or reservoir, are shown.)

CYANOPROKARYOTA

**Anabaena minderi* Huber-Pestalozzi 1938: Yunets 2021/x

Anabaena cf. *oscillarioides* Bory ex Bornet & Flahault 1886: Burgasko Ezero 2018/xx. Additional information in Stefanova et al. (2020).

Anabaena cf. *torulosa* Lagerheim ex Bornet & Flahault 1886: Burgasko Ezero 2018/xx. Additional information in Stefanova et al. (2020).

Anabaena sp. ster. 1 (straight trichomes, ?*Aphanizomenon* sp.): Mechka 2021/x, Uzungeren 2019/x

Anabaena sp. ster. 2 (straight trichomes, ?*Chrysosporum* sp.): Burgasko Ezero 2018/x. Additional information in Stefanova et al. (2020).

Anabaenopsis arnoldii Aptekar 1926: Burgasko Ezero 2018/x, Malka Smolnitsa 2019/xxx, Sinyata Reka 2019/x. Reported for Sinyata Reka in 2019 (Dochin 2021).

Anabaenopsis circularis (G. S. West) Wołoszyńska et V. V. Miller 1923: Kriva Reka 2019/xx, Duvanli 2019/x

Anabaenopsis cunningtonii W. R. Taylor 1932: Shablensko Ezero 2019/x, Malka Smolnitsa 2019/x

Anabaenopsis elenkinii V. V. Miller 1923: Mogila 2021/xxxxx, Burgasko Ezero 2021/xxx, Duvanli 2019/x, Sinyata Reka 2018/x. Additional information in Stoyneva-Gärtner et al. (2023). Reported among the dominants of Burgasko Ezero in July and September 2018 (Teneva et al. 2020).

**Anabaenopsis milleri* Woronichin 1929: Burgasko Ezero 2018/x, Izvornik 2 2019/xxxx. Additional information in Stoyneva-Gärtner et al. (2023).

**Anathece bachmannii* (Komárek & Cronberg) Komárek, Kastovsky & Jezberová 2011: Krichim 2023/xx

Anathece clathrata (West & G. S. West) Komárek, Kastovsky & Jezberová 2011: Shiroka Polyana 2023/x, Durankulashko Ezero 2018/x (cf. – single young colony). Reported as occurring in Sinyata Reka in 2019 and as dominant in Koprinka in 2019 (Dochin 2021).

**Anathece floccosa* (Zalessky) Cronberg & Komárek 1994: Durankulashko Ezero 2018/x

**Anathece minutissima* (West) Komárek, Kastovsky & Jezberová 2011: Aheloy 2018/x, Durankulashko Ezero 2021/x

Anathece smithii (Komárková-Legnerová & Cronberg) Komárek, Kastovsky & Jezberová 2011: Kriva Reka 2019/x

Anagnostidinema acutissimum (Kufferath) Strunecký, Bohunická, J. R. Johansen & J. Komárek 2017: Mogila 2021/xx

Anagnostidinema amphibium (C. Agardh ex Gomont) Strunecký, Bohunická, J. R. Johansen & J. Komárek 2017: Dubnitsa 2021/x, Ablanitsa 2021/x, Chetiridesette Izvora 2021/x, Burgasko Ezero 2018/x and 2019/x, Poroy 2018/x and 2023/x, Plachidol 2 2019/xxx, Byalata Prust 2023/x, Al. Stamboliyski 2019/x

**Anagnostidinema pseudacutissimum* (Geitler) Strunecký, Bohunická, J. R.

Johansen & J. Komárek 2017: Duvanli 2019/x

Aphanizomenon gracile Lemmermann 1907: Satovcha 2021/x, Byalata Prust 2021/x, Mandra 2018/x and 2023/x, Poroy 2019/x, Eleshnitsa 2019/xx. Reported for Sinyata Reka and Koprinka in 2019 (Dochin 2021).

Aphanizomenon klebahnii (Elenkin) Pechar & Kalina ex Komárek & Komárková 2006: Vucha 2023/x, Ivaylovgrad 2023/xxxx, Mechka 2021/xx, Byalata Prust 2021/xx, Mogila 2021/x, Hadzhi Yani 2021/xxxx, Mandra 2019/xxxxx, 2021/xxx and 2023/xxxxx, Poroy 2019/xxxxx and 2021/xxxxx, Durankulashko Ezero 2019/xx and 2021/x, Plachidol 2 2019/xxx, Yastrebino 2023/xxx, Zhrebchevo 2019/xx. Additional information in Uzunov et al. (2021b), Stoyneva-Gärtner et al. (2023). Reported among the dominants of Burgasko Ezero in July and September 2018 (Teneva et al. 2020).

Aphanizomenon yezoense M. Watanabe 1991: Studena 2021/xxxxx, Mandra 2021/xxx, Poroy 2018/xx and 2019/x, Durankulashko Ezero 2018/xx, 2019/xx and 2021/xxxx, Yastrebino 2023/xxx. Additional information in Stefanova et al. (2020), Stoyneva-Gärtner et al. (2023).

Aphanocapsa conferta (West & G. S. West) Komárková-Legnerová & Cronberg 1994: Burgasko Ezero 2023/x, Poroy 2023/xxx, Birgo 2021/xx, Studena 2021/x, Koprinka 2019/xx

Aphanocapsa delicatissima West & G. S. West 1912: Dospat 2021/x, Shiroka Polyana 2021/x, Golyam Beglik 2021/x, Mechka 2021/x, Burgasko Ezero 2018/x, Poroy 2019/x, Aheloy 2018/xx, Eleshnitsa 2019/xx, Burgasko Ezero 2018/x, Durankulashko Ezero 2019/x, Fisek 2019/x, Shumensko Ezero 2019/xxxx, Sopot 2019/xx. Additional information in Stoyneva-Gärtner et al. (2023). Reported for Sinyata Reka in 2019 (Dochin 2021).

Aphanocapsa elachista West & G.S.West 1894: Mandra 2023/x

**Aphanocapsa fusco-lutea* Hansgirg 1893: Kriva Reka 2019/xxxx

Aphanocapsa grevillei (Berkeley) Rabenhorst 1865: Tsonevo 2023/x

Aphanocapsa holsatica (Lemmermann) G. Cronberg & Komárek 1994: Hadzhi Yani 2021/xxxx, Burgasko Ezero 2018/x and 2023/xxx, Durankulashko Ezero 2018/xxxx and 2019/xx, Izvornik 2 2019/xxx. Additional information in Stoyneva-Gärtner et al. (2023).

Aphanocapsa incerta (Lemmermann) G. Cronberg & Komárek 1994: Burgasko Ezero 2018/x, Durankulashko Ezero 2018/xx and 2019/x, Suedinenie 2019/x

Aphanocapsa nubila Komárek & H. J. Kling 1991: Aheloy 2018/x, Durankulashko Ezero 2018/x, Plachidol 2 2019/x, Yastrebino 2023/xxx, Al. Stamboliyski 2019/x

Aphanocapsa planctonica (G. M. Smith) Komárek & Anagnostidis 1995: Toshkov Chark 2023/x, Izvornik 2 2019/xx

Aphanocapsa sp.: Trakiets 2023/x

Aphanothece elabens (Meneghini) Elenkin 1936: Duvanli 2019/xx

Arthrospira platensis Gomont 1892: Shablensko Ezero 2019/x

*_Aulosira_ cf. _fertilissima_ S. L. Ghose 1924: Malko Sharkovo 2023/x
*_Borzia brevis_ (Kufferath) Anagnostidis 2001: Poroy 2018/x
Borzia trilocularis Cohn ex Gomont 1892: Shiroka Polyana 2021/x, Trakiets 2023/x
*_Chroococcopsis gigantea_ Geitler 1925: Golyam Beglik 2023/x
Chroococcus distans (G. M. Smith) Komárková-Legnerová & Cronberg 1994: Plachidol 2 2019/x
Chroococcus minimus (Keissler) Lemmermann 1904: Satovcha 2 2021/x
Chroococcus minutus (Kützing) Nägeli 1849: Ablanitsa 2021/xx (cf.), Hadzhi Yani 2021/x (cf.), Durankulashko Ezero 2018/xxx, Shumensko Ezero 2019/xx
*_Chroococcus limneticus_ var. _elegans_ G. M. Smith 1918: Durankulashko Ezero 2019/xx, Plachidol 2 2019/x
*_Chroococcus obliteratus_ Richter 1885: Malko Sharkovo 2023/xx
Chroococcus sp.: Poroy 2023/x
Chrysosporum bergii (Ostenfeld) E. Zapomelová, O. Skácelová, P. Pumann, R. Kopp & E. Janecek 2012: Burgasko Ezero 2018/xx, Zhrebchevo 2019/xx. Additional information in Stefanova et al. (2020), Stoyneva-Gärtner et al. (2023).
*_Chrysosporum minus_ (Kisselev) Komárek 2012: Poroy 2021/xx, Plachidol 2 2019/xxxxx. Additional information in Stoyneva-Gärtner et al. (2023).
Chrysosporum sp. ster. (?_Sphaerospermopsis_ sp. ster./_Aphanizomenon_ sp. ster.): Burgasko Ezero 2023/x, Malka Smolnitsa 2019/xxx
Coelomoron pusillum (Van Goor) Komárek 1988: Mogila 2021/x, Byalata Prust 2021/xx, Mandra 2018/x, Preselka 2019/xx, Izvornik 2 2019/x, Kriva Reka 2019/xxxx, Yastrebino 2023/x, Suedinenie 2019/x, Al. Stamboliyski 2019/x, Sopot 2019/x, Duvanli 2019/xx. Additional information in Stoyneva-Gärtner et al. (2023).
Coelomoron sp.: Burgasko Ezero 2018/x
Coelosphaerium aerugineum Lemmermann 1898: Duvanli 2019/xx
Coelosphaerium cf. _kuetzingianum_ Nägeli 1849: Durankulashko Ezero 2019/x
*_Cronbergia paucicellularis_ Komárek, Zapomelová & Hindák 2010: Burgasko Ezero 2018/x
*_Cronbergia planctonica_ Komárek, Zapomelová & Hindák 2010: Plachidol 2 2019/x
Cuspidothrix elenkinii (I. A. Kisselev) P. Rajaniem, J. Komárek, R. Willame, P. Hrouzek, K. Kastovská, L. Hoffmann & K. Sivonen 2005: Mechka 2021/x, Byalata Prust 2021/xx (cf.), Mogila 2021/xx, Burgasko Ezero 2018/x, Durankulashko Ezero 2018/x (as _Raphidiopsis_ sp. ster.) and 2019/x, Yastrebino 2023/xxx, Koprinka 2019/x. Additional information in Stefanova et al. (2020), Stoyneva-Gärtner et al. (2022, 2023).
Cuspidothrix issatschenkoi (Usachev) P. Rajaniemi, Komárek, R. Willame, P. Hrouzek, K. Kastovská, L. Hoffmann & K. Sivonen 2005: Mogila 2021/xxxxx, Mandra 2018/x, Uzungeren 2018/x, Burgasko Ezero 2018/x, Poroy

2081/x and 2019/x, Eleshnitsa 2019/x, Durankulashko Ezero 2018/x, Plachidol 2019/x, Izvornik 2 2019/x, Duvanli 2019/x, Sinyata Reka 2018/x. Additional information in Stefanova et al. (2020), Stoyneva-Gärtner et al. (2022, 2023). Reported for Koprinka in 2019 (Dochin 2021).

**Cuspidothrix tropicalis* (Horecká & Komárek) Rajaniem & al. 2005: Byalata Prust 2021/xx, Studena 2021/xx (similar to Umezakia natans sensu Yoneda 1953 – fig. 959 in Komárek 2013), Mogila 2021/xx, Hadzhi Yani 2021/x, Burgasko Ezero 2018/x, Poroy 2018/x, Durankulashko Ezero 2018/xx, Sinyata Reka 2018/x and 2019/x. Additional information in Stefanova et al. (2020), Stoyneva-Gärtner et al. (2022, 2023).

Cyanodictyon planctonicum B. A. Mayer 1994: Batak 2023/xxxx, Golyam Beglik 2021/x, Krichim 2023/xxxxx, Mandra 2018/x, Burgasko Ezero 2018/x, Durankulashko Ezero 2018/x, Beli Lom 2023/x

Cyanodictyon reticulatum (Lemmermann) Geitler 1925: Toshkov Chark 2023/x, Durankulashko Ezero 2018/x and 2021/x

Dolichospermum cf. *affine* (only sterile trichomes): Izvornik 2 2019/x

**Dolichospermum circinale* (Rabenhorst ex Bornet & Flahault) Wacklin, Hoffmann & Komárek 2009: Beli Lom 2023/x

Dolichospermum crassum (Lemmermann) P. Wacklin, L. Hoffmann & J. Komárek 2009: Burgasko Ezero 2018/xx. Additional information in Stefanova et al. (2020).

Dolichospermum compactum (Nygaard) P. Wacklin, L. Hoffmann & J. Komárek 2009: Mogila 2021/xxx, Burgasko Ezero 2018/x, Izvornik 2 2019/xxxxx. Additional information in Stefanova et al. (2020), Stoyneva-Gärtner et al. (2023).

Dolichospermum flos-aquae (Bornet & Flahault) P. Wacklin, L. Hoffmann & Komárek 2009: Trakiets 2023/xxx, Mogila 2021/xx, Burgasko Ezero 2018/xxx. Additional information in Stefanova et al. (2020). Reported among the dominants of Burgasko Ezero in July and September 2018 (Teneva et al. 2020) and as occurring in Sinyata Reka in 2019 (Dochin 2021).

**Dolichospermum mucosum* (Komárková-Legnerová & Eloranta) Wacklin, L. Hoffmann & Komárek 2009: Izvornik 2 2019/x

Dolichospermum perturbatum (H. Hill) Wacklin, L. Hoffmann & Komárek 2009: Burgasko Ezero 2018/xxxxx, Durankulashko Ezero 2018/x, Izvornik 2 2019/xxxx. Additional information in Stefanova et al. (2020), Stoyneva-Gärtner et al. (2023).

**Dolichospermum planctonicum* (Brunnthaler) Wacklin, L. Hoffmann & Komárek 2009: Ablanitsa 2021/xxxxx, Toshkov Chark 2023/x, Golyam Beglik 2021/xxxxx, Dospat 2023/xxxx, Ivaylovgrad 2023/xx, Mechka 2021/xx, Sopot 2019/x, Yastrebino 2023/x. Additional information in Stoyneva-Gärtner et al. (2023).

Dolichospermum scheremetieviae (Elenkin) Wacklin, L. Hoffmann & Komárek

2013: Yunets 2021/xxxxx. Additional information in Stoyneva-Gärtner et al. (2023).

Dolichospermum cf. *tenericaule* (Nygaard) E. Zapomelová, O. Skácelová, P. Pumann, R. Kopp & E. Janecek 2012: Mogila 2021/xx

Dolichospermum sp. ster. 1: Byalata Prust 2021/x

Dolichospermum sp. ster. 2 (?*Chrysosporum* sp. ster.): Shiroka Polyana 2021/x, Burgasko Ezero 2018/x, Izvornik 2 2019/xx, Zhrebchevo 2019/x, Sopot 2019/x. Additional information in Stefanova et al. (2020).

Eucapsis aphanocapsoides (Skuja) Komárek & Hindák 2016: Dubnitsa 2021/x, Burgasko Ezero 2018/x, Uzungeren 2021/xx

Eucapsis microscopica (Komárková-Legnerová & G. Cronberg) Komárek & Hindák 2016: Burgasko Ezero 2018/x, Durankulashko Ezero 2021/x

Geitlerinema sp. (?*Anagnostidinema* sp.): Byalata Prust 2021/x, Burgasko Ezero 2018/x, Beli Lom 2023/x

Glaucospira laxissima (G. S. West) Simic, Komárek & Dordevic 2014: Burgasko Ezero 2018/x, Shablensko Ezero 2019/xxx, Plachidol 2 2019/xxx, Malka Smolnitsa 2019/xx, Preselka 2019/xxx, Duvanli 2019/xxxxx. Additional information in Uzunov et al. (2021b).

Gloeocapsa sp. (colorless mucilage, cell content destroyed, single colony of 8 cells): Izvornik 2 2019/x

Gomphosphaeria aponina Kützing 1836: Burgasko Ezero 2018/x

Jaaginema geminatum (Schwabe ex Gomont) Anagnostidis & Komárek 1988: Duvanli 2019/x

Jaaginema gracile Anagnostidis & Komárek 1988: Uzungeren 2021/x, Izvornik 2 2019/xx

**Jaaginema metaphyticum* Komárek 1988: Malka Smolnitsa 2019/x

**Jaaginema subtilissimum* (Kützing ex Forti) Anagnostidis & Komárek 1988: Beglika 2023/x

Kamptonema chlorinum (Kützing ex Gomont) Strunecký, Komárek & J. Smarda 2014: Burgasko Ezero 2023/xx

Komvophoron cf. *constrictum* (Szafer) Anagnostidis & Komárek 1988: Durankulashko Ezero 2021/x

Komvophoron schmidlei (Jaag) Anagnostidis & Komárek 1988: Burgasko Ezero 2023/xxx

Lemmermanniella pallida (Lemmermann) Geitler 1942: Duvanli 2019/x

Leptolyngbya cf. *tenuis* (Gomont) Anagnostidis & Komárek 1988: Kurzdhali 2023/xx

Leptolyngbya cf. *valderiana* (Gomont) Anagnostidis & Komárek 1988: Krichim 2023/x

Limnococcus limneticus (Lemmermann) Komárková, Jezberová, O. Komárek & Zapomelová 2010: Byalata Prust 2019/x, Studena 2021/x, Aheloy 2018/x, Tsonevo 2021/x, Durankulashko Ezero 2018/x and 2019/x, Fisek 2019/x, Suedinenie 2019/xx, Nikolovo 2021/x, Duvanli 2019/xx

**Limnothrix mirabilis* Anagnostidis 2001: Uzungeren 2018/xx, Poroy 2018/xxxx. Additional information in Stoyneva-Gärtner et al. (2023).

Limnothrix planctonica (Wołoszyńska) Meffert 1988: Toshkov Chark 2023/x (cf.), Burgasko Ezero 2021/x, Poroy 2021/x, Yunets 2021/x (cf.), Durankulashko Ezero 2019/x

Limnothrix redekei (Goor) Meffert 1988: Mandra 2018/x, Shablensko Ezero 2019/xxx, Malka Smolnitsa 2019/xxx, Preselka 2019/xxxxx. Additional information in Stoyneva-Gärtner et al. (2023). Reported among the dominants of Burgasko Ezero in April 2018 (Teneva et al. 2020).

Limnothrix sp. 1 (fragments): Birgo 2021/x

Limnothrix sp. 2 (transparent / empty cells) – Hadzhi Yani 2021/xx

**Mantellum communis* Hindák 2002: Durankulashko Ezero 2018

Merismopedia glauca (Ehrenberg) Kützing 1845: Durankulashko Ezero 2018/x, Izvornik 2 2019/x

**Merismopedia marssonii* Lemmermann 1900: Durankulashko Ezero 2018/xx

Merismopedia tranquilla (Ehrenberg) Trevisan 1845: Hadzhidimovo 2021/x, Mogila 2021/x, Durankulashko Ezero 2018/xx, Tsonevo 2021/x, Malka Smolnitsa 2019/xx, Izvornik 2 2019/xx

Merismopedia tenuissima Lemmermann 1898: Uzungeren 2018/x, Burgasko Ezero 2018/x, Aheloy 2018/x, Kriva Reka 2019/xxx

Merismopedia warmingiana (Lagerheim) Forti 1907: Burgasko Ezero 2018/x, Poroy 2018/x, Durankulashko Ezero 2018/xx and 2019/xxx, Malka Smolnitsa 2019/xxx, Preselka 2019/x

Microcrocis cf. *obvoluta* (Tiffany) T. H. Frank & A. G. Landman, nom. inval. 1988: Burgasko Ezero 2018/x

Microcystis aeruginosa (Kützing) Kützing 1846: Mogila 2021/xx, Mandra 2018/x, 2019/xx, 2021/xxxx and 2023/xxxx, Uzungeren 2019/x, Burgasko Ezero 2018/x and 2021/xx, Poroy 2021/xxx, Durankulashko Ezero 2018/xxx and 2021/xxxx, Plachidol 2 2019/xx, Malka Smolnitsa 2019/x, Preselka 2019/x, Izvornik 2 2019/x, Koprinka 2019/x, Zhrebchevo 2019/x, Duvanli 2019/x, Sinyata Reka 2019/x. Additional information in Radkova et al. (2020), Stoyneva-Gärtner et al. (2021, 2023), Uzunov et al. (2021a, b). Reported as occurring in Koprinka and as a dominant in Sinyata Reka in June 2019 together with *Aphanizomenon flos-aquae* Ralfs ex Bornet et Flahault, in July 2019 together with *Pseudanabaena mucicola* (Dochin 2021).

Microcystis botrys Teiling 1942: Burgasko Ezero 2018/x, Durankulashko Ezero 2018/x. Additional information in Radkova et al. (2020).

Microcystis cf. *botrys* Teiling 1942: Burgasko Ezero 2018/x. Additional information in Radkova et al. (2020).

**Microcystis comperei* Komárek 1984: Izvornik 2 2019/xx, Duvanli 2019/x. Additional information in Uzunov et al. (2021a, b).

Microcystis firma (Kützing) Schmidle 1902: Durankulashko Ezero 2018/x

Microcystis flos-aquae (Wittrock) Kirchner 1898: Hadzhidimovo 2021/x, Mogila 2021/xx, Burgasko Ezero 2018/x, Mandra 2021/x, Durankulashko Ezero 2018/x, Izvornik 2 2019/xx. Additional information in Radkova et al. (2020).

**Microcystis microcystiformis* (Hindák) Joosten 2006: Izvornik 2 2019/x

Microcystis natans Lemmermann ex Skuja 1934: Durankulashko Ezero 2018/x, Izvornik 2 2019/xx, Zhrebchevo 2019/x, Duvanli 2019/xxx. Additional information in Radkova et al. (2020), Uzunov et al. (2021a, b).

Microcystis cf. *natans* Lemmermann ex Skuja 1934: Duvanli 2019/x. Additional information in Uzunov et al. (2021a).

**Microcystis novacekii* (Komárek) Compère 1974: Burgasko Ezero 2018/x, Mandra 2018/xx. Additional information in Radkova et al. (2020), Uzunov et al. (2021b), Stoyneva-Gärtner et al. (2023).

Microcystis cf. *novacekii* (Komárek) Compère 1974: Burgasko Ezero 2018/x, Poroy 2018/x. Additional information in Radkova et al. (2020), Stoyneva-Gärtner et al. (2023).

**Microcystis pseudofilamentosa* Crow 1923: Mogila 2021/x, Plachidol 2 2019/x, Malka Smolnitsa 2021/x, Duvanli 2019/x. Additional information in Uzunov et al. (2021a).

**Microcystis smithii* Komárek & Anagnostidis 1995: Studena 2021/x, Mandra 2018/x, Uzungeren 2021/xx, Burgasko Ezero 2021, Durankulashko Ezero 2018/x, Malka Smolnitsa 2019/xx, Zhrebchevo 2019/x, Sinyata Reka 2019/x. Additional information in Radkova et al. (2020), Uzunov et al. (2021a, b).

Microcystis cf. *viridis* (A. Braun) Lemmermann 1903: ?Poroy 2019/x, ?Ezerets 2019/x, Malka Smolnitsa 2019/x, Preselka 2019/x, ?Koprinka 2021/x, Zhrebchevo 2021/x, Duvanli 2019/x. Additional information in Stoyneva-Gärtner et al. (2021, 2023), Uzunov et al. (2021a).

Microcystis wesenbergii (Komárek) Komárek ex Komárek 2006: Mandra 2019/x, 2021/xxx and 2023/xxxxx, Burgasko Ezero 2018/x, Poroy 2019/x, Durankulashko Ezero 2018/x, Plachidol 2 2019/xx, Malka Smolnitsa 2019/xx, Preselka 2019/x, Izvornik 2 2019/xx, Kriva Reka 2019/xxxxx, Nikolovo 2021/xxxxx, Koprinka 2021/x, Duvanli 2019/x, Sinyata Reka 2018/xxxxx and 2019/xxx. Additional information in Radkova et al. (2020), Stoyneva-Gärtner et al. (2021, 2022, 2023), Uzunov et al. (2021a, b). Reported as dominant in August 2019 in Sinyata Reka together with *Microcystis aeruginosa* and *Dolichospermum* cf. *spiroides* (Klebahn) Wacklin, L. Hoffman et Komárek (Dochin 2021).

