ГОДИШНИК НА СОФИЙСКИЯ УНИВЕРСИТЕТ „СВ. КЛИМЕНТ ОХРИДСКИ“
БИОЛОГИЧЕСКИ ФАКУЛТЕТ
Книга 2 – Ботаника
Том 105, 2021

ANNUAL OF SOFIA UNIVERSITY “ST. KLIMENT OHRIDSKI”
FACULTY OF BIOLOGY
Book 2 – Botany
Volume 105, 2021

SUMMER CYANOPROKARYOTE BLOOMS IN ELEVEN RESERVOIRS IN SOUTH BULGARIA (2019)

KOSTADIN DOCHIN*

Department of Aquaculture and Water Ecosystems, Institute of Fisheries and Aquaculture, 248 Vasil Levski St, 4003 Plovdiv, Bulgaria

Abstract. Forty taxa from the Cyanoprokaryota division were identified in eleven reservoirs in South Bulgaria, and seventeen of them dominated by biomass in 2019. The potential producers of cyanotoxins *Microcystis aeruginosa*, *Microcystis wesenbergii*, *Dolichospermum spiroides* and *Planktothrix agardhii* caused intense blooms. Cyanoprokaryote blooms persisted throughout the summer, and their contribution to the total phytoplankton biomass varied from 15 to 100%. In September, in the Sinyata Reka reservoir, the biomass of *Microcystis aeruginosa* reached 35.3 mg L^{-1}, and of *Microcystis wesenbergii* - 10.5 mg L-1. In Novo Zhelezare reservoir in July the biomass of *Dolichospermum spiroides* reached 18.81 mg L^{-1}, and *Planktothrix agardhii* in August - 16.8 mg L^{-1}.

Key words: biomass, cyanobacteria, cyanotoxins, dominants, potential toxin producers

INTRODUCTION

Cyanoprokaryotes (cyanobacteria) are photoautotrophic microorganisms that are found in various habitats. Under favorable environmental conditions, they have the ability to reproduce rapidly, causing "blooms" of water, as well as the potential

* *corresponding author*: K. Dochin – Department of Aquaculture and Water Ecosystems, Institute of Fisheries and Aquaculture, 248 Vasil Levski St, 4003 Plovdiv, Bulgaria; dochin_k@abv.bg

to produce cyanotoxins, which represent a threat to the health of living organisms (Teneva et al. 2010, Temniskova & Stoyneva 2011, Svirčev et al. 2019, Meriluoto et al. 2017, Tasinov et al. 2020). The eutrophication of water bodies leads to accelerated development of algae, including cyanoprokaryotes (Bláha et al. 2009). A significant number of publications in recent years on the algal flora in different types of reservoirs in Bulgaria show that the representatives of the Cyanoprokaryota division increasingly dominate these water bodies (*e.g.*, Teneva et al. 2009; Teneva et al. 2010; Pavlova et al. 2013; Dochin & Stoyneva 2014; Dochin & Stoyneva 2016; Stoyanov et al. 2016; Stoyneva-Gärtner et al. 2017, 2021; Dochin & Ivanova 2017a; Dochin et al. 2017; Dochin et al. 2018; Teneva et al. 2018; Dochin 2019; Dochin & Iliev 2019; Radkova et al. 2020; Dochin in press). The present paper is focussed on the dominant role of well-known potentially toxic cyanoprokaryotes in the quantitative abundance and taxonomic structure of algal communities in eleven South-Bulgarian reservoirs in 2019.

MATERIAL AND METHODS

The study was conducted from June to October 2019 in eleven reservoirs (**Table 1**), situated in South Bulgaria, included with their inventory number in the Inventory of Bulgarian Wetlands (Michev & Stoyneva 2007): Sinyata Reka (IBW1890), Bakurdere (IBW1213), Radnevo (IBW2261), Ezerovo (IBW1642), Novo Zhelezare (IBW1475), Tsarimir (IBW1471), Dushantsi (IBW1408), Lenovo (IBW1592), Pyasuchnik (IBW1472), Koprinka (IBW2062) and Tsanko Tserkovski (IBW 2727) – **Fig. 1**. These water bodies are used as important water resources in irrigation, aquaculture and for recreational purposes (Michev & Stoyneva 2007).

Table 1. Studied reservoirs in South Bulgaria and dates of their sampling in 2019.