Microcystis cf. *wesenbergii* (Komárek) Komárek ex Komárek 2006 (transitional form without strong mucilage): Durankulashko Ezero 2019/x, Malka Smolnitsa 2019/x, Kriva Reka 2019/xxx, Duvanli 2019/xx

Microcystis spp. (as separate cells): Uzungeren 2018/x, Poroy 2018/x, Tsonevo 2019/x, Ezeretsko Ezero 2019/x, Durankulashko Ezero 2019/x, Plachidol 2

2019/x, Malka Smolnitsa 2019/x, Preselka 2019/x, Izvornik 2 2019/xx, Fisek 2019/x, Shumensko Ezero 2019/x, Suedinenie 2019/x, Koprinka 2021/x, Zhrebchevo 2019/x, Duvanli 2019/xxxx. Additional information in Radkova et al. (2020), Uzunov et al. (2021a, b), Stoyneva-Gärtner et al. (2023).

Microcystis sp. juv.: Uzungeren 2021/x, Poroy 2019/x, Shablensko Ezero 2019/x, Preselka 2019/x. Additional information in Uzunov et al. (2021a).

**Myxobactron* sp.: Hadzhidimovo 2021/xxx, Dospat 2021/x

Oscillatoria sancta Kützing ex Gomont 1892: Mogila 2021/x

Oscillatoria simplicissima Gomont 1892: Beglika 2023/x, Mechka 2021/x, Burgasko Ezero 2021/xxxx and 2023/x. Additional information in Stoyneva-Gärtner et al. (2023).

Oscillatoria cf. *tenuis* C. Agardh ex Gomont 1892: Dubnitsa 2021/x, a 2021/x, Beli Lom 2023/x, Durankulashko Ezero 2021/x, Nikolovo 2021/x

Oscillatoria sp. 1 (?*Phormidium* sp.): Poroy 2018/x

Oscillatoria sp. 2: Burgasko Ezero 2018/x. Additional information in Stefanova et al. (2020).

**Pannus planus* Hindák 1993: Durankulashko Ezero 2018/x

**Pannus punctiferus* (Komárek & Komárková-Legnerová) Joosten 2006: Burgasko Ezero 2018/x

**Pannus spumosus* B. Hickel 1991: Durankulashko Ezero 2018/xx

Pannus sp. (fragment of colony, cells ca. 0.8 µm): Al. Stamboliyski 2019/x

Phormidium granulatum (N. L. Gardner) Anagnostidis 2001: Ezeretsko Ezero 2019/x

Phormidium inundatum Kützing ex Gomont 1892: Burgasko Ezero 2018/x

Phormidium terebriforme (C. Agardh ex Gomont) Anagnostidis & Komárek 1988: Izvornk 2 2019/x

Phormidium sp. (? Lyngbya sp.): Duvanli 2019/x

**Planktolyngbya brevicellularis* G. Cronberg & Komárek 1994: Kurdzhali 2023/x, Burgasko Ezero 2018/x and 2023/xx, Durankulashko Ezero 2019/x

Planktolyngbya limnetica (Lemmermann) Komárková-Legnerová & Cronberg 1992: Hadzhidimovo 2021/x, Trakiets 2023/xx, Chetiridessette Izvora 2021/x, Mechka 2021/x, Byalata Prust 2021/xx, Studena 2021/xxx, Burgasko Ezero 2018/x, Eleshnitsa 2018/xxxx, Shablensko Ezero 2019/xx, Durankulashko Ezero 2018/x, Plachidol 2 2019/x, Malka Smolnitsa 2019/x, Suedinenie 2019/x, Yastrebino 2023/xx, Zhrebchevo 2019/xxx, Sopot 2019/xx, Duvanli 2019/xx. Reported for Sinyata Reka and Koprinka in 2019 (Dochin 2021). Additional information in Stoyneva-Gärtner et al. (2022, 2023).

Planktolyngbya undulata Komárek & H. Kling 1991: Eleshnitsa 2019/x, Yastrebino 2023/x

Planktolyngbya sp. 1: Satovcha 2021/x, Burgasko Ezero 2023/x

Planktolyngbya sp. 2 (transparent cells): Hadzhidimovo 2021/x, Byalata Prust 2021/x Burgasko Ezero 2023/x, Mechka 2021/x, Yastrebino 2023/x

Planktothrix agardhii (Gomont) Anagnostidis & Komárek 1988: Burgasko Ezero 2018/xxxx, 2019/xx and 2021/x, Suedinenie 2019/x. Reported among the dominants of Burgasko Ezero in July and September 2018 (Teneva et al. 2020) and as occurring in Koprinka in 2019 (Dochin 2021). It has to be underlined that we observe a decline of this species, known since years as one of the most frequent species in Burgasko Ezero (Dimitrova et al. 2014; Descy et al. 2018), and its replacement by the combination *P. isothrix* and *P. suspensa* (see below).

Planktothrix isothrix (Skuja) Komárek & Komárková 2004: Burgasko Ezero 2018/xxxxx and 2019/xxxxx, Durankulashko Ezero 2019/x, Malka Smolnitsa 2019/xx, Preselka 2019/x. Additional information in Uzunov et al. (2021b), Stoyneva-Gärtner et al. (2023). Reported among the dominants of Burgasko Ezero in July and September 2018 (Teneva et al. 2020).

**Planktothrix suspensa* (Pringsheim) Anagnostidis & Komárek 1988: Satovcha 2021/xxx, Mandra 2021/xx, Burgasko Ezero 2019/xxxxx, Shablensko Ezero 2019/xx. Additional information in Uzunov et al. (2021b), Stoyneva-Gärtner et al. (2023).

Pseudanabaena articulata Skuja 1948: Mogila 2021/x, Plachidol 2 2019/x, Duvanli 2019/x

**Pseudanabaena balatonica* Scherffel & Kol 1938: Burgasko Ezero 2018/x

Pseudanabaena catenata Lauterborn 1915: Mechka 2021/x, Mandra 2018, Burgasko Ezero 2018/x and 2023/xx, Durankulashko Ezero 2018/xx

Pseudanabaena galeata Böcher 1949: Yunets 2021/x, Shablensko Ezero 2019/xxx, Durankulashko Ezero 2019/x, Izvornik 2 2019/xx

Pseudanabaena limnetica (Lemmermann) Komárek 1974: Mechka 2021/x, Burgasko Ezero 2019/x and 2023/xx, Yunets 2021/x, Eleshnitsa 2019/x, Shablensko Ezero 2019/xxxx, Plachidol 2 2019/x, Malka Smolnitsa 2019/xxxxx, Preselka 2019/xxxx, Suedinenie 2019/x, Duvanli 2019/xxxxx. Additional information in Uzunov et al. (2021b), Stoyneva-Gärtner et al. (2023). Reported for Sinyata Reka in 2019 (Dochin 2021).

Pseudanabaena mucicola (Naumann & Huber-Pestalozzi) Schwabe 1964: Hadzhidimovo 2021/x, Mandra 2023/xxxx, Durankulashko Ezero 2018/xx and 2021/xxxx, Nikolovo 2021/xxxx, Koprinka 2019/x. Additional information in Radkova et al. (2020), Stoyneva-Gärtner et al. (2023). Reported as dominant in Sinyata Reka in July 2019 together with *Microcystis aeruginosa* and as occurring in Koprinka in 2019 (Dochin 2021).

Pseudanabaena sp. 1: Dospat 2021/x. "*Pseudanabaena* sp." without notes has been reported for Sinyata Reka in 2019 (Dochin 2021).

Pseudanabaena sp. 2 (?Unconstricted form of *Ps. limnetica*): Zhrebchevo 2019/x

**Raphidiopsis acuminato-crispa* (Couvy & Bouvy) Aguilera, Berrendero Gómez, Kastovsky, Echeniqe & Salerno 2018: Mechka 2021/xxxx. Additional information in Stoyneva-Gärtner et al. (2023).

*_Raphidiopsis cuspis_ (Komárek & Kling) Aguilera, Berrendero Gómez, Kastovsky, Echenique & Salerno 2018: Mechka 2021/xxxx (as _R. raciborskii_ p.p. in Stoyneva-Gärtner et al. 2023), Byalata Prust 2021/xxxx, Shablensko Ezero 2019/xx

*_Raphidiopsis gangetica_ (G. U. Nair) Aguilera, Berrendero Gómez, Kastovsky, Echenique & Salerno 2018: Mechka 2021/xxxxx. Additional information in Stoyneva-Gärtner et al. (2023).

*_Raphidiopsis helicoidea_ (Cronberg & Komárek) Aguilera, Berrendero Gómez, Kastovsky, Echenique, & Salerno 2018: Burgasko Ezero 2018/x

Raphidiopsis mediterranea Skuja 1937: Mogila 2021/xxx, Burgasko Ezero 2018/x, Shablensko Ezero 2019/xxx, Plachidol 2 2019/xxxxx, Malka Smolnitsa 2019/xxx, Suedinenie 2019/xx. Additional information in Stefanova et al. (2020), Stoyneva-Gärtner et al. (2023).

Raphidiopsis cf. _mediterranea_ Skuja 1937 (?_Raphidiopsis setigera_ (Aptekarj) Eberly 1966): Burgasko Ezero 2018/x, Poroy 2018/x, Durankulashko Ezero 2019/x

*_Raphidiopsis philippinensis_ (W. R. Taylor) Aguilera, Berrendero Gómez, Kastovsky, Echenique & Salerno 2018: Shablensko Ezero 2019/x, Malka Smolnitsa 2019/x

Raphidiopsis raciborskii (Wołoszynska) Aguilera & al. 2018: Mechka 2021/xxxxx, Byalata Prust 2021/xxxx, Mogila 2021/xxx, Uzungeren 2018/xxx, Burgasko Ezero 2018/xx, Poroy 2018/xxxx, Tsonevo 2019/xx, Shablensko Ezero 2019/xxxx, Malka Smolnitsa 2019/xxxxx, Preselka 2019/xxxx. Additional information in Stefanova et al. (2020), Stoyneva-Gärtner et al. (2022, 2023).

*_Raphidiopsis setigera_ (Aptekarj) Eberly 1966): Mogila 2021/xxx. The name belongs to an entity that is currently accepted taxonomically (Guiry & Guiry 2023). According to Komárek (2013) this species, described from Ukraine, is possibly a form of _Cuspidothrix_ or _Raphidiopsis_ without heterocytes and akinetes. In the material from Mogila we never saw heterocytes, but very rarely wider cells (?initial akinetes – **Fig. 5, 168**) have been seen below the apical cell, and once a young akinete was observed below the apical cell. It is more cylindrical than the oval akinetes of _R. mediterranea_, which does not allow us to make a strong statement. However, the often common finding of the trichomes of both species, allowed us tentatively to suppose their close relationship and the possibility _R. setigera_ to be a stage of _R. mediterranea_ with undeveloped akinetes. Doubtless, further molecular-genetic studies are necessary to clarify the both species.

*_Raphidiopsis turcomanica_ Kogan 1967: Mechka 2021/xx. Despite finding of trichomes with akinetes fitting to the diagnosis, we tentatively suppose that this is a stage of _R. mediterranea_ Skuja 1937.

*_Rhabdoderma compositum_ (G. M. Smith) Fedorov 1967: Mandra 2018/x

Rhabdoderma lineare Schmidle & Lauterborn 1900: Burgasko Ezero 2018/x (cf., <1 µm wide), Shablensko Ezero 2019/xx

Rhabdoderma sp.: Ezeretsko Ezero 2019/x

**Romeria gracilis* (Koczwara) Koczwara 1932: Burgasko Ezero 2018/x, Ezeretsko Ezero 2018/x

Romeria simplex (Hindák) Hindák 1988: Izvornik 2 2019/xxx, Duvanli 2019/xxxxx. Additional information in Stoyneva-Gärtner et al. (2022, 2023).

Snowella arachnoidea Komárek & Hindák 1988: Durankulashko Ezero 2019

Snowella lacustris (Chodat) Komárek & Hindák 1988: Malka Smolnitsa 2019/x, Izvornik 2 2019/xx, Beli Lom 2023/x, Koprinka 2019/xxx, Zhrebchevo 2019/xx, Duvanli 2019/xx. Reported as abundant in July and dominant in August 2019 in Koprinka and as occurring in Sinyata Reka in 2019 (Dochin 2021).

Snowella litoralis (Häyrén) Komárek & Hindák 1988: Plachidol 2 2019/x, Duvanli 2019/xx. Reported among the dominants of Burgasko Ezero in April 2018 (Teneva et al. 2020).

Snowella septentrionalis Komárek & Hindák 1988: Durankulashko Ezero 2018/x

Spirulina cf. *major* Kützing ex Gomont 1892: (?*Vorticella* fragment): Burgasko Ezero 2023/x

Sphaerospermopsis aphanizomenoides (Forti) Zapomelová, Jezberová, Hrouzek, Hisem, Reháková & Komárková 2010: Byalata Prust 2021/xx, Studena 2021/xxxxx, Mogila 2021/xxx, Burgasko Ezero 2019/x and 2021/xxxxx, Shablensko Ezero 2019/xxxxx (as "*Chrysosporum ovalisporum*" – err. typogr. in Stoyneva-Gärtner et al. 2023), Malka Smolnitsa 2019/xxx, Yastrebino 2023/x. Additional information in Stoyneva-Gärtner et al. (2023).

**Sphaerospermopsis* cf. *reniformis* (Lemmermann) Zapomelová, Jezberová, Hrouzek, Hisem, Reháková & Komárková 2010: Studena 2021/xx

**Sphaerospermopsis torques-reginae* (Komárek) Werner, Laughinghouse IV, Fiore & Sant'Anna 2012: Sinyata Reka 2019/xxxxx. Additional information in Uzunov et al. (2021b), Stoyneva-Gärtner et al. (2022, 2023).

**Synechococcus endogloeicus* Hindák 1996: Plachidol 2 2019/x, Sinyata Reka 2018/x and 2019/xx

**Synechococcus epigloeicus* Hindák 1996: Mandra 2021/xx, Burgasko Ezero 2023/xx, Plachidol 2 2019/xx, Sinyata Reka 2019/xx

Synechococcus cf. *nidulans* (Pringsheim) Komárek 1970: Burgasko Ezero 2018/xx

Synechococcus sp. 1 (?*Cyanobium* sp.): Shablensko Ezero 2019/x

Synechococcus sp. 2 (?*Synechocystis* sp.): Krapets 2019/x

Synechocystis cf. *aquatilis* Sauvageau 1892: Uzungeren 2018/x, Burgasko Ezero 2018/x, Poroy 2018/x. Additional information in Radkova et al. (2020).

**Synechocystis endobiotica* (Elenkin & Hollerbach) Elenkin 1938: Burgasko Ezero 2018/x, Durankulashko Ezero 2018/xx and 2021/xxxx, Plachidol 2 2019/xx, Koprinka 2019/x, Sinyata Reka 2019/xxx. Additional information in Stoyneva-Gärtner et al. (2023).

Synechocystis sp. (af. *S. bigranulatus* Skuja 1933): Poroy 2019/xx
**Trichodesmium iwanoffianum* Nygaard 1926: Yunets 2021/x
Trichormus cf. *variabilis* (Kützing ex Bornet & Flahault) Komárek & Anagnostidis 1989: Toshkov Chark 2023/x
Trichormus sp. ster. 1 (af. *T. doliolum* Bharadwaja) Komárek & Anagnostidis 1989): Burgasko Ezero 2018/x
Trichormus sp. ster. 2: Beli Lom 2023/xx
**Tychonema sequanum* (J. W. G. Lund) Anagnostidis & Komárek 1988: Durankulashko Ezero 2019x and 2021/x, Beli Lom 2023/x
**Wollea* sp.: Studena 2021/x
Woronichinia elorantae Komárek & Komárková-Legnerová 1992: Durankulashko Ezero 2019/xx
**Woronichinia microcystoides* (Komárek) Joosten 2006: Durankulashko Ezero 2018/x
Woronichinia naegeliana (Unger) Elenkin 1933: Yastrebino 2023/x. Reported for Koprinka in 2019 (Dochin 2021).

The highest total number of cyanoprokaryote species was found in Burgasko Ezero in the year 2018 – 55 species, followed by Durankulashko Ezero in 2018 – 34, Duvanli in 2019 – 29, Izvornik 2 in 2019 – 26 and Malka Smolnitsa in 2019 – 23 (**Fig. 2**). The lowest number (1 species) was detected in the reservoirs Batak (2023), Vucha (2023), Shiroka Polyana (2023), Tsonevo (2019, 2023), Shilkovtsi (2019) and Krapets (2019), and in the lakes Ezeretsko Ezero (2018) and Shablensko Ezero (2018). The representatives of this group have not been recorded in the samples processed from the following four reservoirs: Beglika (2021), Studen Kladenets (2023), Rozov Kladenets (2023) and Suedinenie (2023) – **Fig 2**.

With this large variation in the diversity, ranging from 0 to 55 species per site, the average contribution of cyanoprokaryotes to the summer phytoplankton of each waterbody was estimated as 8 species, or 44% of the total phytoplankton diversity (**Fig. 3**) In 12 cases their contribution exceeded 50% of the total biodiversity, being the highest in Plachidol 2 in 2019 (84%), Golyam Beglik in 2021 (80%), Burgasko Ezero 2021 and 2023 (70 and 77%), Mechka in 2021 (71%), Shumensko Ezero in 2021 (66%), Preselka in 2019 (64%), Izvornik 2 in 2019 (57%), Koprinka in 2021 (52%) and Mogila 2021 (51%) – **Fig. 3**.

Considering the total number of taxa per site, one of the results from this study has to be boldly underlined – this number varied significantly from year to year and, since the identification was done by one and the same person, we state that it reflects the real changes in the biodiversity depending on the moment conditions in the certain waterbodies. For example, in the years 2019, 2021 and 2023, after the strong spring and early summer rains, the number of cyanoprokaryotes in Burgasko Ezero was much lower – 7, 7 and 12, respectively in comparison with the drier and warmer 2018, when they were represented by 55 taxa (**Fig. 2**). In the same time, the contribution of these algae to the biodiversity in the years 2019 and 2021 was much higher (70 and 77%, respectively) than in 2018 (43%) - **Fig 3**. According to the morphology, the recorded algae were distributed as follows: 83 coccal, 52 non-heterocytous filamentous and 51 heterocytous filamentous cyanoprokaryotes. Their average contribution to the phytoplankton diversity was estimated as 4 coccal, 2 non-heterocytous and 2 heterocytous species per site. In the results below are not mentioned the waterbodies, in which cyanoprokaryotes have not been detected. The highest number of coccal unicellular and colonial species was found in Durankulashko Ezero in the year 2018 – 27, followed by Burgasko Ezero in 2018 – 23 and Duvanli in 2019 – 19 (Fig. 4). In the reservoirs with detected biodiversity

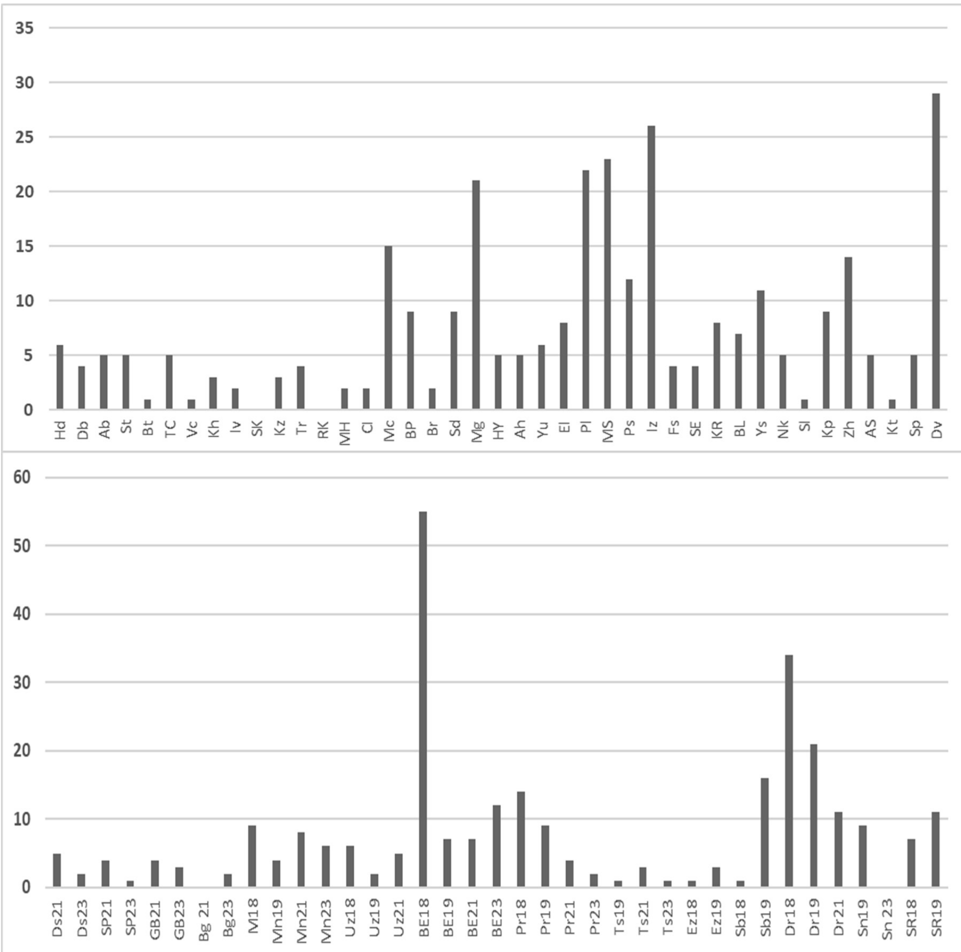


Fig. 2. Total number of cyanoprokaryote species in the summer phytoplankton of Bulgarian lakes and reservoirs sampled once (upper part of the figure) and sampled repeatedly (lower part of the figure). Abbreviations of the names of the waterbodies are according to **Table 1**.