Reservoir name	Sampling date			
Sinyata Reka	20.6.2019	18.7.2019	14.8.2019	13.9.2019
Bakurdere	21.6.2019	18.7.2019	14.8.2019	13.9.2019
Radnevo	1.7.2019	1.8.2019	29.8.2019	28.9.2019
Ezerovo	24.6.2019	25.7.2019	26.8.2019	18.9.2019
Novo Zhelezare	20.6.2019	19.7.2019	14.8.2019	13.9.2019
Tsarimir	20.6.2019	19.7.2019	14.8.2019	13.9.2019
Dushantsi	20.6.2019	18.7.2019	14.8.2019	13.9.2019
Lenovo	24.6.2019	25.7.2019	26.8.2019	18.9.2019
Pyasuchnik	20.6.2019	18.7.2019	14.8.2019	13.9.2019
Koprinka	4.7.2019	1.8.2019	29.8.2019	28.9.2019
Tsanko Tserkovski	2.7.2019	1.8.2019	29.8.2019	28.9.2019

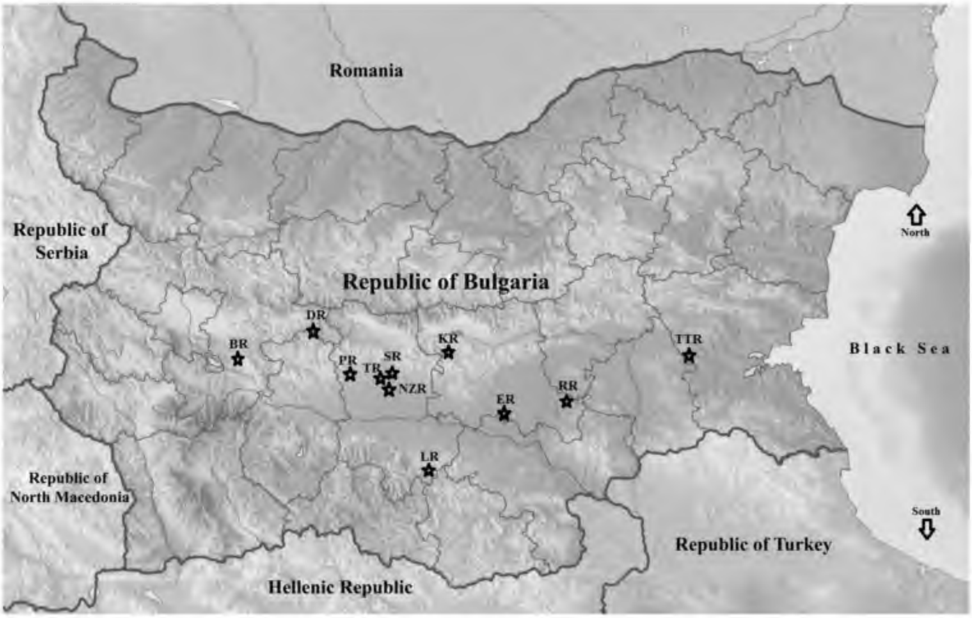

Fig. 1. Map of the Republic of Bulgaria with the location of sampling sites indicated. **Legend:** SR - Sinyata Reka Reservoir, BD - Bakur Dere Reservoir, RR - Radnevo Reservoir, ER - Ezerovo Reservoir, NZR - Novo Zhelezare Reservoir, TR - Tsarimir Reservoir, DR - Dushantsi Reservoir, LR - Lenovo Reservoir, PR - Pyasuchnik Reservoir, KR - Koprinka Reservoir, TTR - Tsanko Tserkovsi Reservoir.

Forty-four water samples for phytoplankton analysis were collected by Niskin-Type water sampler 5 L model Hydro-Bios Apparatebau GmbH, Germany (**Table 2**). Water temperature, dissolved oxygen (DO) and oxygen saturation were measured in situ with an oxygen meter (WTW OXY 1970i). Electrical conductivity and pH were measured with WTW conductivity meter (Cond3310/SET) and WTW pH-meter (315/SET) respectively. The depth of the euphotic layer was determined by measuring the water transparency with a 20 cm diameter Secchi disk.

The phytoplankton samples were collected and processed by standard methods of fixation with formalin to final concentration 4% and further sedimentation (ISO5667-1:2006/AC: 2007; ISO5667-3: 2003/AC: 2007). The species composition was determined on light microscope (Carl Zeiss, Axioscope 2 plus) with magnification 400x using standard taxonomic literature with critical use of AlgaeBase (Guiry & Guiry 2021). Counting was done on Bürker chamber with the individuals (cell, filament or colony) being the counting units and the biomass was estimated by the method of stereometrical approximations (Rott 1981; Deisinger 1984). The total biomass of each sample was assessed as the amount of biomass of all species summarized by separate taxonomic groups. Dominant species were determined according to the percentage contribution of individual species to the total biomass (Stoyneva 2000).