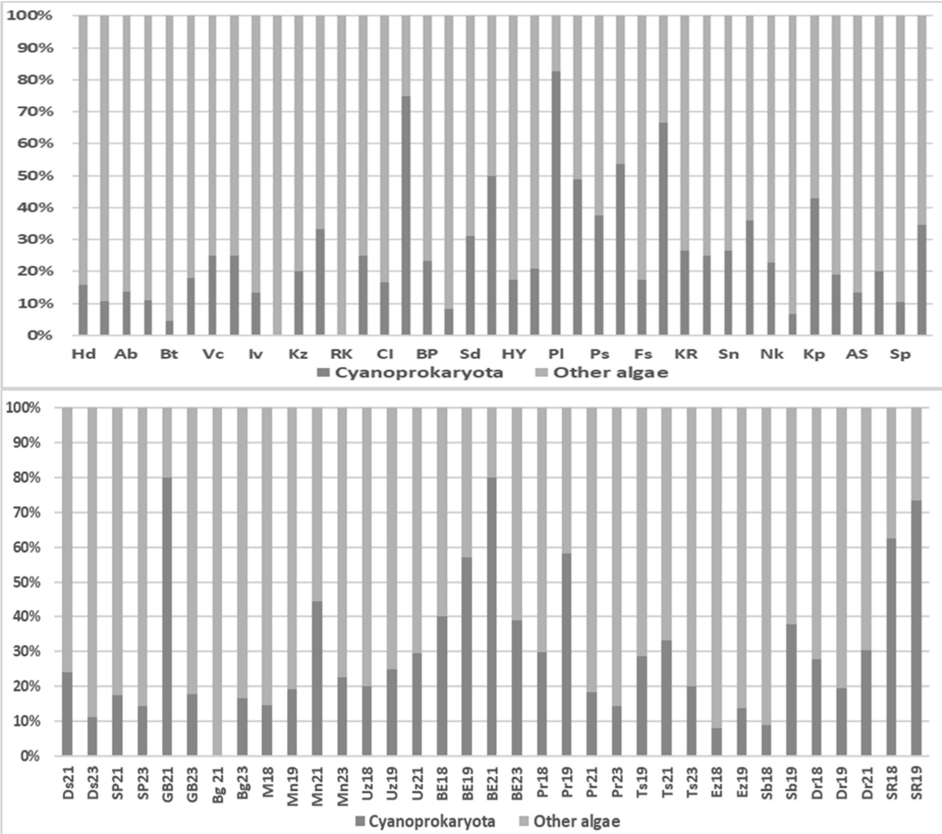


Fig. 3. Contribution of cyanoprokaryotes (%) to the total biodiversity of the summer phytoplankton of Bulgarian lakes and reservoirs sampled once (upper part of the figure) and sampled repeatedly (lower part of the figure). Abbreviations of the names of the waterbodies are according to **Table 1**, with indication of the sampling year.

of cyanoprokaryotes, their coccal representatives have not been seen in the samples from the reservoirs Dospat, Beglika, Vucha, Ivaylovgrad and Kurdzhali (all from 2023), Chetiridesette Izvora and Yunets (all from 2021), as well as in the lakes Uzungeren (2019), Shablensko Ezero (2018) – **Fig. 4**. The highest number of the non-heterocytous filamentous forms was 12 and 8 in Burgasko Ezero (2018 and 2023), followed by 7 species in the Malka Smolnitsa, and 6 species in Shablensko Ezero and Duvanli (all from 2019). These algae have not been documented: 1) in the samples from 2018 collected from Ezeretsko Ezero; 2) in 2019 samples from Mandra, Uzungeren, Poroy, Aheloy, Tsonevo, Fisek, Shumensko Ezero, Kriva Reka and Krapets; 3) in 2021 samples from Golyam Beglik, Beglika, Tsonevo and Yunets, and 4) in 2023 samples from Batak, Dospat, Shiroka Polyana, Vucha, Ivaylovgrad, Malko Sharkovo and Tsonevo. The highest number of heterocytous

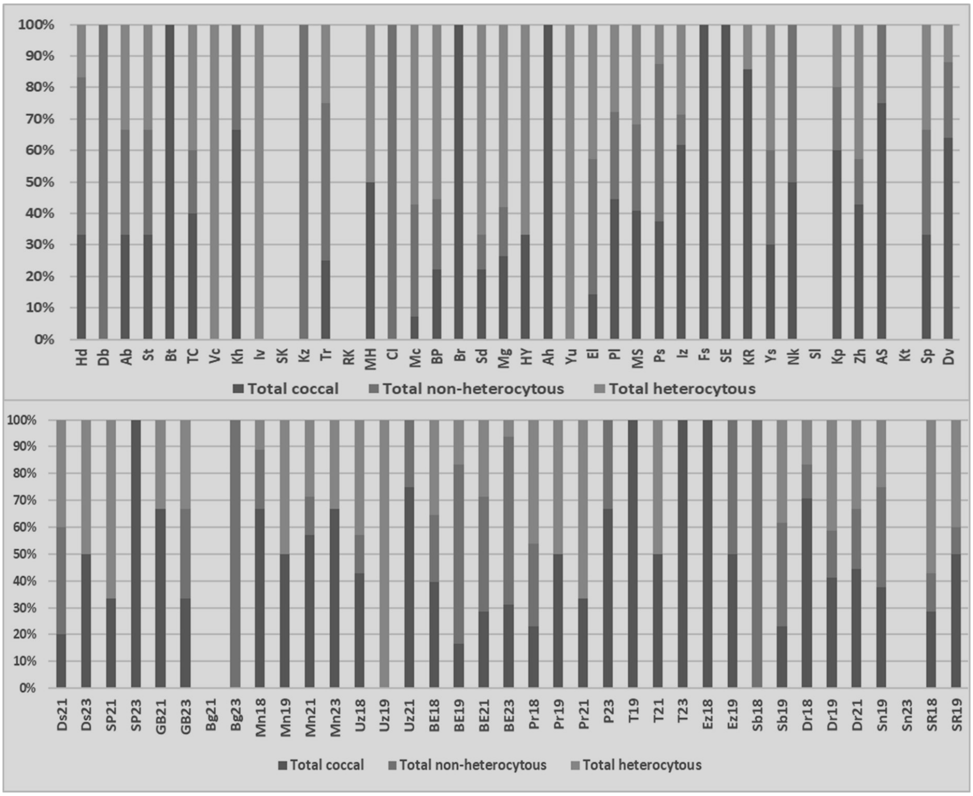


Fig. 4. Contribution of different morphological types of cyanoprokaryotes (coccal, filamentous non-heterocytous and filamentous heterocytous) to their biodiversity in of the summer phytoplankton of Bulgarian lakes and reservoirs sampled once (upper part of the figure) and sampled repeatedly (lower part of the figure). Abbreviations of the names of the waterbodies are according to **Table 1**.

filamentous taxa was recorded in the lake Burgasko Ezero in 2018 – 20, followed by 13 in the microreservoir Mogila (2021) and 8 in the microreservoir Izvornik 2 (2019) 2021 – **Fig. 4**. Heterocytous cyanoprokaryotes have not been found in the samples from Aheloy, Ezeretsko Ezero, Shablensko Ezero (all in 2018), from Tsonevo, Ezeretsko Ezero, Fisek, Shumensko Ezero, Aleksandur Stamboliyski and Krapets (all in 2019), from Hadzhidimovo, Dubnitsa, Beglika, Chetiridisette Izvora, Birgo, Uzungeren, Nikolovo (all in 2021), and from Batak, Shiroka Polyana, Beglika, Krichim, Kurdzhali, Poroy and Tsonevo (all in 2023).

Among the most rarely spread algae, which have been recorded only once, 39 were coccal, 23 were non-heterocytous and 32 were heterocytous forms.

It is out of the scope of this paper to discuss the driving forces that favor and factors detrimental for the cyanoprokaryote biodiversity, among which currently increased the interest to the fungal parasites (*e.g.*, Rasconi et al. 2012, 2014, 2022). Although the phytoplankton algae long ago have been pointed as hosts for zoosporic parasites (*e.g.*, Skuja 1948; Canter 1950, 1972; Canter & Lund 1948, 1951), according to our best knowledge, there are no current data concerning the spread of such fungi in Bulgarian waterbodies. Therefore, here we would like to note that during all four sampling campaigns, chytrid parasites were recorded only once. Although *Sphaerospermopsis aphanizomenoides* was found eight times in seven sites, chytrids have been observed only in the microreservoir Studena (2021) on some of the trichomes and have been tentatively identified as *Rhizosiphon anabaenae* (Rodhe & Skuja) Canter 1951 (Syn. *Phlyctidium anabaenae* Rodhe & Skuja 198) – **Fig. 5, 176**.

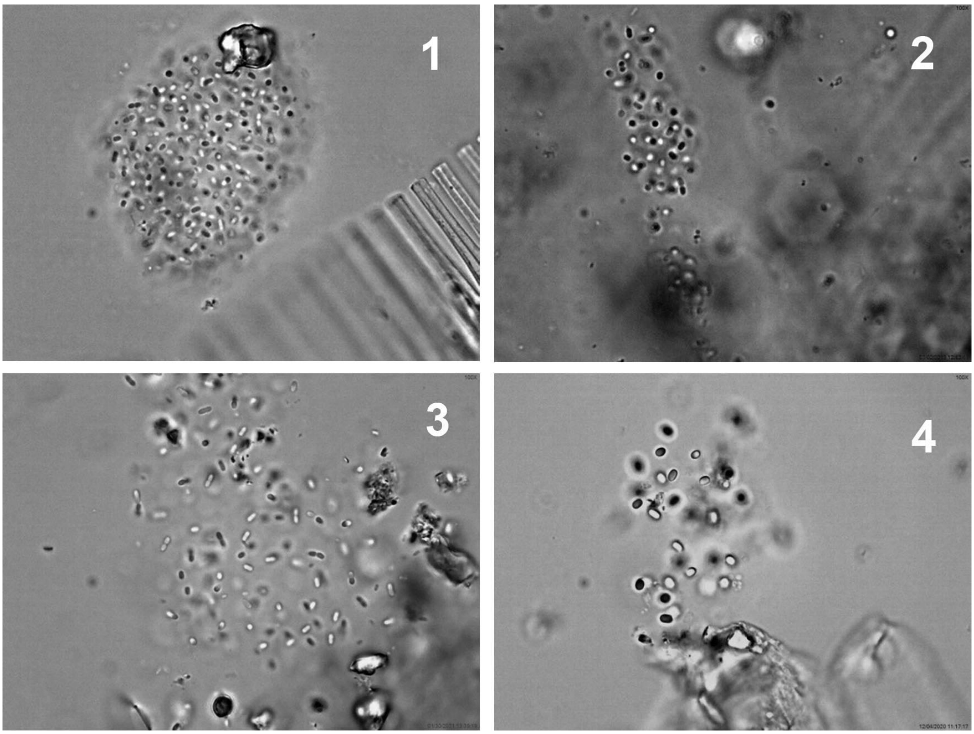
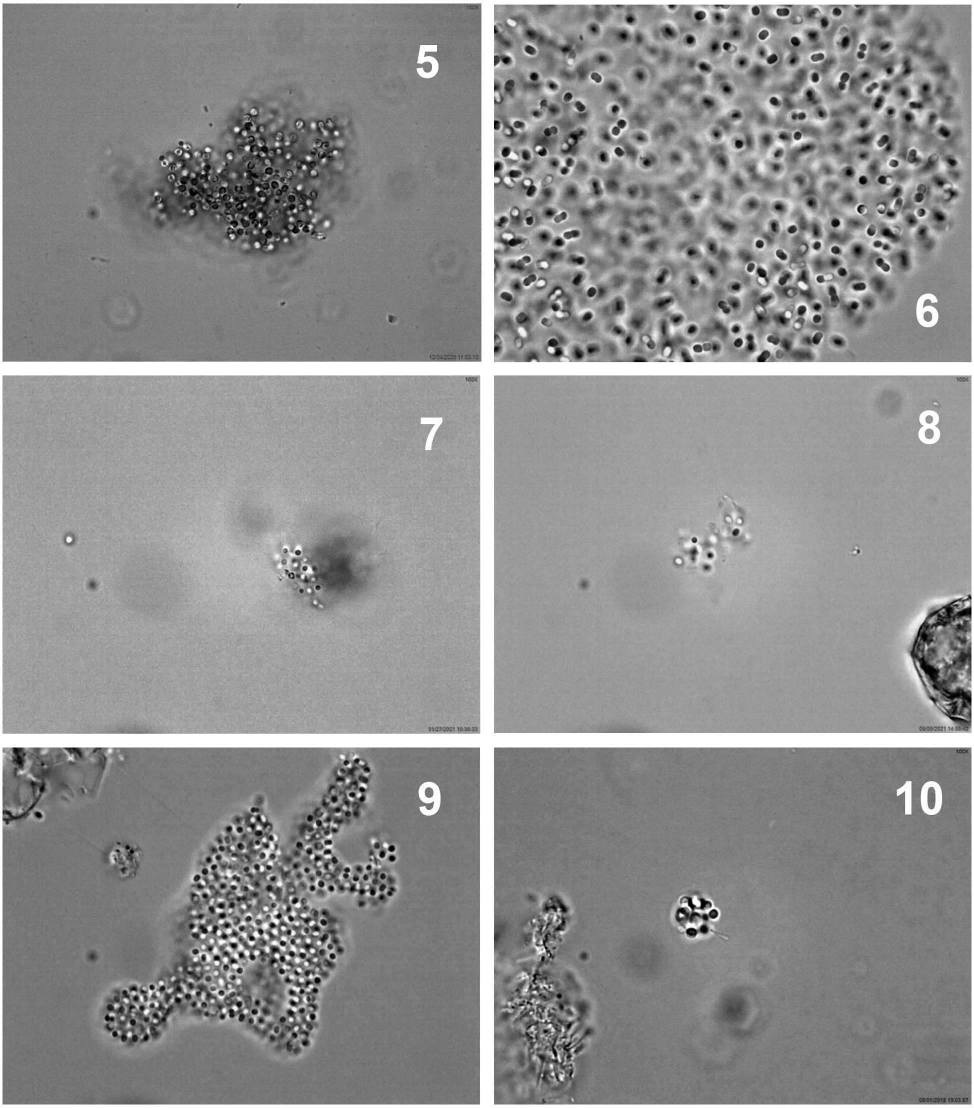
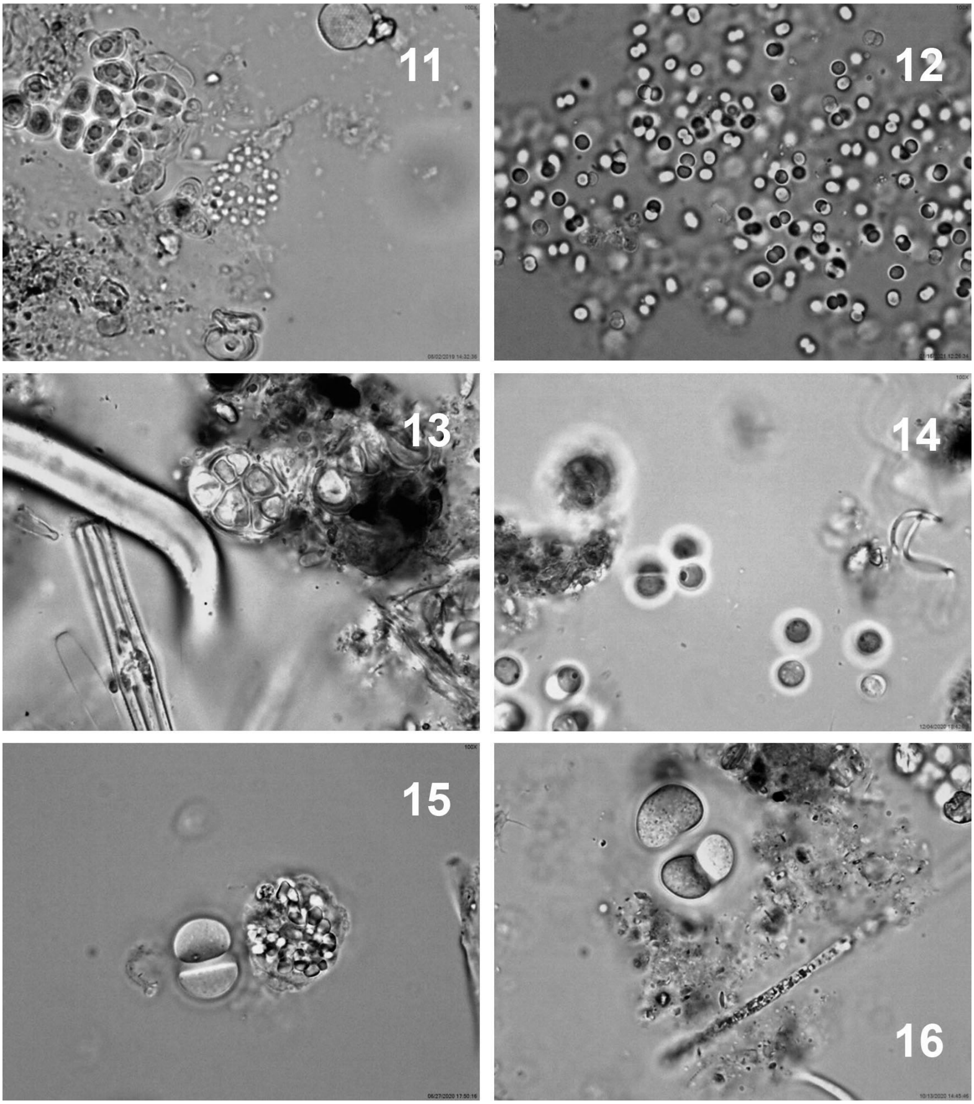


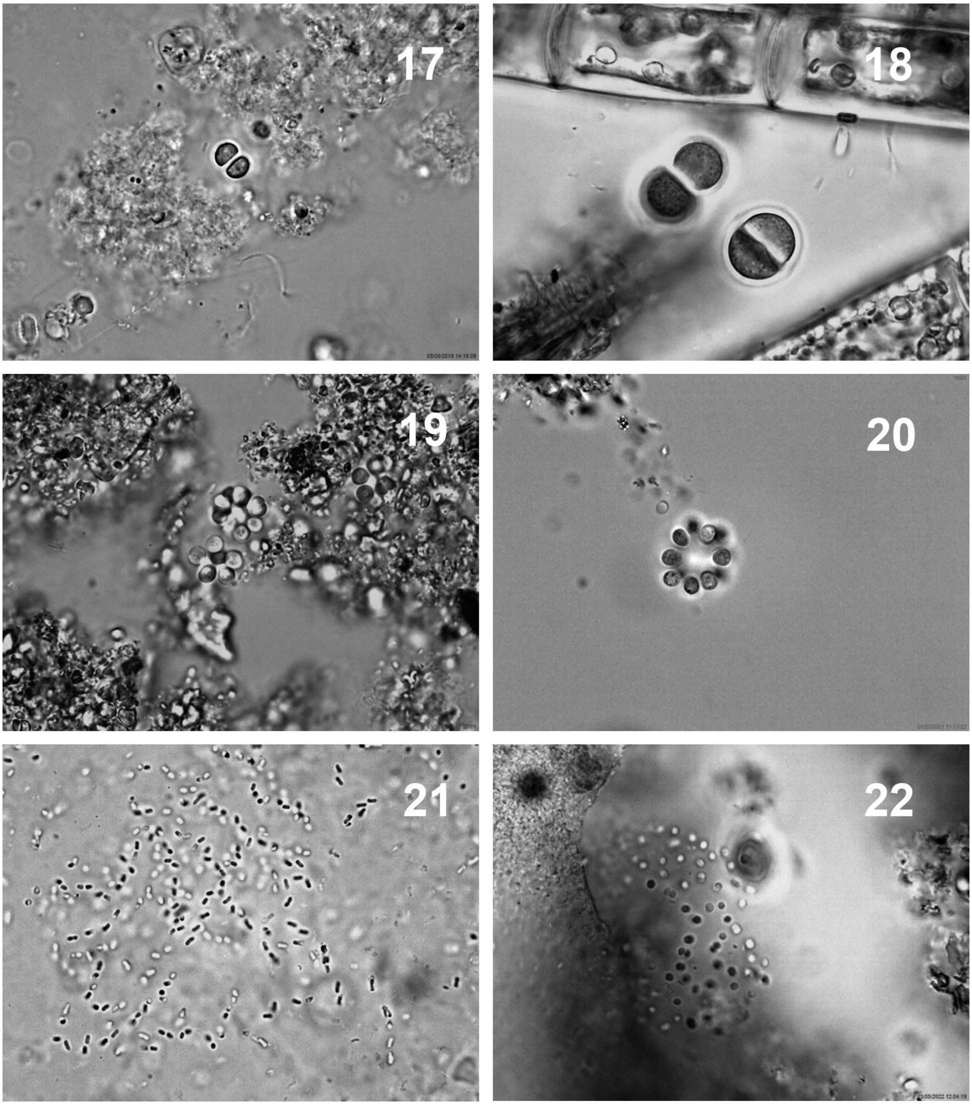
Fig. 5. Microphotos of cyanoprokaryotes from the phytoplankton samples of 55 waterbodies in Bulgaria: **1** - *Anathece bachmannii* in reservoir Krichim (2023); **2** - *Anathece floccosa* in lake Durankulashko Ezero (2018); **3** - *Anathece minutissima* in reservoir Zhrebchevo (2019); **4** - *Anathece smithii* in reservoir Kriva Reka (2019); **5** - *Aphanocapsa fusco-lutea* in reservoir Kriva Reka (2019); **6** - *Aphanocapsa conferta* in lake Burgasko Ezero (2023); **7** - *Aphanocapsa delicatissima* in reservoir Duvanli (2019); **8** - *Aphanocapsa delicatissima* in reservoir Eleshnistsa (2019); **9** - *Aphanocapsa holsatica* in lake Burgasko Ezero (2023); **10** - *Aphanocapsa incerta* in lake Durankulashko Ezero (2018); **11** - *Aphanocapsa nubila* in lake Durankulashko Ezero (2018); **12** - *Aphanocapsa planctonica* in reservoir Izvornik 2 (2019); **13** - *Chroococcopsis gi-*



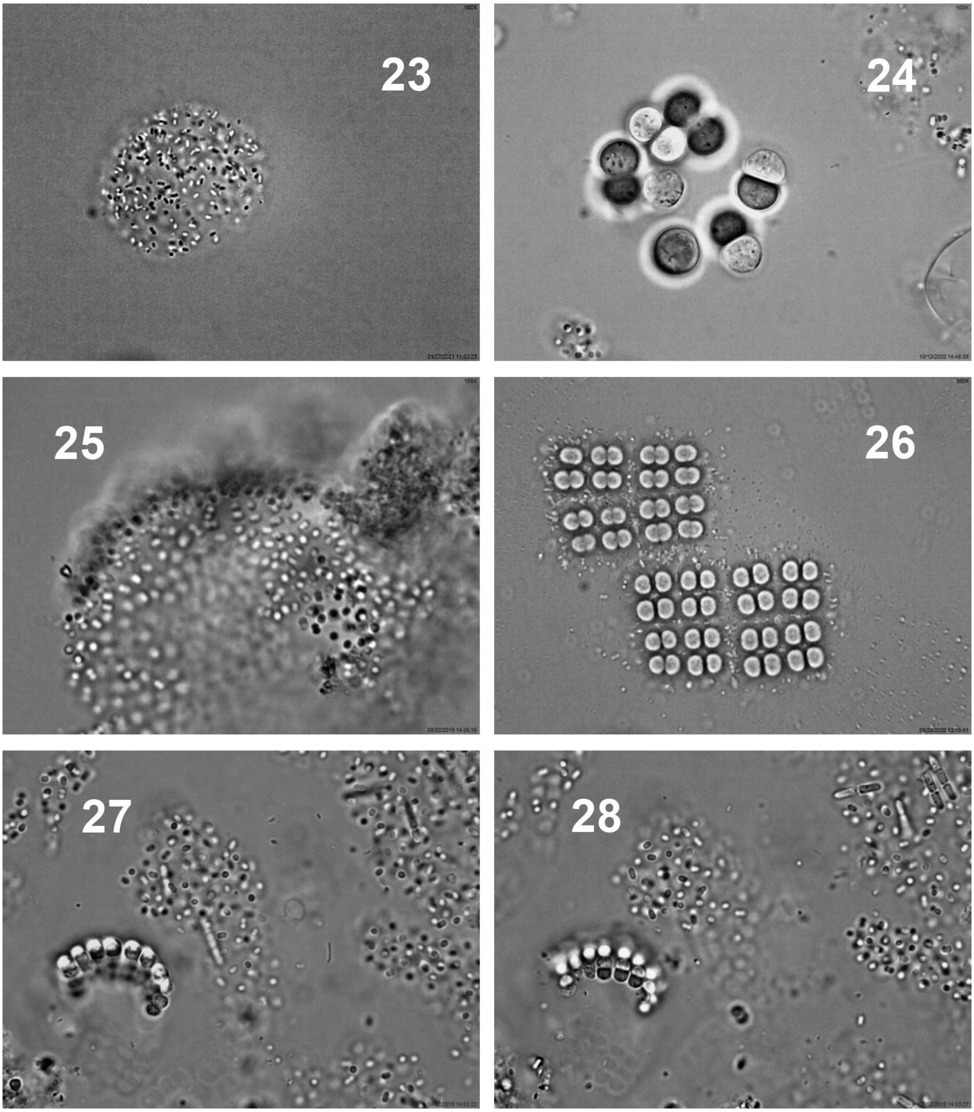
gantea in reservoir Golyam Beglik (2023); **14** - *Chroococcus distans* in reservoir Plachidol 2 (2019); **15, 16** - *Chroococcus limneticus* var. *elegans* in lake Durankulashko Ezero (2019); **17** - *Chroococcus minutus* in lake Durankulashko Ezero (2018); **18** - *Chroococcus obliteratus* in reservoir Malko Sharkovo (2023); **19** - *Coelomoron pusillum* in reservoir Izvornik 2 (2019); **20** - *Coelomoron pusillum* in reservoir Duvanli (2019); **21** - *Cyanodictyon planctonicum* in reservoir Batak (2023); **22** - *Cyanodictyon reticulatum* in lake Durankulashko Ezero (2021); **23** - *Lemmermanniella pallida* in reservoir Duvanli (2019); **24** - *Limnococcus limneticus* in lake Durankulashko Ezero (2019); **25** - *Mantellum communis* in lake Durankulashko Ezero (2018); **26** - *Merismopedia glauca* in reservoir Izvornik 2 (2019); **27**, **28** - *Merismopedia marssonii* in lake Durankulashko Ezero (2018); **29** - *Merismopedia tranquilla* in lake Durankulashko Ezero (2018); **30** - *Merismopedia warmingiana* in lake Durankulashko Ezero (2019); **31** - *Microcystis*



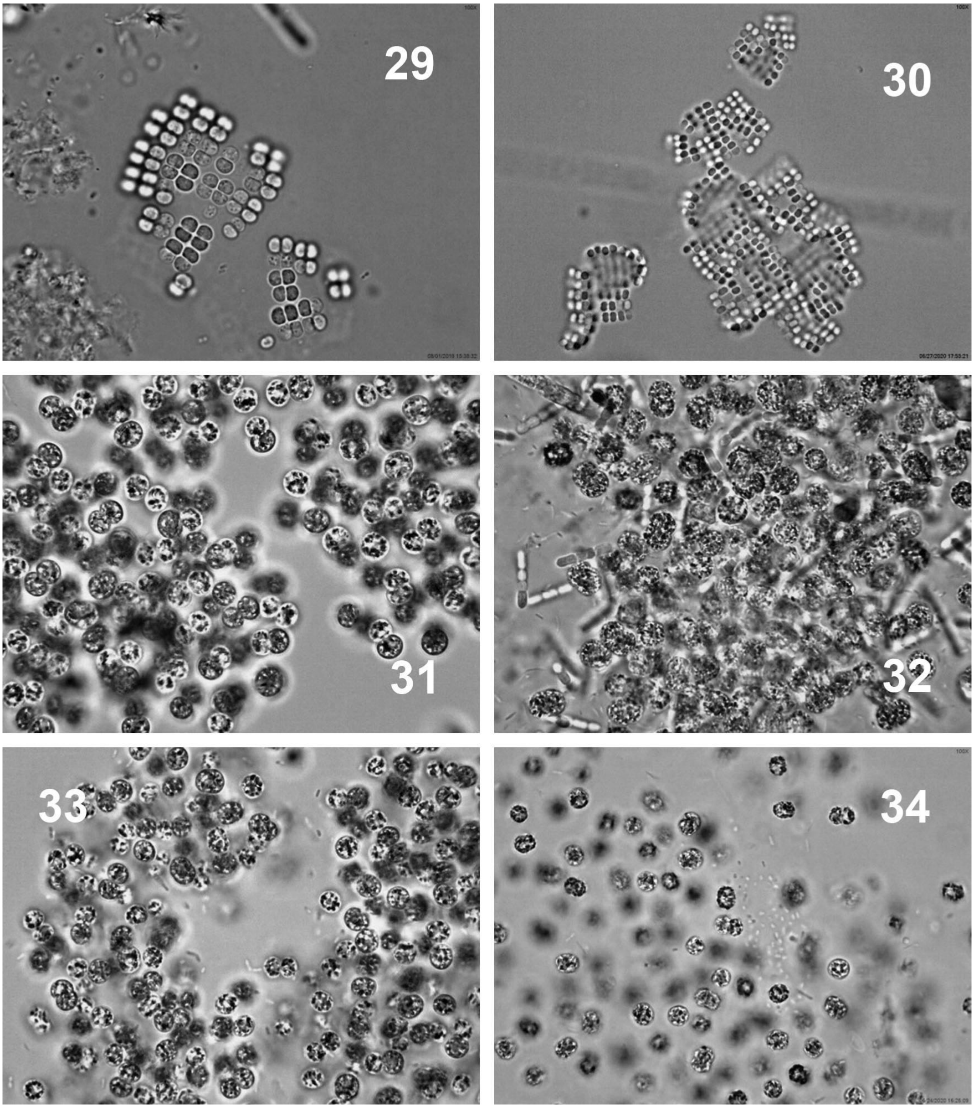
aeruginosa in lake Burgasko Ezero (2023); **32** - *Microcystis aeruginosa* with *Pseudanabena mucicola* in reservoir Mandra (2023); **33** - *Microcystis aeruginosa* with *Synechococcus epigloeicus* in lake Burgasko Ezero (2023); **34** - *Microcystis aeruginosa* with *Synechocystis endobiotica* in reservoir Sinyata Reka (2019); **35** - *Microcystis comperei* in reservoir Izvornik 2 (2019); **36** - *Microcystis firma* in lake Durankulashko Ezero (2018); **37** - *Microcystis flos-aguae* in reservoir Izvornik 2 (2019); **38** - *Microcystis microcystiformis* in reservoir Izvornik 2 (2019); **39** - *Microcystis natans* in reservoir Zhrebchevo (2019); **40** - *Microcystis novacekii* in reservoir Mandra (2018); **41** - *Microcystis pseudofilamentosa* in reservoir Plachidol 2 (2019); **42** - *Microcystis smithii* in reservoir Zhrebchevo (2019); **43** - *Microcystis* cf. *smithii* in reservoir Studena (2021); **44** - *Microcystis smithii* in lake Uzungeren (2021); **45** - *Microcystis wesenbergii* in reservoir Mandra (2021); **46** - *Microcystis wesenbergii* in reservoir Mandra (2023); **47** - *Pannus planus* in



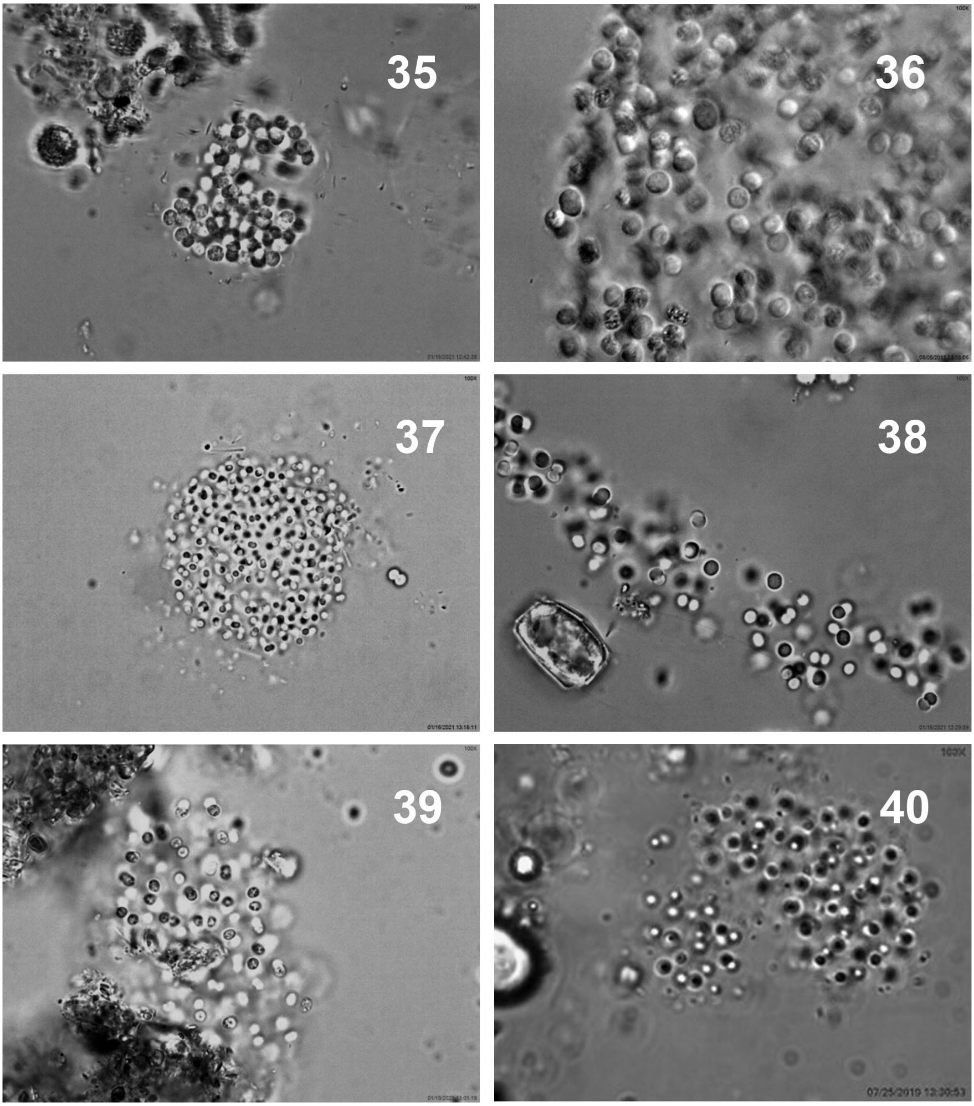
lake Durankulashko Ezero (2019); **48** - *Pannus punctiferus* in lake Burgasko Ezero (2018); **49**, **50** - *Pannus spumosus* in lake Durankulashko Ezero (2018); **51**, **52** - *Pannus spumosus* with *Synechocystis endobiotica* in lake Durankulashko Ezero (2018); **53** - *Rhabdoderma compositum* in reservoir Mandra (2018); **54** - *Rhabdoderma lineare* in lake Burgasko Ezero (2018); **55** - *Rhabdoderma lineare* in lake Shablensko Ezero (2019); **56** - *Rhabdoderma* sp. in lake Ezeretsko Ezero (2019); **57**, **58** - *Snowella arachnoidea* – the same colony at different focus in lake Durankulashko Ezero (2019); **59**, **60** - *Snowella lacustris* in reservor Zhrebchevo (2019); **61** - *Snowella lacustris* in reservoir Duvanli (2019); **62** - *Snowella septentrionalis* in lake Durankulashko Ezero (2018); **63**, **64** - *Synechocystis endogloeicus* in *Microcystis wesenbergii* in reservoir Sinyata Reka (2019); **65** - *Synechococcus epigloeicus* on *Microcystis aeruginosa* in reservoir Plachidol 2 (2019); **66** - *Synechococcus epigloeicus* on *Microcystis wesenbergii* in reservoir



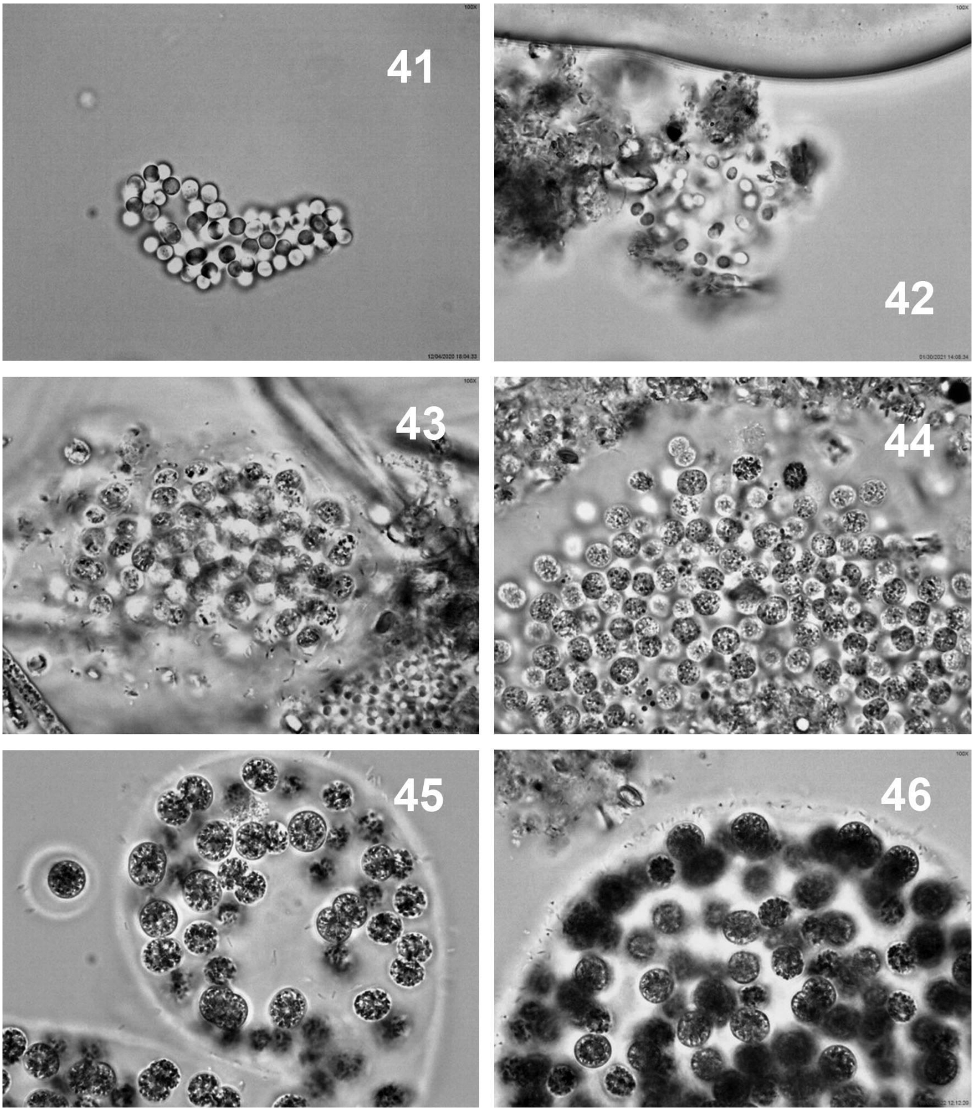
Sinyata Reka (2019); **67** - *Synechococcus* sp. (?*Cyanobium* sp.) in lake Shablensko Ezero (2019); **68** - *Synechococcus* sp. in reservoir Poroy (2019); **69** - *Synechococcus* sp. (?*Synechocystis* sp.) in reservoir Krapets (2019); **70** - *Synechocystis endobiotica* in *Microcystis aeruginosa* in lake Durankulashko Ezero (2018); **71**, **72** - *Woronichinia microcystoides* – the same colony at two focuses in lake Durankulashko Ezero (2018); **73** - *Woronichinia elorantae* in lake Durankulashko Ezero (2019); **74** - *Woronichinia naegeliana* in reservoir Yastrebino (2023); **75** - *Anagnostidinema amphibium* in reservoir Plachidol 2 (2019); **76** - *Anagnostidinema pseudoacutissimum* in reservoir Duvanli (2019); **77** - *Borzia brevis* in reservoir Poroy (2018); **78** - *Borzia trilocularis* in reservoir Shiroka Polyana (2021); **79** - *Glaucospira laxissima* in lake Shablensko Ezero (2019); **80** - *Glaucospira laxissima* in reservoir Duvanli (2019); **81** - *Jaaginema gracile* in reservoir Izvornik 2 (2019); **82** - *Jaaginema metaphyticum* in reservoir Malka Smolnitsa (2019); **83**



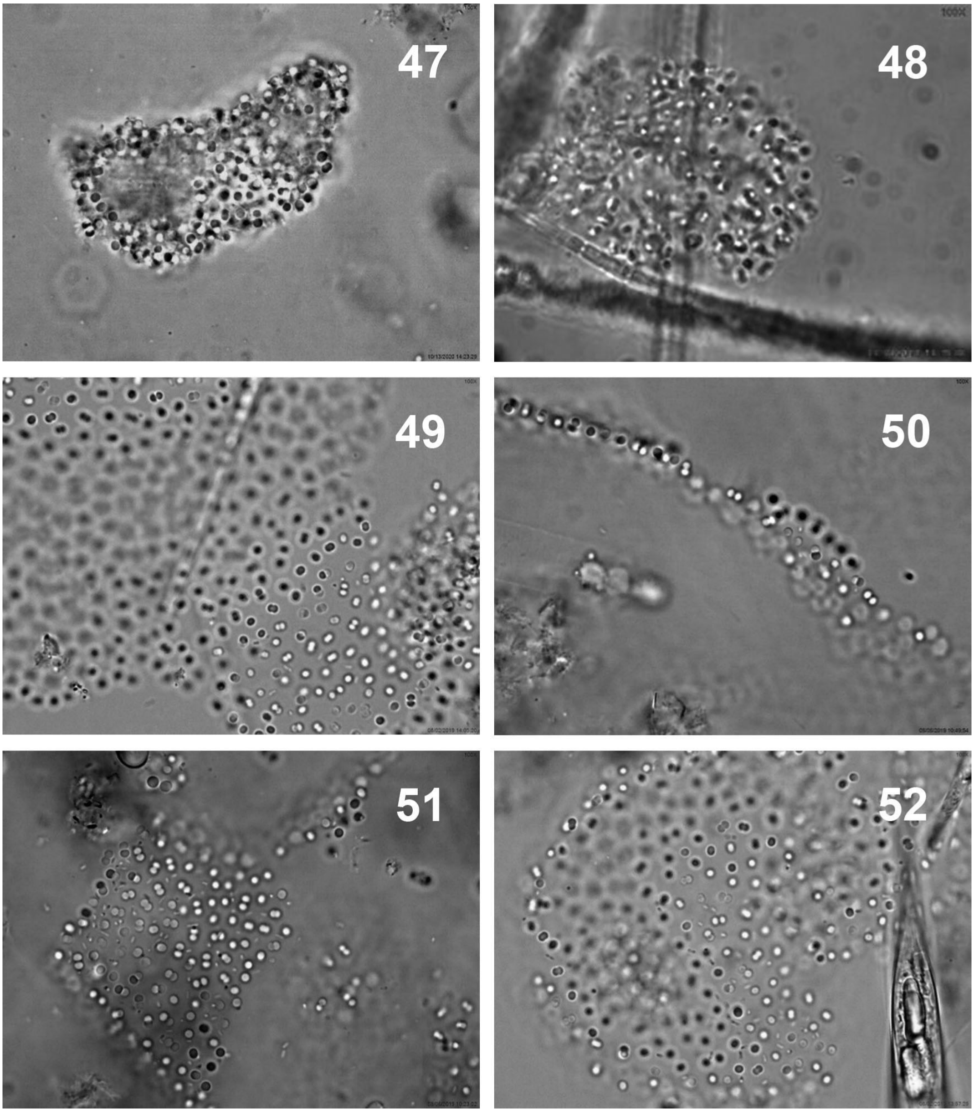
- *Jaaginema subtilissimum* in reservoir Beglika (2023); **84** - *Kamptonema chlorinum* in lake Burgasko Ezero (2023); **85** - *Komvophoron* cf. *constrictum* in lake Durankulashko Ezero (2021); **86** - *Komvophoron schmidlei* in lake Burgasko Ezero (2023); **87**, **88** - *Limnothrix mirabilis* in reservoir Poroy (2018); **89**, **90**, **91** - *Limnothrix mirabilis* – typical fragmentation without necridic cells in reservoir Poroy (2018); **92** - *Limnothrix planctonica* in reservoir Poroy (2021); **93** - *Limnothrix redekii* in lake Shablensko Ezero (2019); **94** - *Limnothrix redekei* in reservoir Preselka (2019); **95** - *Limnothrix* sp. 2 (transparent cells) in reservoir Hadzhi Yani (2021); **96** - *Myxobactron* sp. in reservoir Hadzhidimovo (2021); **97** - *Oscillatoria simplicissima* in lake Burgasko Ezero (2021); **98** - *Oscillatoria sancta* in reservoir Mogila (2021); **99** - *Oscillatoria tenuis* with necridic bands in reservoir Nikolovo (2021); **100** - *Oscillatoria* cf. *tenuis* with necridic bands in reservoir Dubnitsa (2021); **101** - *Planktolyngbya articulata* in reservoir Mogila



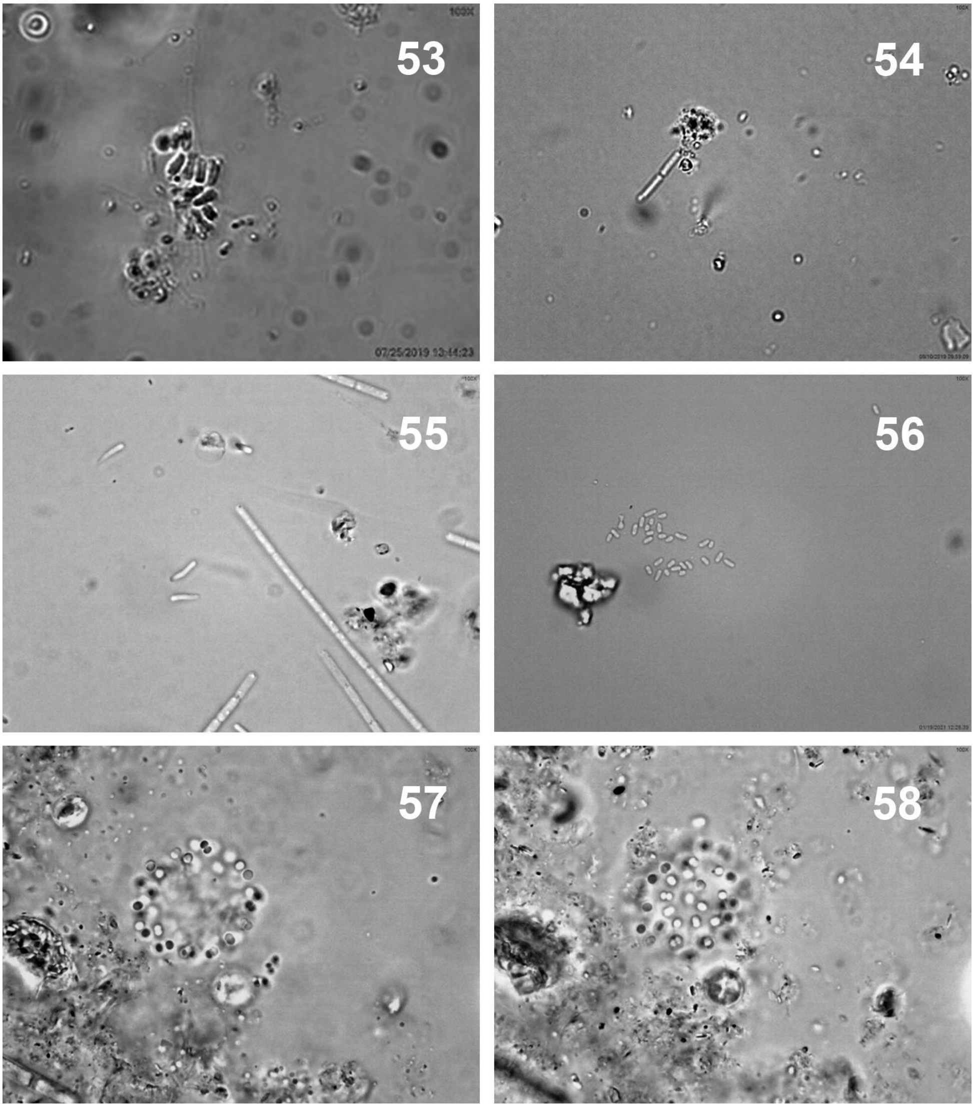
(2021); **102** - *Planktolyngbya brevicellularis* in reservoir Kurdzhali (2023); **103, 104** - *Planktolyngbya brevicellularis* – trichome and hormogonium in lake Burgasko Ezero (2023); **105** - *Planktolyngbya limnetica* in reservoir Yastrebino (2023); **106** - *Planktolyngbya limnetica* in reservoir Studena (2021); **107** - *Planktolyngbya* sp. in reservoir Satovcha (2021); **108** - *Planktolyngbya* sp. (transparent cells) in reservoir Mechka (2021); **109** - *Planktothrix agardhii* in lake Burgasko Ezero (2019); **110, 111** - *Planktothrix isothrix* in lake Burgasko Ezero (2019); **112** - *Planktothrix isothrix* in reservoir Preselka (2019); **113**, **114** - *Planktothrix suspensa* – apical cell and part of trichome with well visible isodiametric cells - in lake Burgasko Ezero (2019); **115** - *Planktothrix suspensa* in reservoir Satovcha 2 (2021); **116** - *Planktothrix suspensa* in reservoir Mandra (2021); **117** - *Pseudanabaena galeata* in reservoir Yunets (2021); **118** - *Pseudanabaena limnetica* in lake Burgasko Ezero (2019); **119** - *Pseudanabaena mucicola* - in lake