Table 2. Main physico-chemical parameters of water in the studied eleven reservoirs in South Bulgaria in 2019. **Legend:** SR - Sinyata Reka Reservoir; BD-Budak dere Reservoir; RR - Radnevo Reservoir; ER - Ezerovo Reservoir; NZR - Novo Zhelezare Reservoir; TR - Tsarimir Reservoir; DR - Dushantsi Reservoir; LR - Lenovo Reservoir.

Parameter	Water temperature				Secchi Disk				Conductivity				pH				Dissolved Oxygen				O_2			
Measure	°C				m				µS cm-1								mg.l				%			
Reservoir	mean	sd	min	max	mean	sd	min	max	mean	sd	min	max	mean	sd	min	max	mean	sd	min	max	mean	sd	min	max
SR	25.2	2.5	21.6	27.3	0.38	0.15	0.3	0.6	450	19.5	421	463	9.8	0.329	9.54	10.27	11.3	4.53	7.6	17.8	143	62.61	89	232
BD	24.52	12.8	22.3	29.2	1.062	0.298	0.85	1.5	220.5	9.1	211	232	8.4	0.57	7.67	8.86	7.8	0.31	7.5	8.2	101	6.782	93	108
RR	26.6	4.9	20.3	30.9	0.312	0.149	0.15	0.5	489	35.4	457	5	8.8	0.263	8.5	9.13	9.9	2.44	6.4	11.8	124.75	34.98	77	160
ER	27.35	4.4	21.7	32.2	0.225	0.086	0.1	0.3	358.3	29.4	323	394	9.6	0.519	9.05	10.26	11.2	5.074	7.2	18.6	145	76.52	91	258
NZR	23.4	2.3	20.2	25.1	0.025	0.05	0	0.1	625.5	49.4	569	689	9.2	1.156	7.76	10.58	9.9	5.5	6.7	18.1	119.75	67.59	83	221
TR	24.2	1.6	21.8	25.5	0.537	0.268	0.25	0.9	425.3	5.0	420	430	7.6	0.23	7.37	7.9	4.8	3.872	4.6	5	58.5	3.872	53	62
DR	23.3	2.6	20.7	26.2	0.95	0.129	0.8	1.1	88.8	5.3	83	95	8.6	0.855	7.43	9.24	8.0	2.6	4.5	10.8	101.25	33.55	54	133
LR	24.7	1.9	23	27.4	0.712	0.154	0.5	0.85	197.9	8.9	190	209	8.8	0.153	8.65	9.01	8.8	2.5	7	12.4	107.75	28.33	86	147
PR	24.1	1.9	23.3	25.8	0.85	0.544	0.4	1.6	217.5	10.3	205	229	8.9	0.201	8.7	9.09	8.8	1.3	7.6	10.5	108	19.13	88	133
KR	25.1	3.5	20	27.8	1.2	0.535	0.9	2	192.3	19.2	175	218	8.7	0.242	8.5	8.98	7.3	0.6	6.6	7.9	91.75	12.03	76	105
TTR	26.8	3.1	22.2	28.6	0.225	0.125	0.1	0.4	834	69.4	761	911	8.8	0.078	8.68	8.85	11.0	2.3	8.9	13.3	138.75	25.72	115	167

RESULTS

The average data of the monitored in situ parameters are presented in **Table 2**. In 2019, 197 phytoplankton taxa from 7 divisions were identified in the studied reservoirs. Among them 40 taxa were from the Cyanoprokaryota division (**Table 3**). The percentage of registered cyanoprokaryotic species in the studied reservoirs was as follows: Sinyata Reka (35.2%), Bakurdere (18.8%), Radnevo (24.7%), Ezerovo (34.1%), Novo Zhelezare (25%), Tsarimir (16.2%), Dushantsi (15.5%), Lenovo (27.1%), Pyasuchnik (21.2%), Koprinka (18%) and Tsanko Tserkovski (26.1%). In all analyzed samples from the reservoirs Sinyata Reka, Ezerovo and Tsarimir cyanoprokaryote blooms persisted throughout the summer: in the Sinyata Reka reservoir their contribution in the total phytoplankton biomass (TPB) was between 90 and 100%, in Ezerovo reservoir - from 65 to 100%, and in Tsarimir reservoir - from 15 to 52%. In three of the four samplings in the reservoirs Bakurdere (83-97%), Radnevo (37.5-73%), Novo Zhelezare (51-95%) and Doushantsi (37-86%) cyanoprokaryotes cause mass blooms. Once in the reservoirs Lenovo (95%), Pyasuchnik (74%), Koprinka (32%) and Tsanko Tserkovski (35.3%) the cyanobacteria were most abundant. Out of the forty cyanoprokaryote taxa identified, seventeen were dominant during the study period and fourteen of the identified species are known to be potential producers of cyanotoxins. The following number of representatives of the Cyanoprokaryota division was identified in the studied reservoirs: Sinyata Reka – 16, Bakurdere –12, Radnevo –19, Ezerovo –12, Novo Zhelezare –13, Tsarimir –10, Doushantsi –8, Lenovo –16, Pyasuchnik –11, Koprinka–10 and Tsanko Tserkovski –18 (**Table 3**).