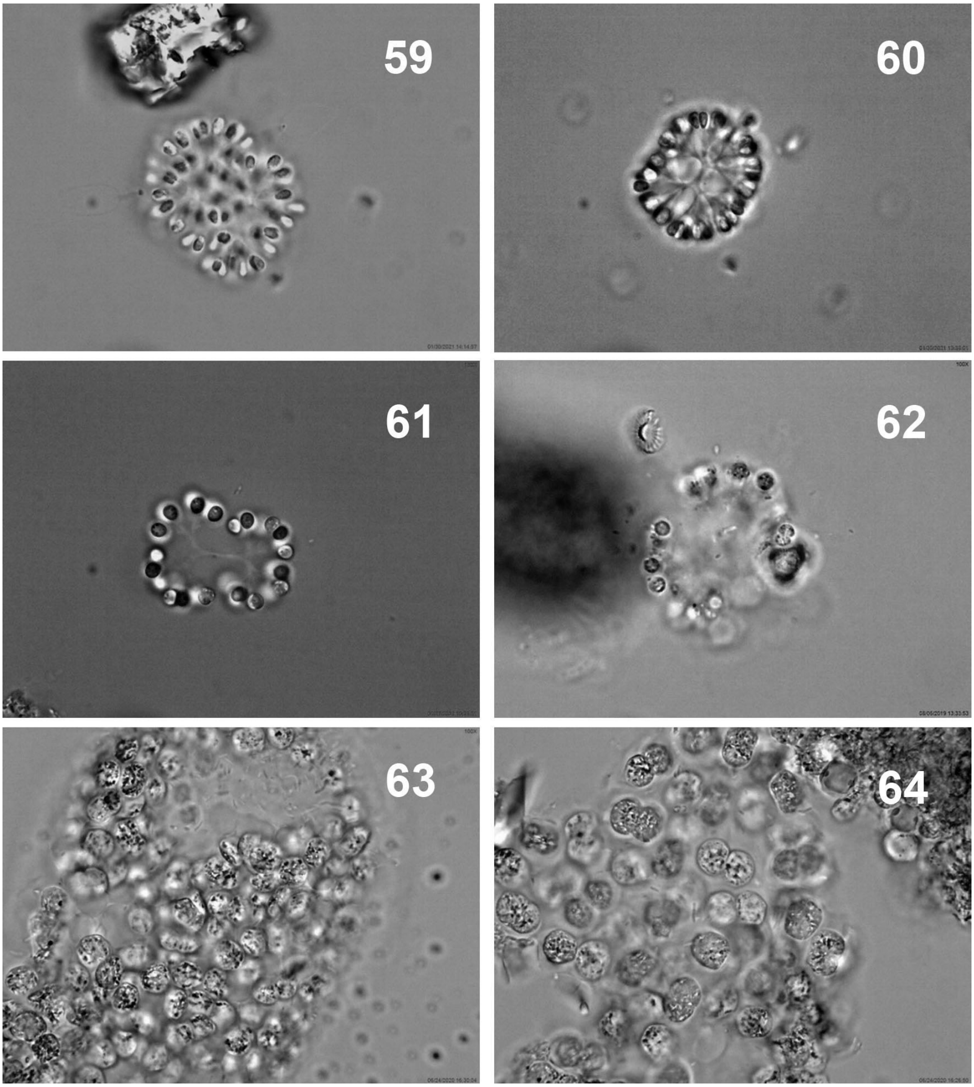
Durankulashko Ezero (2021); **120** - *Pseudanabaena mucicola* on *M. wesenbergii* in reservoir Nikolovo (2021); **121** - *Pseudanabaena* sp. 2 in reservoir Zhrebchevo (2019); **122** - *Romeria simplex* in reservoir Duvanli (2019); **123** - *Romeria gracilis* in lake Ezeretsko Ezero (2018); **124** - *Spirulina* cf. *major* in lake Burgasko Ezero (2023); **125** - *Trichodesmium iwanoffianum* in reservoir Yunets (2021); **126** - *Tychonema sequanum* in lake Durankulashko Ezero (2021); **127** - *Anabaena minderi* in reservoir Yunets (2021); **128** - *Anabaena* cf. *tenericaule* in reservoir Mogila (2021); **129** - *Anabaenopsis circularis* in reservoir Duvanli (2019); **130** - *Anabaenopsis cunningtonii* in reservoir Malka Smolnitsa (2019); **131** - *Anabaenopsis milleri* in reservoir Izvornik 2 (2019); **132** - *Aphanizomenon klebahnii* in reservoir Yastrebino (2023); **133**, **134** - *Aphanizomenon klebahnii* trichome with apical cell and trichome with akinete in reservoir Mandra (2019); **135** - *Aphanizomenon yezoense* in reservoir Studena (2021); **136** - *Aphanizomenon grac-*



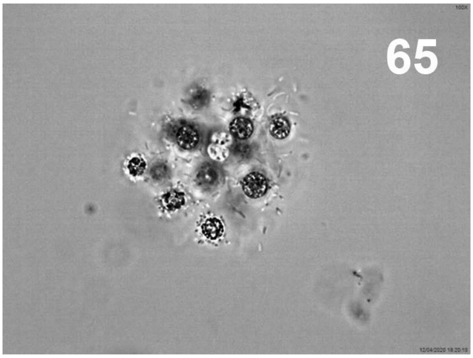
ile in reservoir Byalata Prust (2021); **137** - *Aulosira* cf. *fertilissima* in reservoir Malko Sharkovo (2023); **138** - *Cronbergia paucicellularis* in lake Burgasko Ezero (2018); **139** - *Cronbergia planctonica* in reservoir Plachidol 2 (2019); **140** - *Chrysosporum bergii* with akinete in reservoir Zhrebchevo (2019); **141**, **142** - *Chrysosporum minus* in reservoir Plachidol 2 (2019); **143**, **144** - *Cuspidothrix elenkinii* with heterocyte and young akinetes in reservoir Yastrebino (2023); **145** - *Cuspidothrix tropicalis* in reservoir Byalata Prust (2021); **146** - *Cuspidothrix tropicalis* (?*Umezakia natans*) in reservoir Studena (2021); **147** - *Dolichospermum* cf. *affine* in reservoir Izvornik 2 (2019); **148** - *Dolichospermum circinale* - trichome and akinete in reservoir Beli Lom (2023); **149** - *Dolichospermum compactum* in reservoir Izvornik 2 (2019); **150** - *Dolichospermum flos-aquae* in reservoir Trakiets (2023); **151** - *Dolichospermum mucosum* – trichome with heterocyte and young akinete - in reservoir Izvornik 2 (2019); **152** - *Dolichospermum perturba-*



tum with akinete in reservoir Izvornik 2 (2019); **153** - *Dolichospermum perturbatum* in reservoir Izvornik 2 (2019); **154** - *Dolichospermum planctonicum* in reservoir Ablanitsa (2021); **155**, **156** - *Dolichospermum scheremetievei* -sterile and with akinete - in reservoir Yunets (2021); **157** - *Raphidiopsis cuspis* in reservoir Byalata Prust (2021); **158** - *Raphidiopsis cuspis* in reservoir Mogila (2021); **159** - *Raphidiopsis cuspis* in reservoir Mechka (2021); **160** - *Raphidiopsis mediterranea* – fragment with apical cell and an akinete – in lake Shablensko Ezero (2019); **161**, **162** - *Raphidiopsis mediterranea* – fragment with apical cell and akinete, trichome with an akinete – in reservoir Mogila (2021); **163** - *Raphidiopsis raciborskii* in lake Shablensko Ezero (2019); **164** - *Raphidiopsis raciborskii* in reservoir Eleshnitsa (2019); **165** - *Raphidiopsis raciborskii* in reservoir Malka Smolnitsa (2019); **166** - *Raphidiopsis raciborskii* – akinete and heterocyte – in reservoir Malka Smolnitsa (2019); **167** - *Raphidiopsis setigera* in lake Shablensko Ezero (2019);



168 - *Raphidiopsis setigera* in reservoir Mogila (2021); **169, 170** - *Raphidiopsis setigera* with initial akinetes below the apical cell and with a young akinete in reservoir Mogila (2021); **171, 172** - *Raphidiopsis turcomanica* with apical hyaline cell and two akinetes in reservoir Mogila (2021); **173, 174** - *Sphaerospermopsis aphanizomenoides* with apical cell, heterocyte and akinete in lake Burgasko Ezero (2019); **175** - *Sphaerospermopsis aphanizomenoides* in lake Shablesnko Ezero (2019); **176** - *Phlyctidium anabaenae* on *Sphaerospermopsis aphanizomenoides* in reservoir Studena (2021); **177** - *Sphaerospermopsis* cf. *reniformis* in reservoir Studena (2021); **178**, **179**, **180, 181, 182** - *Sphaerospermopsis torqua-reginae* in reservoir Sinyata Reka (2019); **183**, **184**, **185**, **186** - *Wollea* sp. – sterile trichomes, trichomes with young akinetes, akinete - in reservoir Studena (2023).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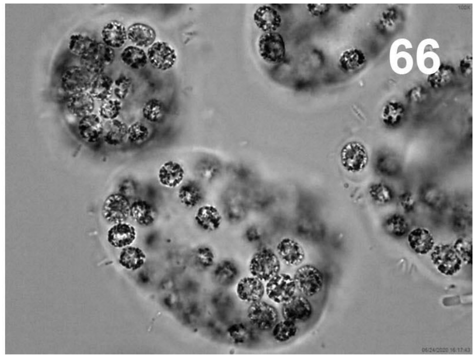
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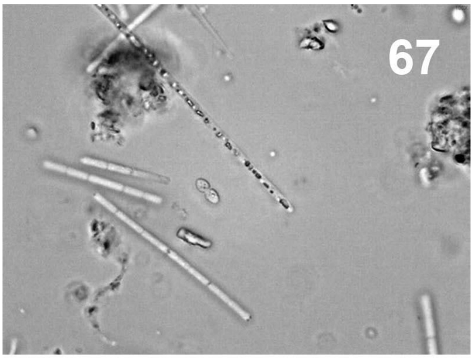
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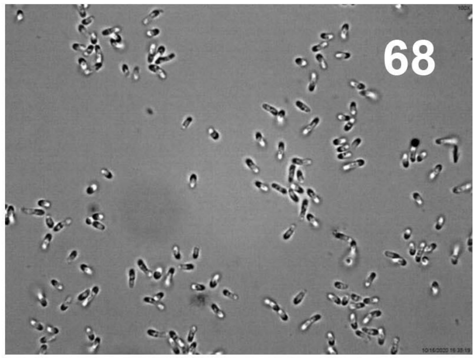
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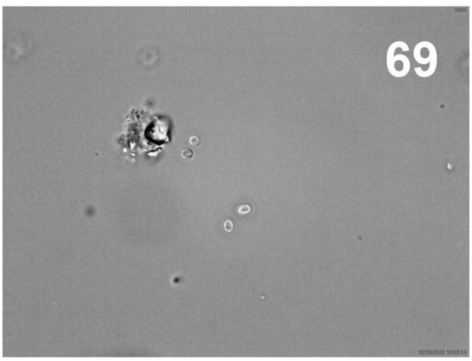
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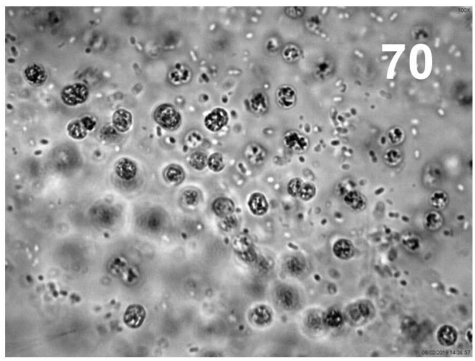
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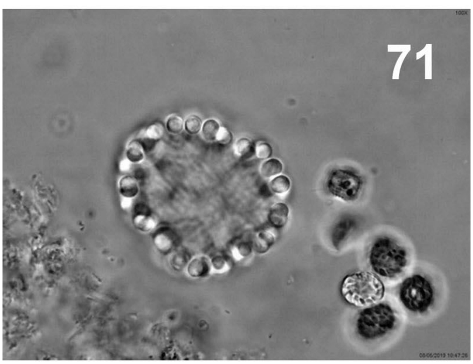
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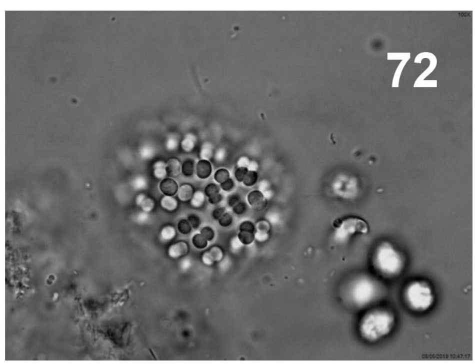
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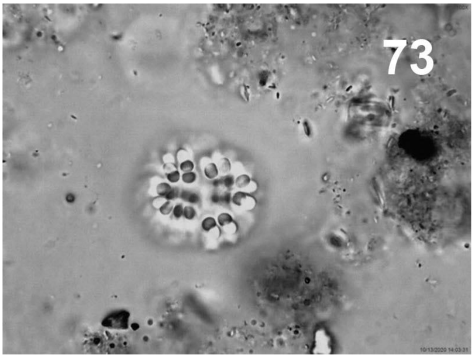
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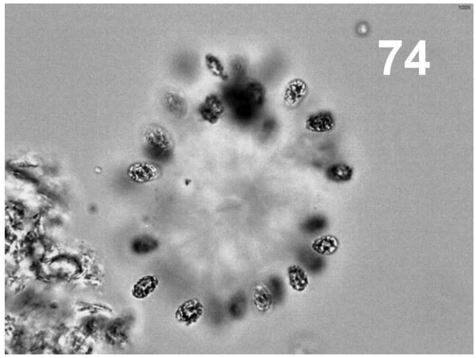
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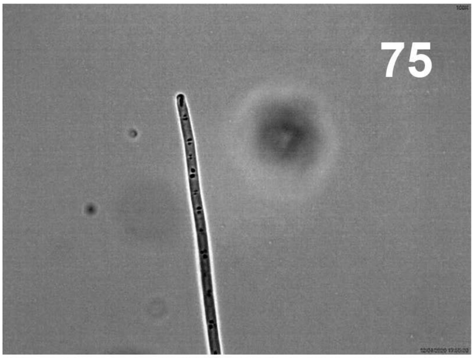
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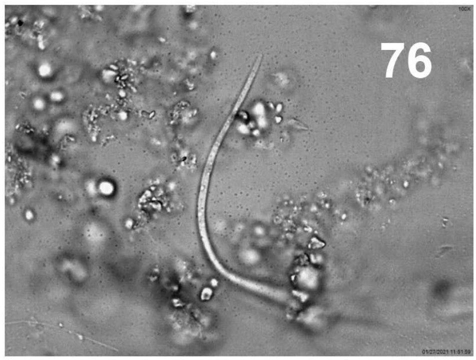
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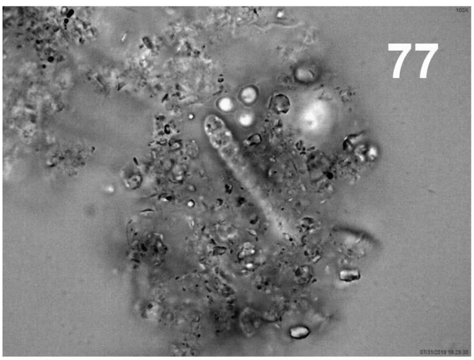
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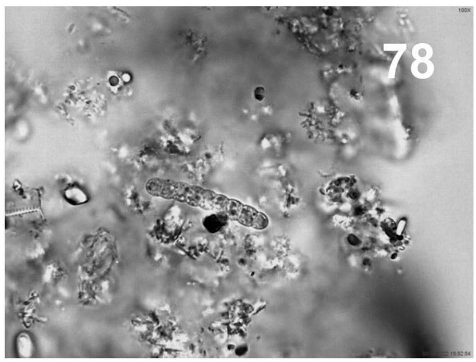
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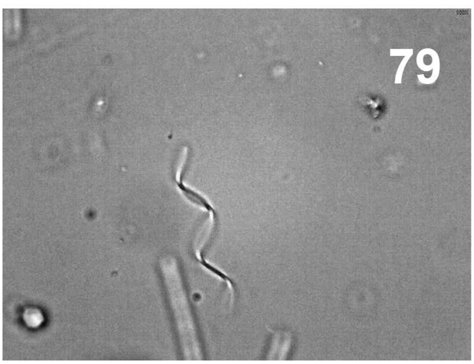
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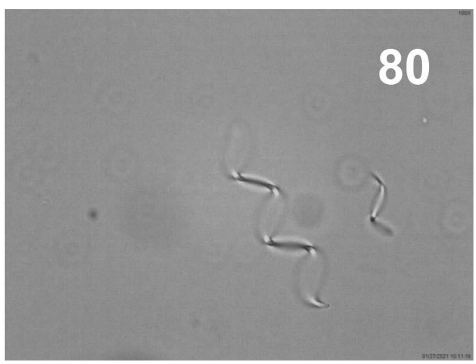
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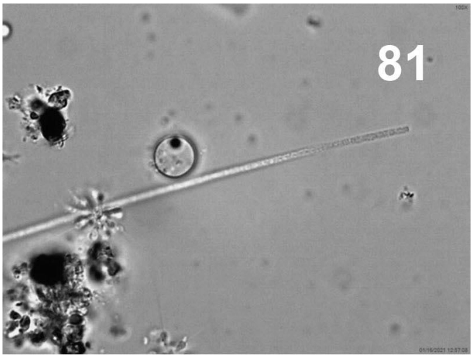
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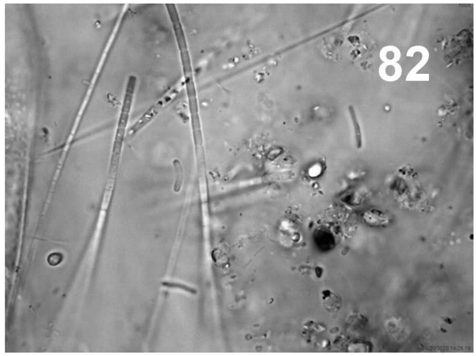
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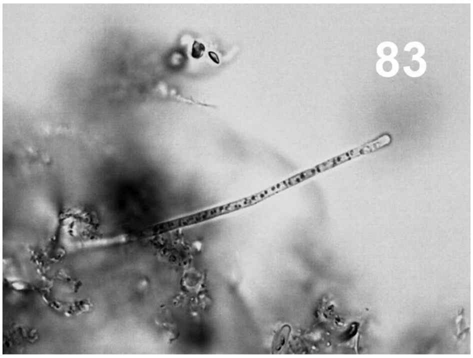
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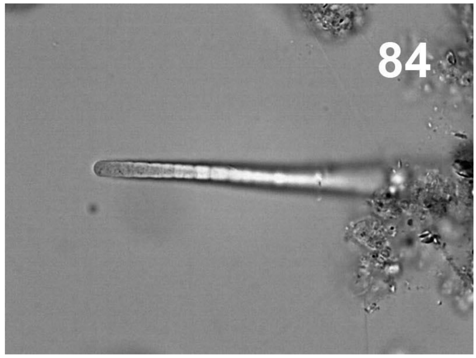
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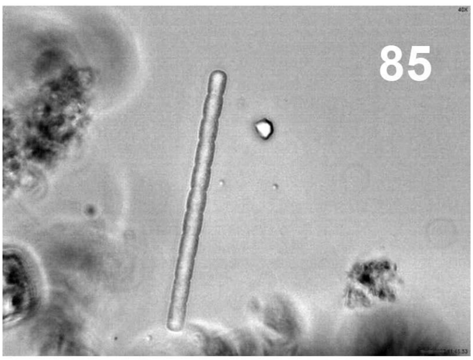
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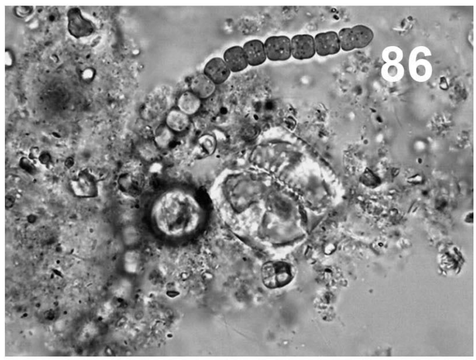
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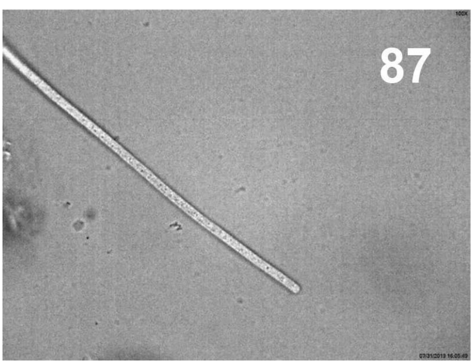
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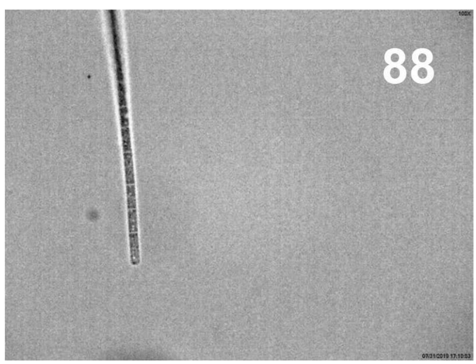
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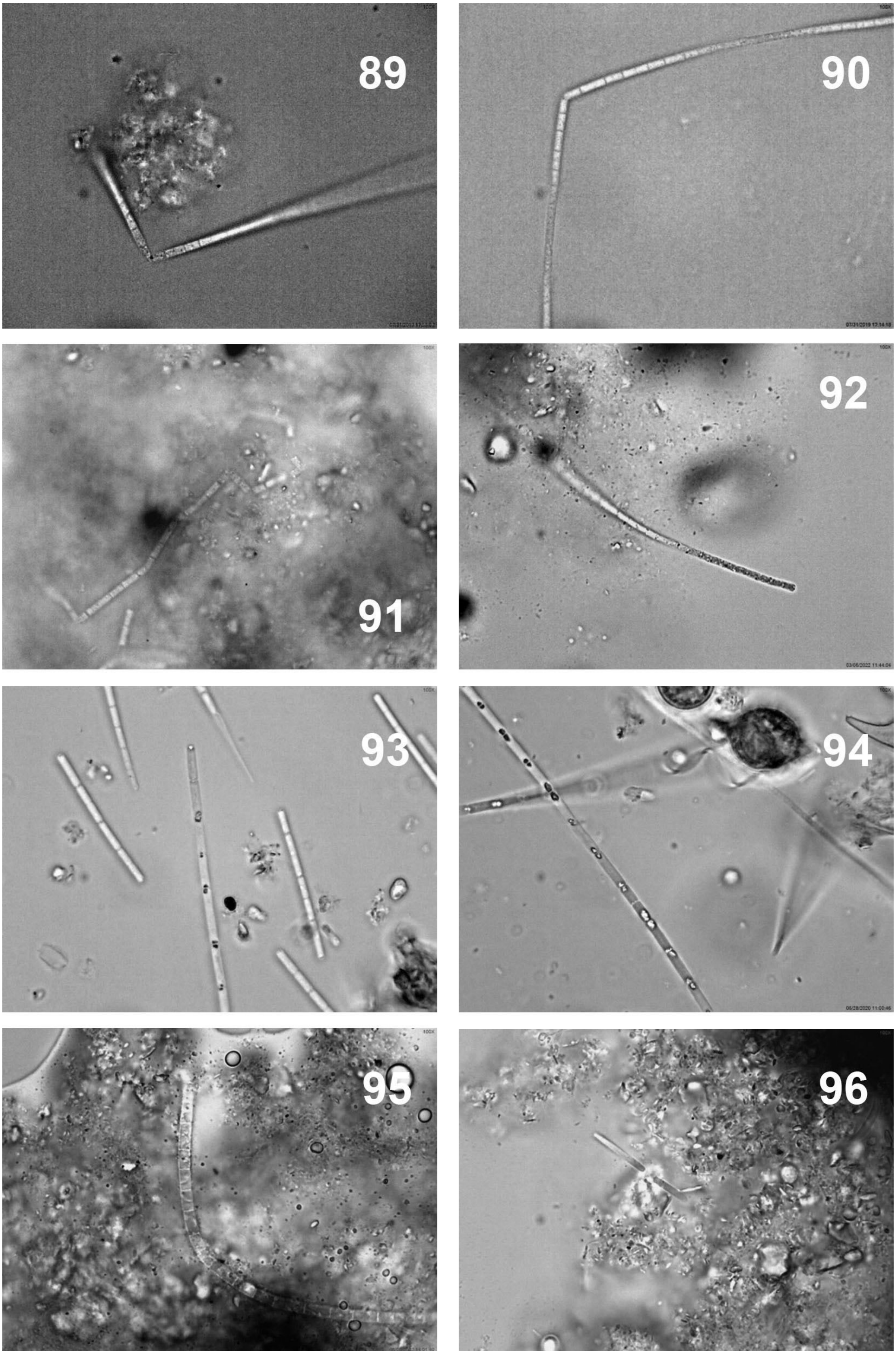
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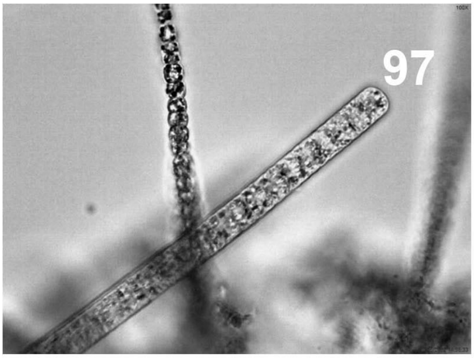
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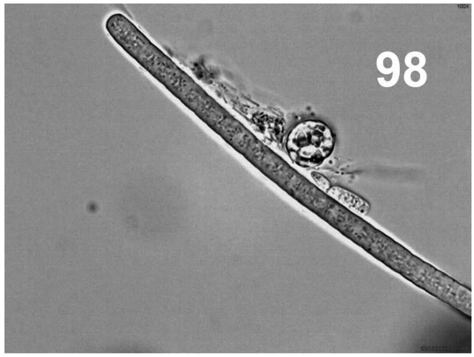
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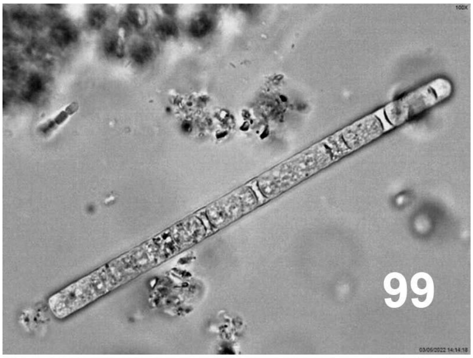
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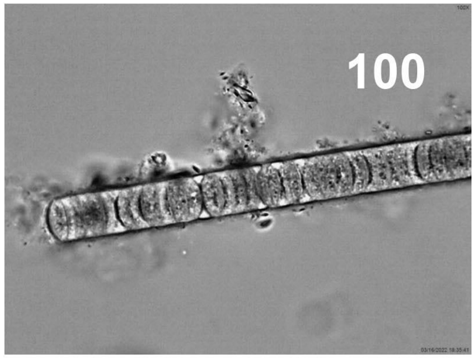
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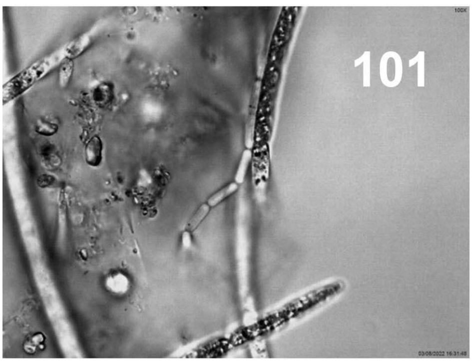
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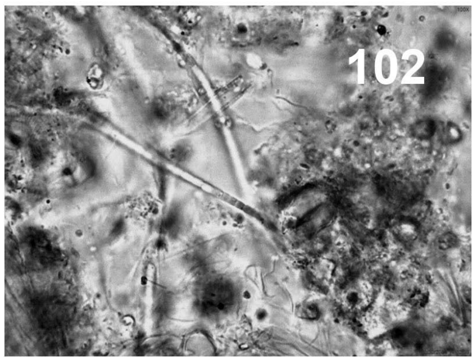
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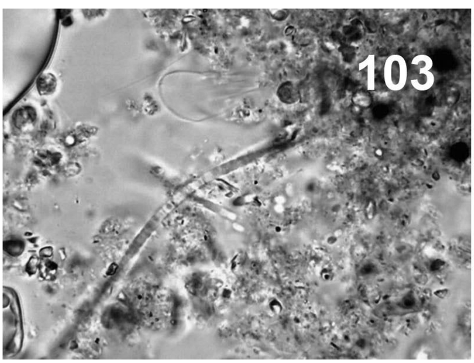
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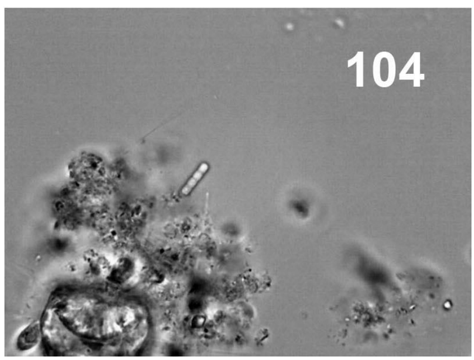
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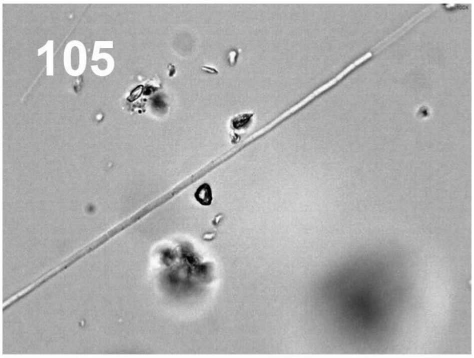
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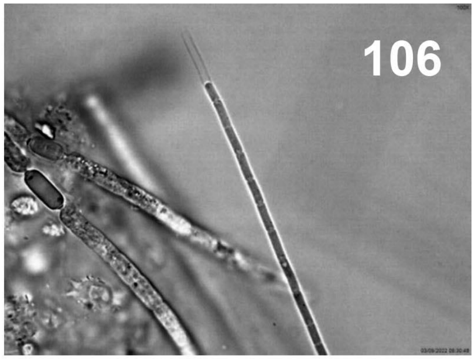
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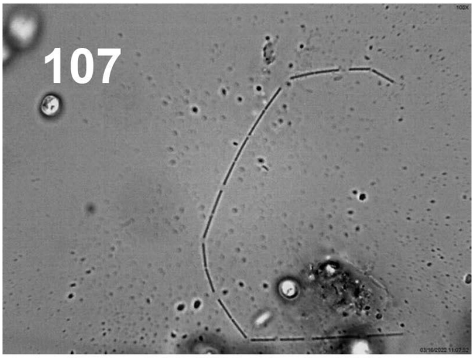
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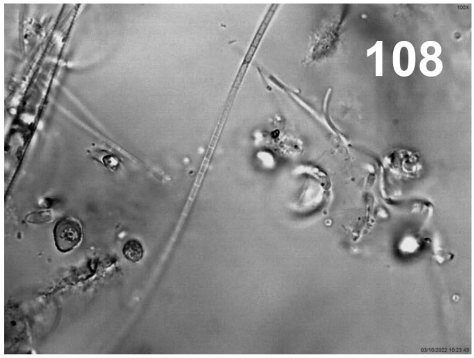
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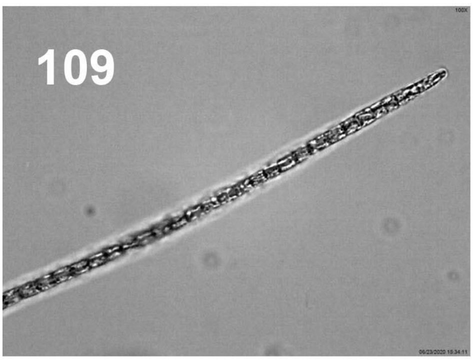
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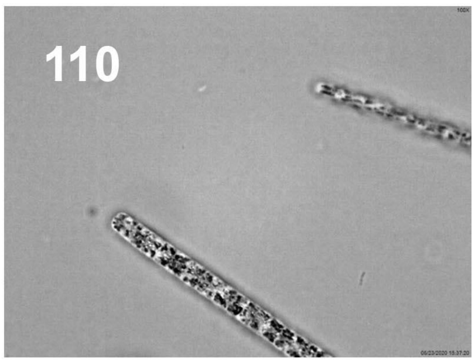
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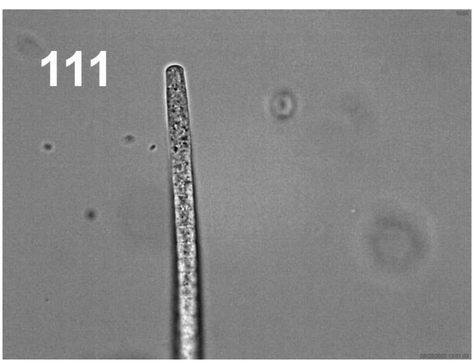
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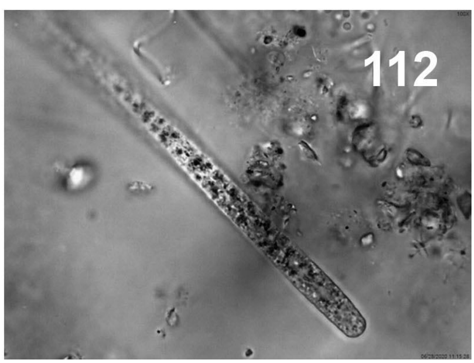
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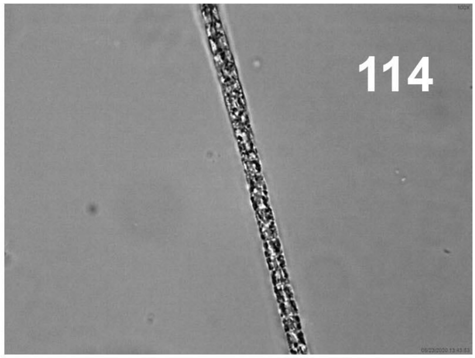
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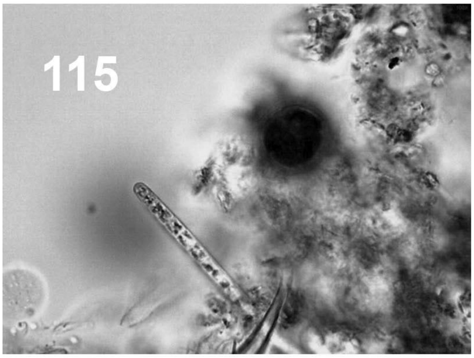
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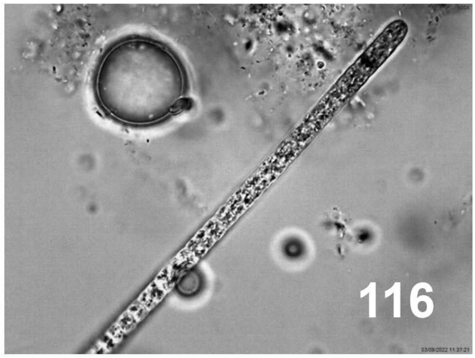
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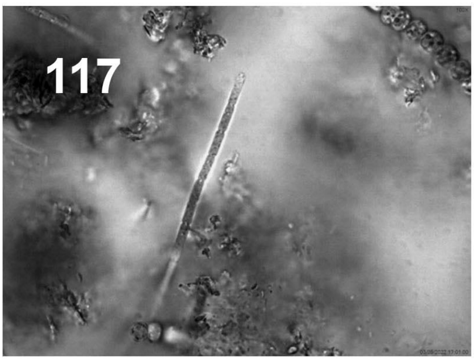
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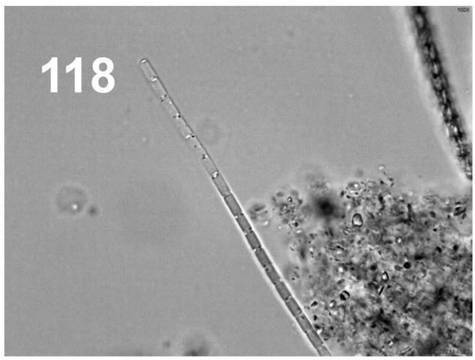
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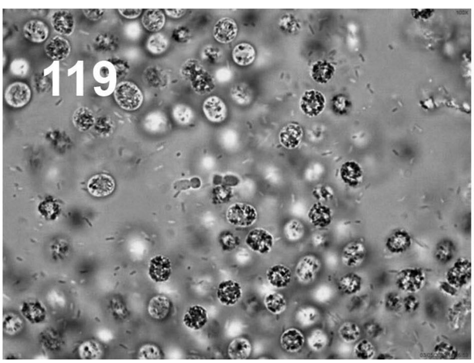
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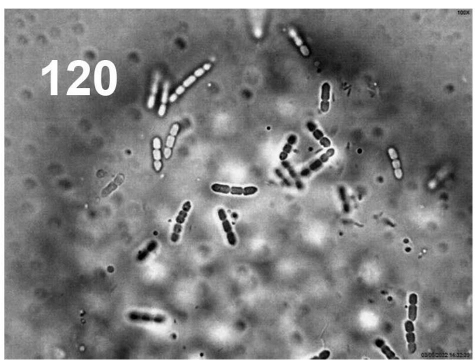
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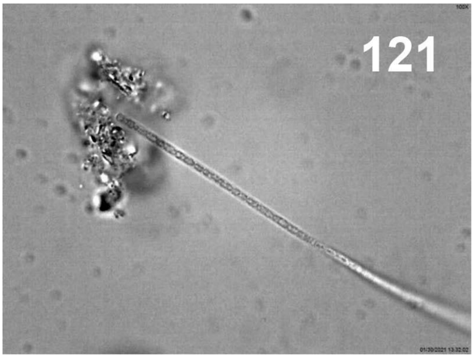
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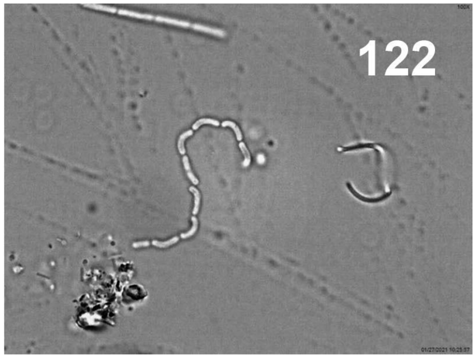
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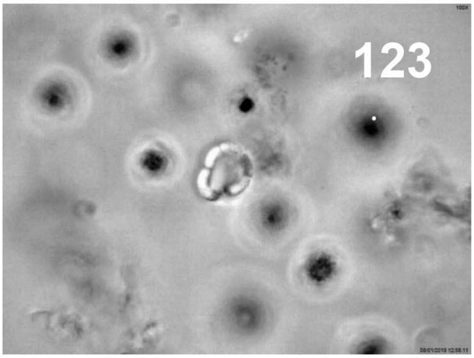
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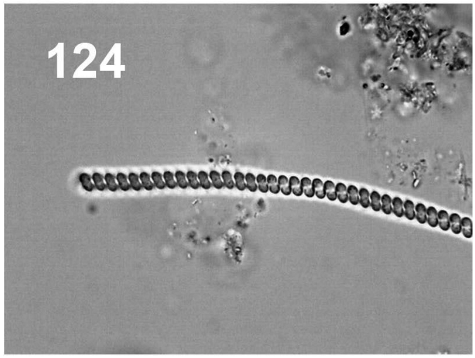
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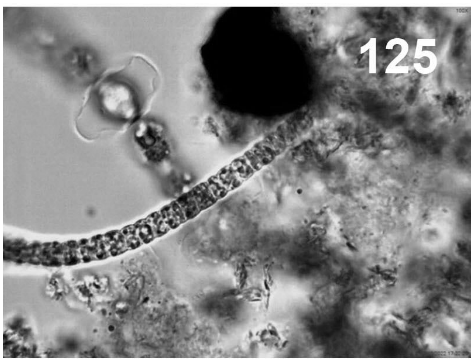
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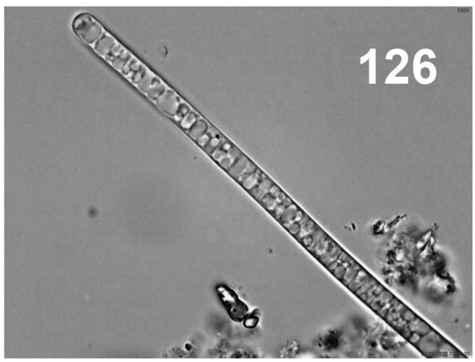
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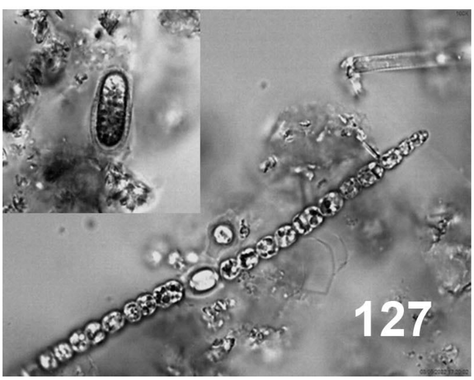
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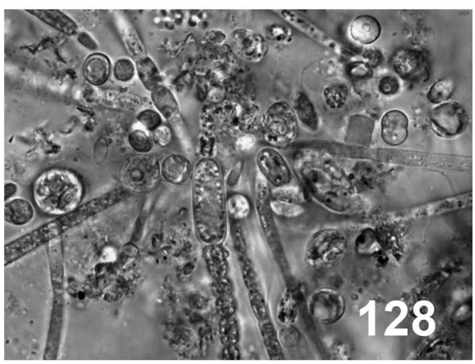
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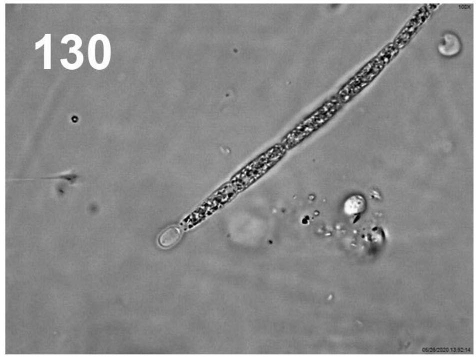
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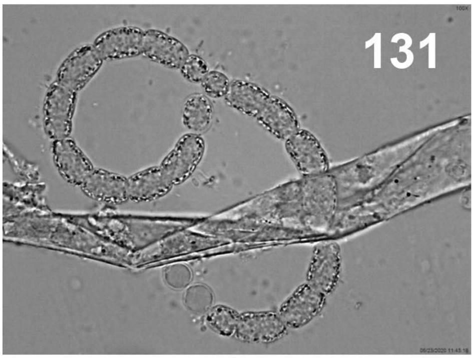
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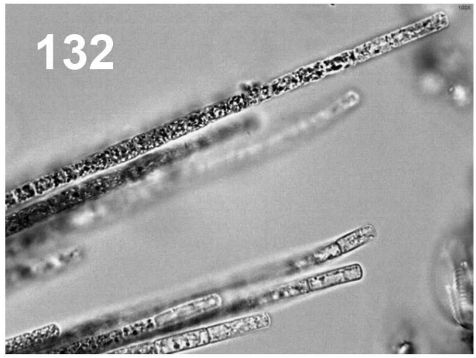
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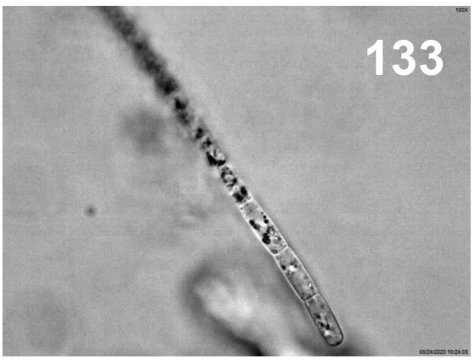
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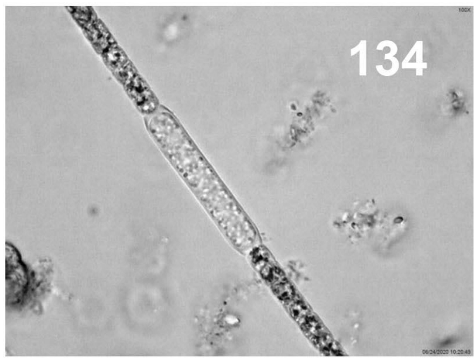
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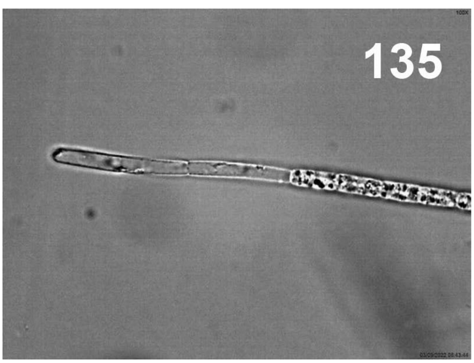
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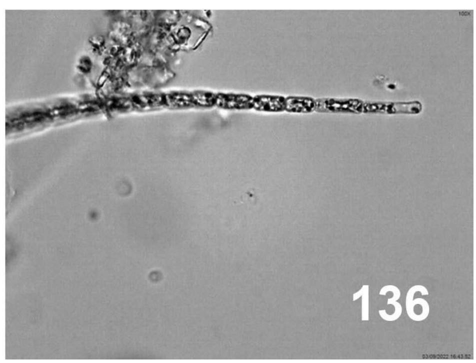
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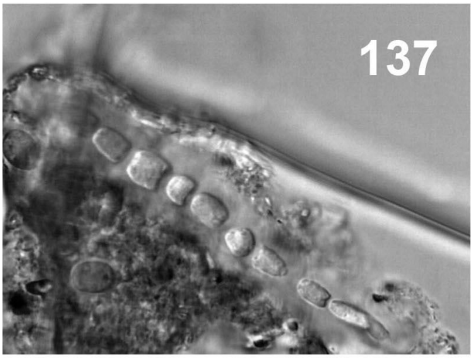
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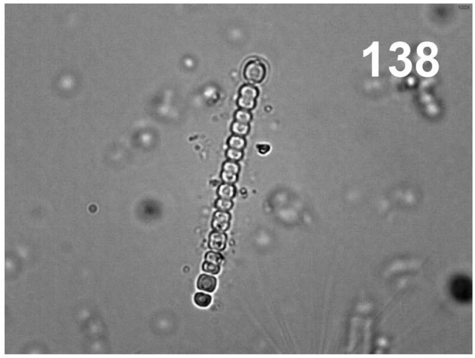
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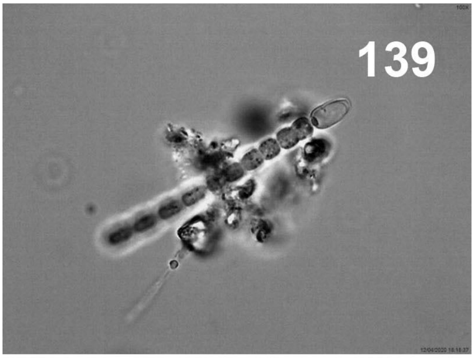
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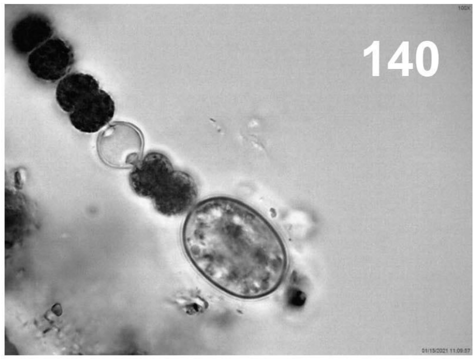
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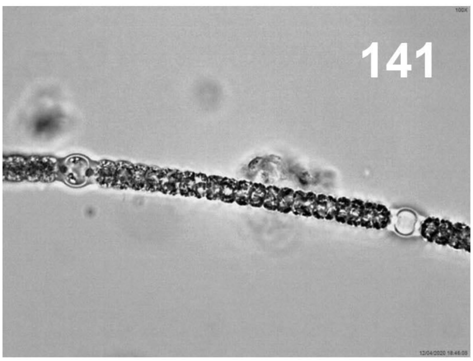
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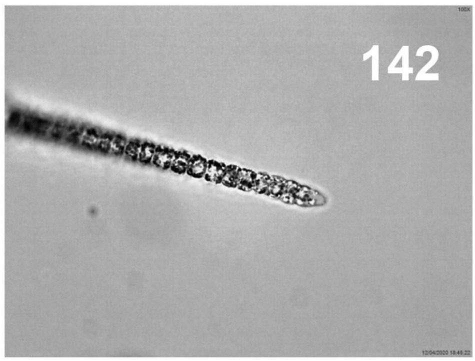
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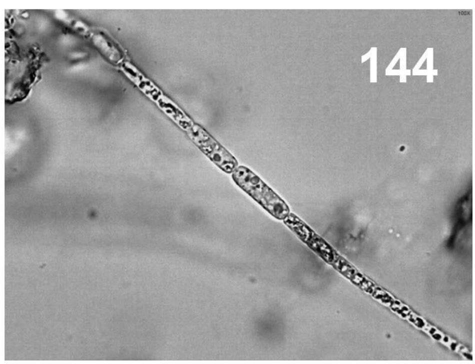
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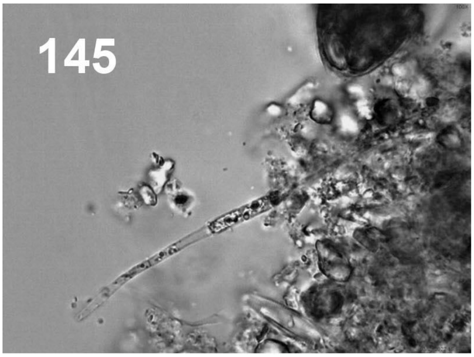
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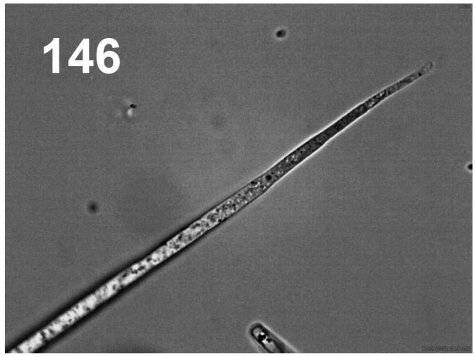
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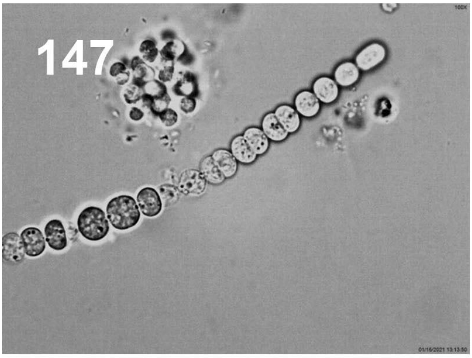
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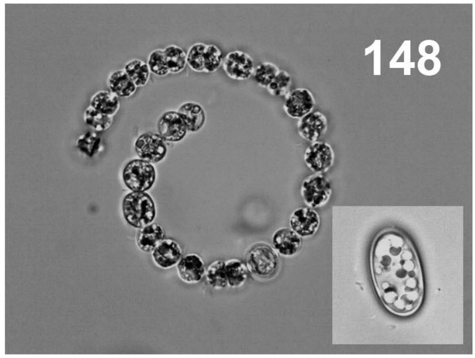
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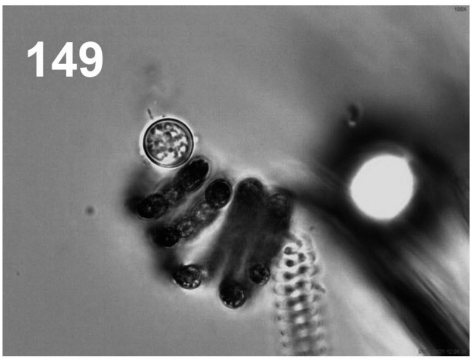
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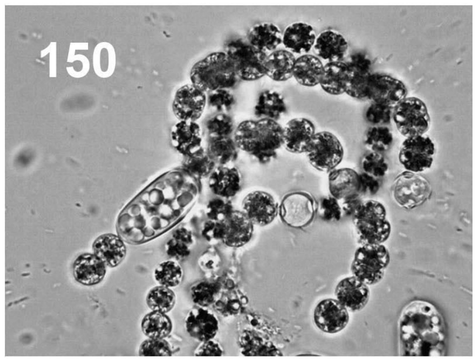
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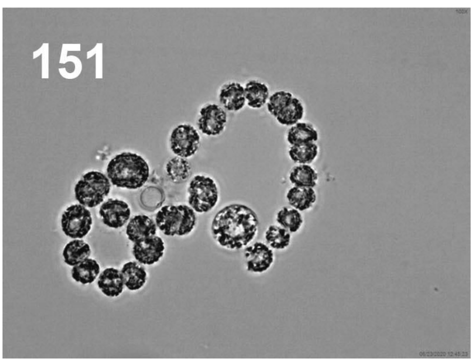
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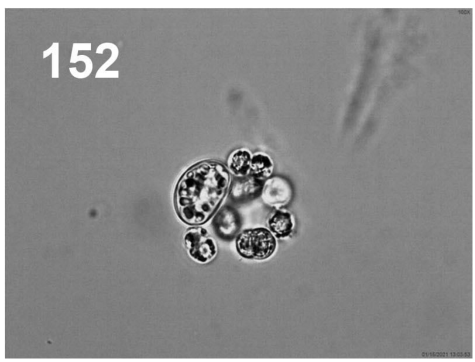
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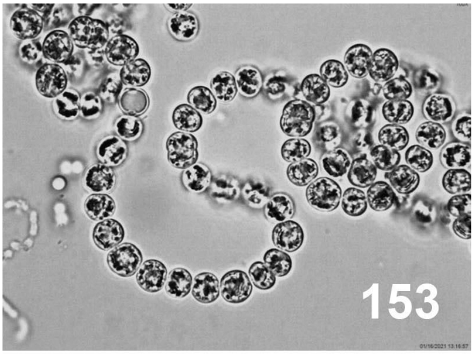
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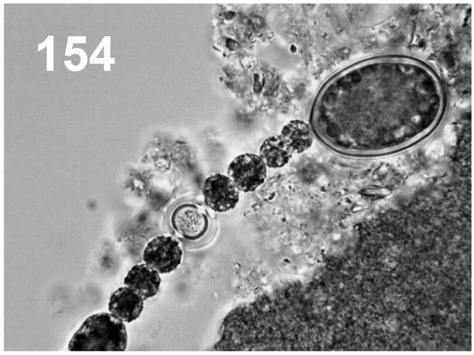
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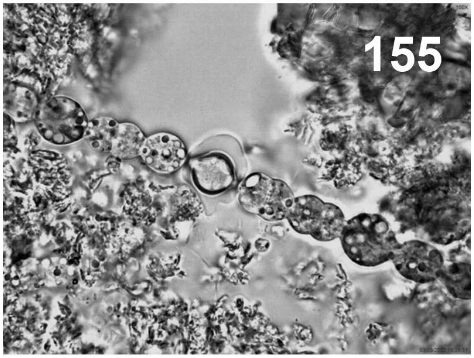
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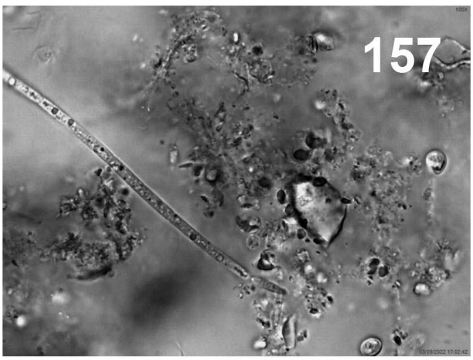
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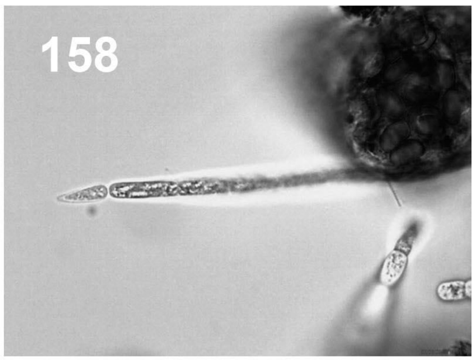
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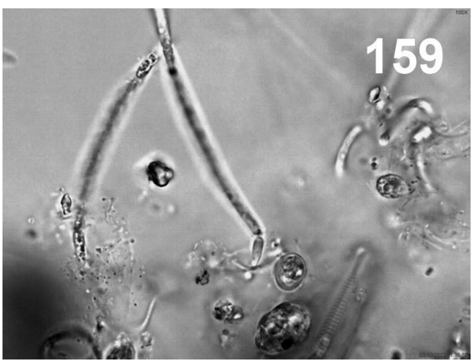
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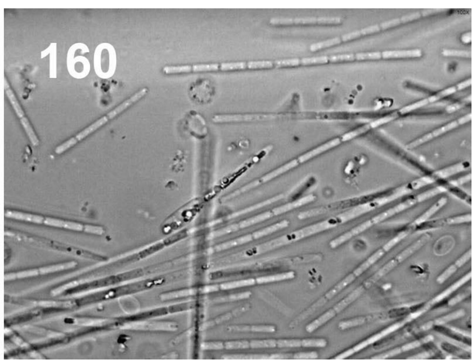
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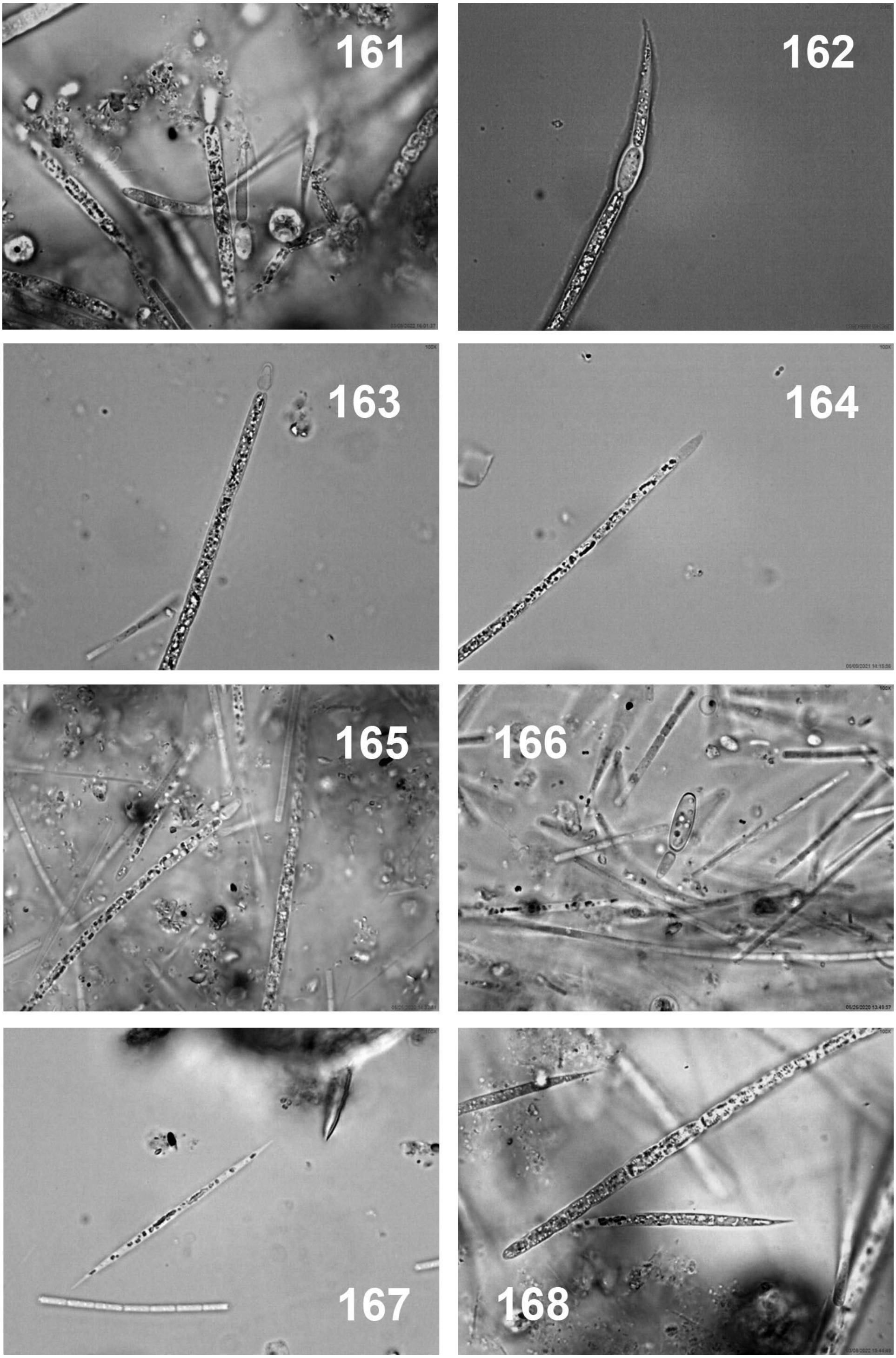
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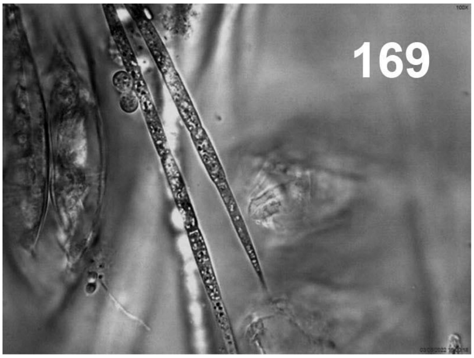
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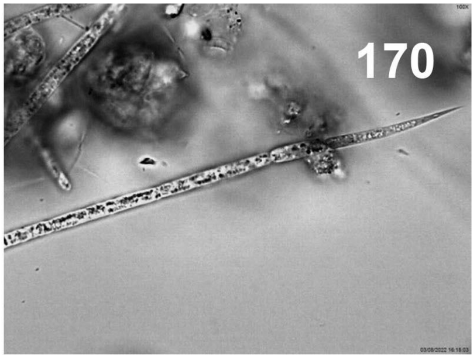
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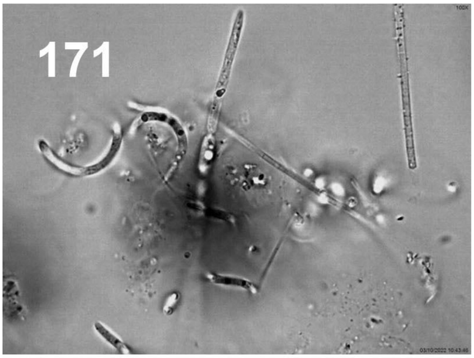
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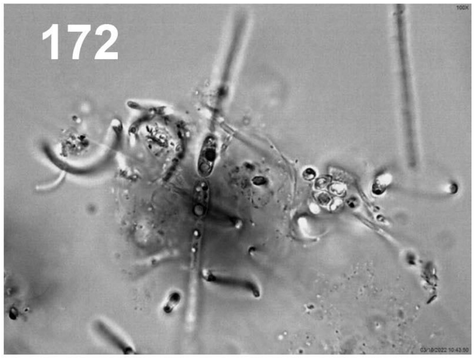
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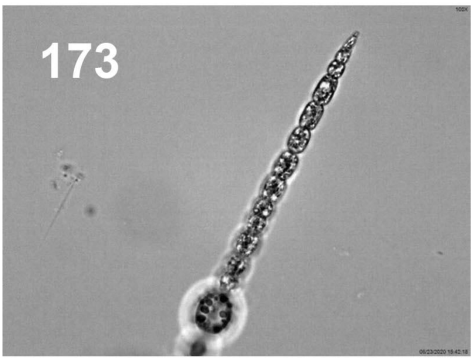
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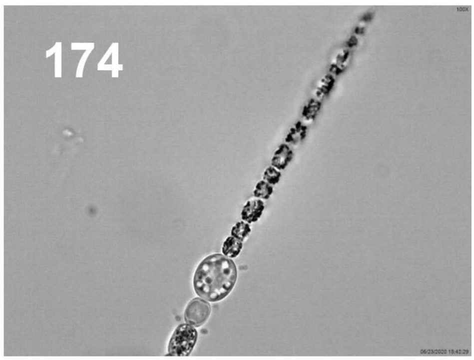
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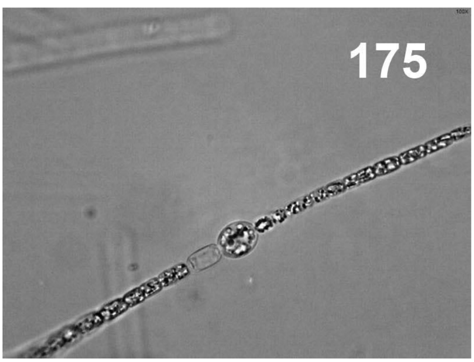
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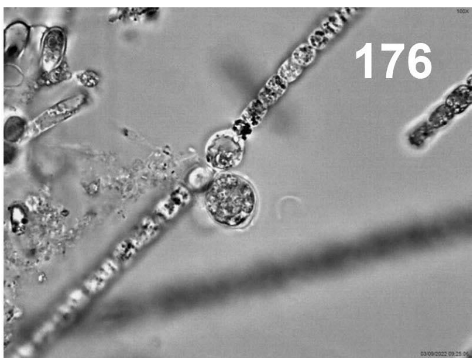
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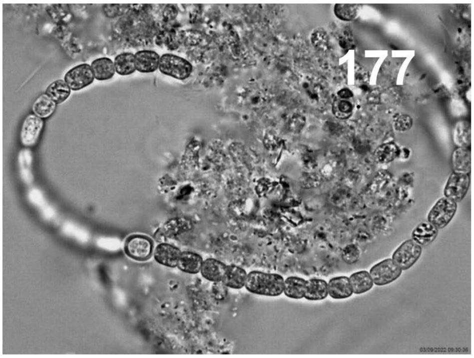
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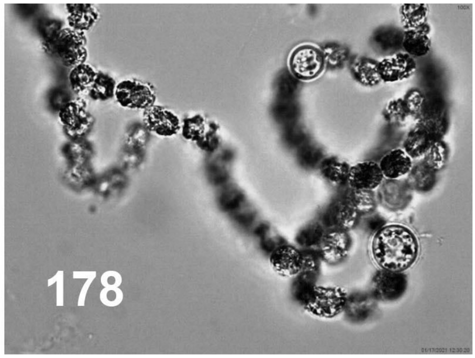
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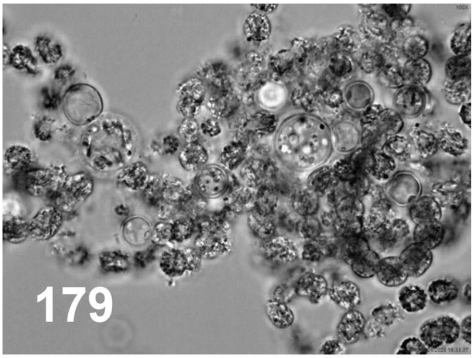
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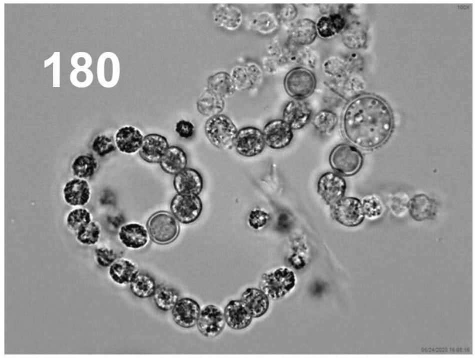
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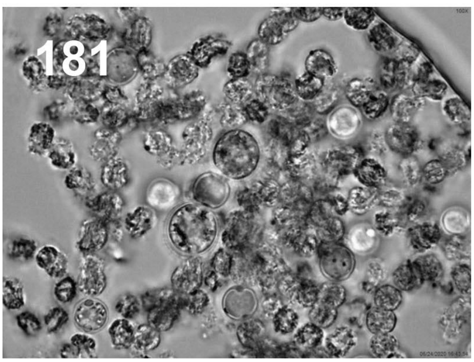
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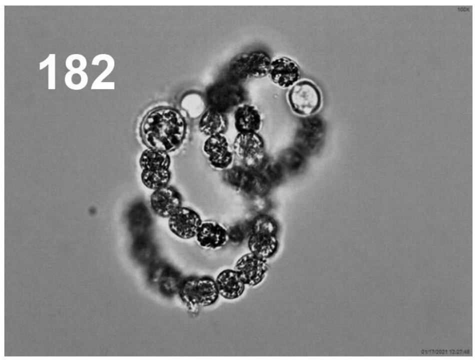
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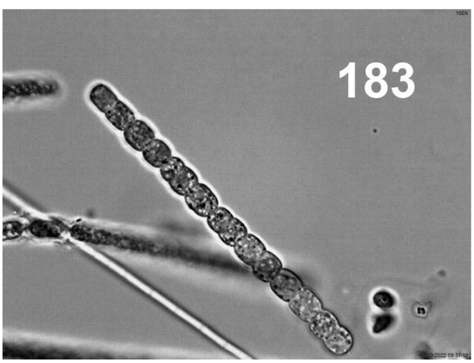
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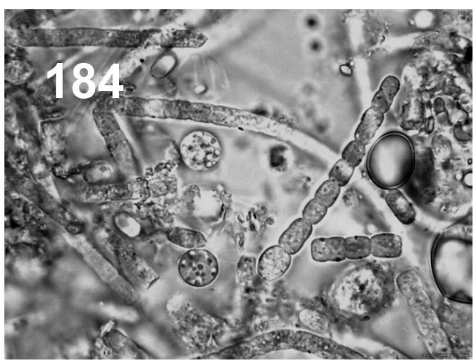
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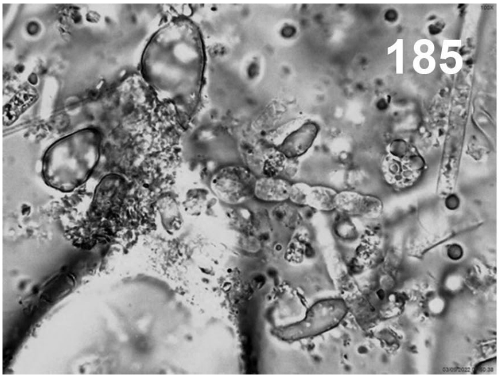

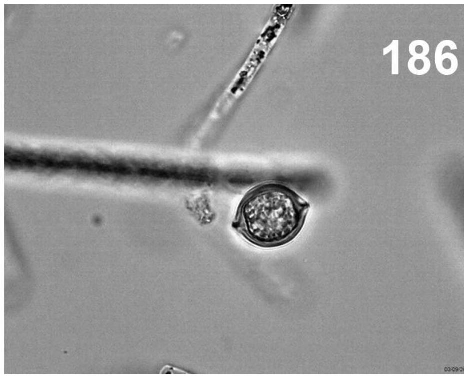

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this article.

ACKNOWLEDGEMENTS

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AUTHORS CONTRIBUTION

Conceptualization and supervision - MSG; writing—original draft preparation, MSG, MA, KI; writing—review and editing, MSG, GG, BA; visualization - BA, MSG, GG; field sampling – BA, GG, MSG, MA; project administration – MSG, BU; funding acquisition – MSG, BU. All authors have read and agreed to the published version of the manuscript.

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ALGAL DIVERSITY ON THE GRANITE MONUMENT IN FRONT OF THE FACULTY OF BIOLOGY OF SOFIA UNIVERSITY

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Abstract. The paper presents the results on the species composition of aeroterrestrial algae that developed on a granite monument in the urban environment in the central part of the Bulgarian capital town Sofia, situated in front of the Faculty of Biology of Sofia University “St. Kliment Ohridski”. After scraping the visible algal layers from both frontal (northern) and back (southern) side of the monument, samples were immediately processed by conventional light microscopy on non-permanent slides. The algal diversity comprised six species from the following four taxonomic phyla: Cyanoprokaryota, Chlorophyta, Streptophyta and Ochrophyta. The obtained samples are deposited in the Living Algal Collection of Sofia University (ACUS) for further proceeding and cultivation.

Key words: Chlorophyta, Cyanoprokaryota, Eustigmatophyceae, biodiversity, aeroterrestrial algae

INTRODUCTION

As the name suggests, the aeroterrestrial algae represent a rather unique ecological group of land-dwelling algal species, that inhabit different solid substrates. These substrates can be natural, such as rocks, stones, tree barks, plant

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or mushroom surfaces, or they are man-made, such as rooftops, concrete walls and different monuments of cultural significance (*e.g.*, Ettl & Gärtner 1995, 2014; Gärtner & Stoyneva 2003; Gärtner et al. 2003; Videv et al. 2017; Gärtner & Hofbauer 2021). Up-to-now, most data collected in different regions of the world concern natural habitats, but there is a rising interest in algae, which inhabit various artificial structures with increasing number of records (for details see Gärtner & Hofbauer 2021).

In Bulgaria, according to the first review by Uzunov et al. (2007, 2008b) the total count of the aeroterrestrial algae published in the period 1898-2007 was 569 taxa from seven phyla: Cyanoprokaryota – 242 species, nine varieties and eight forms from 60 genera; Rhodophyta –four species from three genera; Ochrophyta, Tribophyceae –18 species and one variety from seven genera, Bacillariophyceae – 12 species, six varieties and one form from 11 genera; Chlorophyta – 88 species, 16 varieties and three forms from 54 genera; Streptophyta – 41 species, 15 varieties and six forms from 15 genera; Euglenophyta – six species from five genera.

Subsequently, the papers published by Uzunov et al. (2008a, 2010, 2012), Stoyneva & Gärtner (2009), Gärtner et al. (2010b, 2012, 2015), Stoyneva et al. (2012), along with the PhD theses of Uzunov (2009) and Mancheva (2013), provided new data on the biodiversity of aeroterrestrial algae. According to the last general assessment of the algal biodiversity of the country, the ecological group of aeroterrestrial algae consisted of 589 species, varieties and forms (Stoyneva 2014), and 31% of them were recorded along the Black Sea Coast, where totally 164 species, varieties and forms from 56 genera of 4 divisions were found: Cyanoprokaryota (145), Chlorophyta (9), Ochrophyta (7) and Rhodophyta (3) (Gärtner et al. 2018).

Among the aeroterrestrial algae, those found on cultural monuments were scarcely studied in Bulgaria. The single publication on the topic, concentrated on the study of three statues in the towns of Sofia and Koprivshtitsa, reported three free-living algal species from the genera *Apatococcus*, *Trebouxia* and *Coccomyxa*, as well as the lichens *Lepraria* cf. *neglecta* (Nyl.) Erichsen, *Candelariella vitellina* (Hoffm.) Müll.-Arg., *Protoparmeliopsis muralis* (Schreb.) M. Choisy and *Caloplaca* sp. that comprise algal symbionts (Gärtner & Stoyneva 2003).

The present study serves as a continuation of this research focused on the monuments in urban areas. Such non-investigated in respect to algae monument is the granite memorial, known as Monument of agronomists-antifascists. It is a single rocky piece brought from the Stony Vitosha rivers on Vitosha Mt, known also as Morraines, the glacial origin of which is yet debatable (for details see Management Plan of Vitosha 2005). This memorial is located in the central part of the Bulgarian capital Sofia. The single record in the available literature points that all lichens, which originally were developed on the monument at the moment of its installation in the early fifties of 20th century, have disappeared in the urban conditions of the Bulgarian capital (Filipova 1956).

MATERIAL AND METHODS

The samples for this study were collected on 3rd of June 2023 from the granite rocky memorial that is situated in the front yard of the Faculty of Biology of the Sofia University "St. Kliment Ohridski" positioned near the northern entrance of the building, next to the Dragan Tsankov boulevard with a heavy car traffic, in close proximity of the city park Borisova Gradina (**Figs. 1, 2**). The samples were collected using the direct method of Gärtner et al. (2010a), for which we used pre-made Petri dishes containing solid agar enriched by Bold's Basal Medium (BBM) after the classical recipe of Bischoff & Bold (1963).

Fig.1. Map of Bulgaria with indication of Sofia (left) and map of Sofia with location of the studied memorial (right).

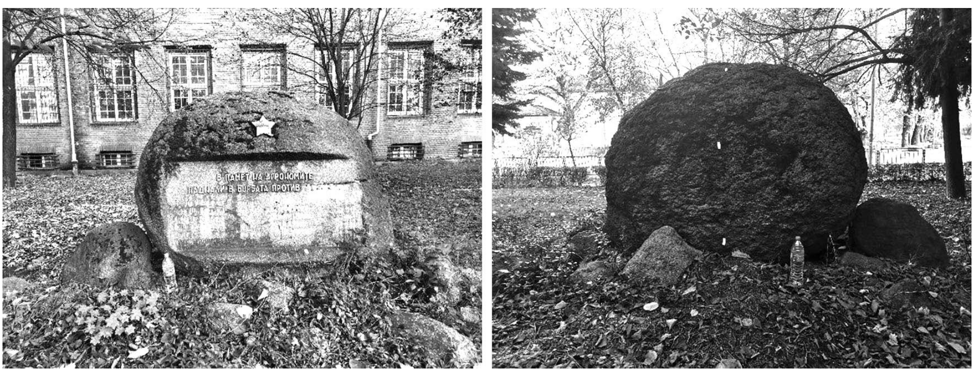

Fig. 2. Photographs of the front (north) side of the monument (left) and its back (south) side (right). Green spots indicate the sampling sites, the 1,5 L bottle is used as a scale.

Following the forementioned technique for direct collection, we made mixed (polycultural) samples from the frontal (northern) side of the memorial facing the boulevard, and three mixed samples from its southern (back) side, which is facing the building of the faculty. From each side we gently scraped small amounts from the visible, colored algal layers on the rough surfaces of the upper, middle and lower parts of the monument, using a dentist borer (**Fig. 2**). All obtained samples are deposited in the Living Algal Collection of Sofia University (ACUS – Stoyneva 2012, Uzunov et al. 2012a) for further proceeding and cultivation.

The first identification of the algae was conducted in the laboratory of ACUS. From the freshly collected samples, before their cultivation, we prepared 30 non-permanent microscope slides, which were studied thoroughly under an Olympus BX53 microscope with the following magnifications - 25x, 40x and 100x, and additionally equipped by differential interference contrast (DIC). Microphotographs were taken with the specialized Olympus DP72 camera and subsequently modified using the licensed Olympus software – cellSens. For the taxonomical identification we used standard manuals (*e.g.*, Gollerbakh et al. 1953, Komárek & Fott 1983, Ettl & Gärtner 1995, 2014, Komárek & Anagnostidis 2005, Hindák 1980, 1984, John et al. 2002), and synonymy was checked in AlgaeBase (Guiry & Guiry 2023). During the identification the several key characteristics were followed:

1. Vegetative cell characteristics – size, shape and motility;
2. Cell wall characteristics – thickness, surface, extra layers, mucilage, etc.;
3. Plastid characteristics – number, shape, color;
4. Occurrence of pyrenoid structures – number, shape, cover, etc.;
5. For the multicellular and colonial organisms – shape, size, color, presence or absence mucilage sheath.

RESULTS AND DISCUSSION

Six species from four divisions – Chlorophyta (4), Streptophyta (1) and Ochrophyta (1) – were identified during the pilot light microscopic observations of the freshly collected material – **Fig. 3.** They were found growing on both the northern and the southern sides of the monument, with no clear distributional patterns.

The annotated taxonomic list is provided below:

Division Chlorophyta
Class Trebouxiophyceae
Order Chlorellales
Family Chlorellaceae

***Chlorella* sp.** – cells are round, spherical or slightly ellipsoidal, diameter averaging 5,3–6 µm. Cell wall is smooth, without any visible roughness or bumps.

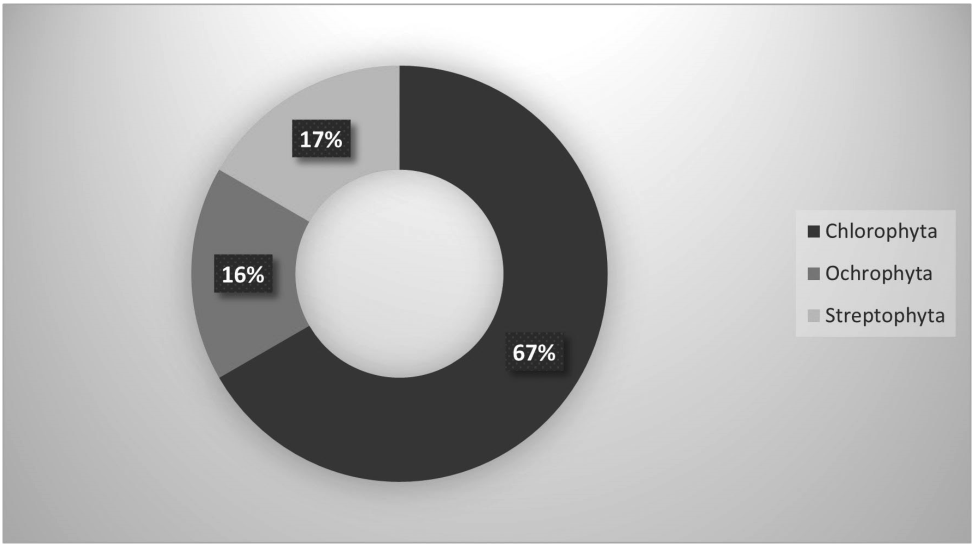

Fig. 3. Algal biodiversity on the memorial Monument of agronomists-antifasciests in Sofia.

Every cell contains a large, single cup-shaped chloroplast with a single pyrenoid, plastered with starch globules, visible after staining with Lugol's solution. Asexual reproduction is carried by the formation of autospores, where daughter cells develop inside the boundaries of the mother cell and are released by rupturing the wall of the autosporangium.

***Chloroidium ellipsoideum* (Gerneck) Darienko, Gustavs, Mudimu, Menendez, Schumann, Karsten, Friedl & Proschold 2010** (Syn.: *Chlorella ellipsoidea* Gerneck 1907) – cells are ellipsoidal or round, usually longer than wide, averaging 8,4–8,8 μm in length and 7,6–8 μm in width. Cell walls are thick, smooth, without visible bumps or rough patches. Cells contain a single small parietal chloroplast, usually cup-shaped, situated near the nucleus in the central regions of the cell. Pyrenoids are present, usually single, enveloped in a thin starch envelope, visible after staining with Lugol's solution. Asexual reproduction is carried by the formation of autospores, which are released by rupturing the mother cell-wall. Daughter cells for a while may remain attached to the remnants of the autosporangium.

Order Prasiolales

Family Stichococcaceae

***Stichococcus* sp.** – cells are cylindrical, with rounded ends, longer than wide, with a ratio of 3:1, averaging 8,9–9,4 μm in length and 3,2–3,7 μm in width. If filamentous forms are present, they are usually short, made up by only a few cells (3-5), without branching and easily fragmenting into single cells. Cell walls are thin, with a smooth surface, lacking a mucilaginous layer. Every cell contains a

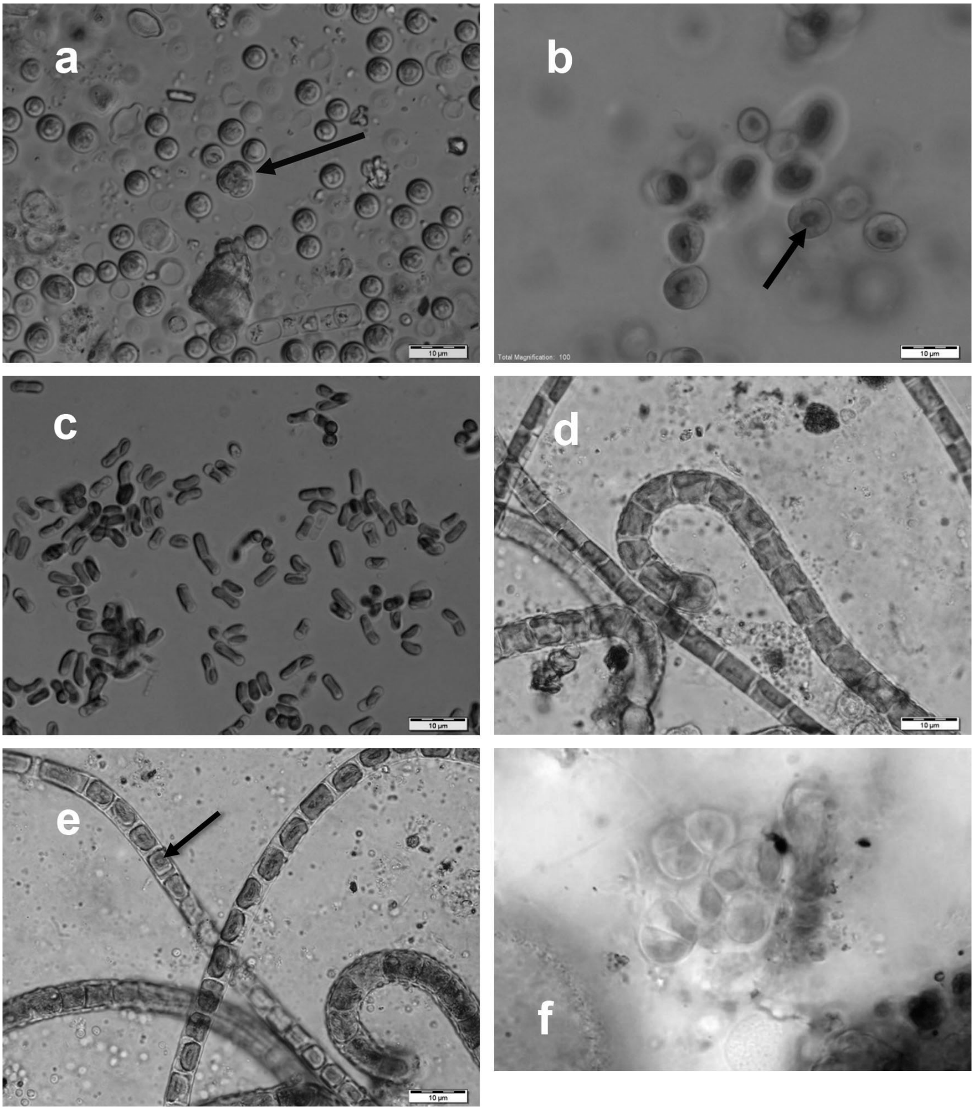

Fig. 4. Microphotographs of the observed aeroterrestrial algae: **a** – *Chlorella* sp. (arrow indicates autosporangium); **b** - *Chloroidium ellipsoideum* (arrow points a pyrenoid visible after coloration by Lugol's solution); **c** - *Stichococcus* sp.; **d** - *Ulothrix tenerrima*; **e** - *Klebsormidium klebsii* (pyrenoids visible after coloration by iodine solution); **f** - *Gloebotrys* sp.

single, large parietal chloroplast with a small, barely visible pyrenoid in the center (sometimes the pyrenoid is absent). Vegetative reproduction is done by binary fission of the cell or by fragmentation of the filament. Spores and gametes were not observed.

Class Ulvophyceae
Order Ulotrichales
Family Ulotrichaceae

***Ulothrix tenerrima* (Kützing) Kützing 1843** (Syn.: *Ulothrix variabilis* Kützing 1849) – filaments are long, sleek, without branches, mucilage is not present. Cells are cylindrical, longer than wide, averaging 6,4-7,2 µm in length and 5,4-5,8 µm in width. Cell walls are thick with a smooth outline. Every cell contains a single, large semi-annular chloroplast with a single pyrenoid, encased in a thin starch envelope, visible after staining with Lugol. Older cells accumulate globules and vesicles. Vegetative reproduction is carried by filament fragmentation. Formation of spores and gametes was not observed.

Division Streptophyta
Class Klebsormidiophyceae
Order Klebsormidiales
Family Klebsormidiaceae

***Klebsormidium klebsii* (G. M. Smith) P. C. Silva, K. R. Mattox & W. H. Blackwell 1972** – filaments are long, straight, flaccid and unbranched, without mucilaginous sheaths. Cells are cylindrical, longer than wide, with a ratio of approximately 2:1, averaging 6,2 µm in length and 3,2 µm in width. Apical cells are not differentiated and look like the rest. Cell walls are thin, with a smooth surface, rarely rough or thickened. Cells contain a single, large parietal laminate chloroplast, occupying the majority of the cell. Chloroplasts contain central pyrenoids, usually a single one, rarely more than one. Pyrenoid is large, encased in a thick starch envelope, visible after staining with Lugol. Vegetative reproduction is carried by fragmentation into short-celled filaments or into single, solitary cells. Asexual and sexual reproduction is not observed, since there were no available spores or gametes present in the sample.

Division Ochrophyta
Class Eustigmatophyceae
Order Eustigmatales
Family Gloeobotrydaceae

***Gloebotrys* sp.** – cells are spherical or slightly ellipsoidal, enveloped in a shared mucilaginous layer. Cells are usually grouped in 4-8 based on the pattern of division. Single cells are with sizes averaging 3,5–4 µm in diameter. Cell walls are smooth, without visible bumps or scars. Every cell contains multiple small lentil-shaped chloroplasts, usually closely associated with the cell wall. Vegetative reproduction is carried by binary fission, asexual and sexual reproduction was not observed, since no zoospores or gametes were present in the sample.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this article.

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NEW HABITATS OF SOME SPECIES OF ORCHIDS ON THE TERRITORY OF THE EUROPEAN ECOLOGICAL NETWORK NATURA 2000 (BULGARIA)

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Abstract. We present new data on the distribution of five orchid species in the Batova Valley Protected Area BG 0000102, part of the European ecological network Natura 2000. Although these orchid species are not new to the floristic region of Northeastern Bulgaria, we report new habitats in Batova River Valley Protected Area. Three of the species are reported for the first time, for the other two species, this is the second report in the study area. All described orchid species are subject to protection by various national and international documents.

Key words: orchids, Batova Valley Protected Area, new chorological data

INTRODUCTION

This study provides new chorological data for five orchid species distributed in the Batova Valley Protected Area (PA) BG 0000102. It is part of the European ecological network Natura 2000 under Directive 92/43 / EEC on the protection of natural habitats (MEW). So far, no targeted studies on the species diversity of orchids have been conducted on the territory of PA BG 0000102. During the field work on "Mapping and determining the conservation status of higher plants, mosses

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and natural habitats" in 2011-2012 (MEW) on the territory of PA "Batova Valley" habitats were found only *Orchis purpurea* Huds.

MATERIALS AND METHODS

Field research was conducted during the growing seasons of 2021 and 2022. For determination of the medicinal plants Handbook for Plants in Bulgaria (Delipavlov et al. 2011) and Key to the native and foreign vascular plants in Bulgaria (Stoyanov et al. 2021) were used. The identification of the native or alien type of the plants according to their origin was based on the Conspectus of the Bulgarian Vascular Flora (Assyov et al. 2012). The Latin names of the species were adopted according to the International Plant Names Index.

The conservation status is presented using the following documents: Annexes II and V to Directive 92/43 / EEC of the Council of the European Community on the conservation of natural habitats and of wild fauna and flora, Annex II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Red Data Book of Bulgaria, Vol. 1. Plants and mushrooms (Peev et al. 2015), IUCN Red list for Bulgaria (Petrova & Vladimirov 2009), Annexes III and IV to the Biodiversity Act.

The boundaries of the protected area are according to the maps of the National Ecological Network Natura 2000 (MEW). Voucher herbarium specimens were prepared from the target species, which are stored in the herbarium of Sofia University “St. Kliment Ohridski ”(SO).

RESULTS

During the field research we found that five species of orchids belonging to five genera of the family Orchidaceae are distributed on the territory of the Batova River Valley Protected Area. Although these species of orchids are not new to the floristic region of Northeastern Bulgaria (Assyov et al. 2012), we report new habitats for PA BG0000102. We report the localities in this floristic region, as the data on the distribution of representatives of the family Orchidaceae so far are only for *Orchis purpurea* Huds. (MEW) and *Himantoglossum calcaratum* ssp. *rumelicum* (H. Baumann & R. Lorenz) Niketic & Djordjevic (Tomović et al. 2021).

New records:

Cephalanthera rubra Rich. - We found a habitat with three specimens of this species. The locality is registered in the land of the village of Sokolnik, district Dobrich, 43.415483N; 27.896596E in deciduous forest from *Acer campestre* L. and *Carpinus orientalis* Mill., 21.05.2022; P. Boycheva (SO 108169).

Cephalanthera rubra is not new for floristics in the region of Northeastern Bulgaria (Assyov et al. 2012). It is a new locality in NATURA 2000 network of

Batova River Valley (BG0000102).

The species has been included on the lists of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Epipactis helleborine (L.) Crantz (**Fig. 1**) - We registered a habitat with three specimens in the flowering phase in the land of the village of Sokolnik, district Dobrich, 43.418686N; 27.881305E in a meadow near deciduous forest; 02.07.2021; P. Boycheva & D. Ivanov (SO 108158).

The species is not new to the floristic region of Northeastern Bulgaria (Assyov et al. 2012), but for the first time a habitat was reported in the Batova River Valley Protected Area. The species has been included on the lists of the CITES.


Fig. 1. *Epipactis helleborine* (Photo P. Boycheva)

Himantoglossum calcaratum* ssp. *rumelicum, (H. Baumann &R. Lorenz) Niketic & Djordjevic - We found a new habitat with five specimens in the land of the village of Novakovo, district Varna, 43.344406N; 27.833131E in a meadow near a deciduous forest; 15.06.2021; P. Boycheva & D. Ivanov (SO 108160).

The authors report a second locality of the species in the protected area. Habitat of *Himantoglossum calcaratum* ssp. *rumelicum,* in the Batova River Valley Protected Area was first reported by Tomović et al. (2021). The species is of high conservation importance, included in CITES, and is a subject to protection under the Biodiversity Act, included in Annex III and Annex IV of the Directive 92/43/EEC. The plant is listed in the Red Data Book of the Republic of Bulgaria (Peev et al. 2015) in the 'vulnerable' category, and included in Red list for Bulgaria (Petrova & Vladimirov 2009) as well.

Neotinea tridentata (Scop.) R. M. Bateman, Pridgeon & M. W. Chase - We registered a new habitat with three specimens in the region of Novakovo village, district Varna, 43.416325N; 27.902556E in a meadow near a deciduous forest; 21.05.2022; P. Boycheva & D. Ivanov (SO 108168).

This is the second report on the habitat of the species in the PA. *Neotinea tridentata* habitat in the Batova Valley Protected Area was first reported by

Sabovjević et al. (2022). The species has a conservation status, included in Annex IV of the Biodiversity Act, subject to protection by CITES.

Orchis simia Lam. – We recorded one habitat with over 20 specimens in the region of the Stozher village, region Dobrich,43.425630N; 27.889730E in a meadow near a deciduous forest; 23.05.2022; P. Boycheva & D. Ivanov (SO 108167). Although widespread throughout the country, the species is new to the area. The species has a conservation status, included in Annex IV of the Biodiversity Act, and is a subject to protection by CITES.

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Index Fungorum. Retrieved from http://www.indexfungorum.org/Names/Names.asp on 19.11.2017.

Or, alternatively

Index Fungorum. http://www.indexfungorum.org/Names/Names.asp (Last accessed on 19.11.2017).

In special cases, as an exception, the websites of electronic publications could be placed in the text.

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Petkov N. H. 1915. La flore algologique du mont Pirin-planina. - Sbornik na Bulgarskata Akademiya na Naukite 20: 1–128 (In Bulgarian, French and Russian summ.).

Book:

Valkanov D. E., Draganova P. M. & Tsvetkova B. B. 1978. Flora of Bulgaria. Algae. Izd. Narodna Prosveta, Sofia, 642 pp. (In Bulgarian)

Valkanov D. E., Draganova P. M. & Tsvetkova B. B. 1978. Flora of Bulgaria. Algae. Izd. Narodna Prosveta, Sofia, 642 pp. (In Bulgarian, English summ.)

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Footnotes should be avoided.

Transliteration should follow the Bulgarian legislative documents (State Gazette 19/13.03.2009, 77/01.10.2010, 77/09.10.2012, 68/02.08.2013 - http:// lex. bg/en/laws/ldoc/2135623667). **The geographic names should be fully transliterated** except the cases of titles of published works.

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