In June, in the Sinyata Reka reservoir *Microcystis aeruginosa* (Kützing) Kützing (88.3%, 8.953 mg L^{-1}) and *Aphanizomenon flosaquae* Ralfs ex Bornet & Flahault (10.7%, 1.081 mg L^{-1}) dominated, forming 99% of the TPB. In July, *M. aeruginosa* (70%, 2.750 mg L^{-1}) dominated together with *Pseudanabaena mucicola* (Naumann & Huber-Pestalozzi) Schwabe (18.3%, 0.720 mg L^{-1}). In August, 100% of the TPB was due to the cyanoprokaryotes and the most abundant were the potentially toxic *Dolichospermum* cf. *spiroides* (Klebahn) Wacklin, L. Hoffmann & Komárek (34.8%, 4.028 mg L^{-1}), *M. aeruginosa* (30.6%, 3.534 mg L^{-1}) and *Microcystis wesenbergii* (Komárek) Komárek ex Komárek (2.6%, 2.728 mg L^{-1}). In September, the biomass of cyanoprokaryotes decreased to 97% of TPB, and the most abundant were *M. aeruginosa* (75%, 35.3 mg L^{-1}) and *M. wesenbergii* (22%, 10.5 mg L^{-1}).

In June, in the Ezerovo reservoir cyanoprokaryotes dominated (100%) and the most abundant were the potentially toxic species *D. spiroides* (49.2%, 5.472 mg L^{-1}) and *M. aeruginosa* (48.1%, 5.352 mg L^{-1}). In July, the biomass of cyanoprokaryotes was 99.3% of the TPB with blooms of *D. spiroides* (87%; 10.93 mg L^{-1}). In August, the contribution of cyanoprokaryotes to the total biomass decreased to 65%, with *M. aeruginosa* (52.6%, 2.012 mg.L^{-1}) and *Ps. mucicola* (8.2%, 0.314 mg.L^{-1}) being

Table 3. List of identified taxa from Cyanoprokaryota. **Legend:** SR - Sinyata Reka Reservoir; BD - Bakur Dere Reservoir; RR - Radnevo Reservoir; ER - Ezerovo Reservoir; NZR - Novo Zhelezare Reservoir;TR - Tsarimir Reservoir; DR - Dushantsi Reservoir; LR - Lenovo Reservoir; xx - dominant.

Cyanoprokaryota	SR	BD	RR	ER	NZR	TR	DR	LR	PR	KR	TTR
Anabaena sp.		x			x						
Anabaenopsis cf. *arnoldii* Aptekar	x										
Anathece clathrata (West & G.S.West) Komárek, Kastovsky & Jezberová	x	x	x		x	x	xx	x	xx	xx	x
Aphanizomenon flosaquae Ralfs ex Bornet & Flahault	xx	xx			x	x		xx	xx	xx	
Aphanizomenon gracile Lemmermann	x	x	xx	x				x		x	x
Aphanizomenon sp.	x	x									
Aphanocapsa delicatissima West & G.S.West	x		x			x		x			x
Aphanocapsa sp.	x		x		x		x	x			x
Aphanothece sp.					x	x			x		
Chroococcus turgidus (Kützing) Nägeli						x		x	x		x
Cuspidothrix issatschenkoi (Usachev) P.Rajaniemi, Komárek, R.Willame, P. Hrouzek, K.Kastovská, L.Hoffmann & K.Sivonen			xx	xx	x			xx		x	xx
Dolichospermum flosaquae (Brébisson ex Bornet & Flahault) P.Wacklin, L.Hoffmann & J.Komárek	x		x	x							x
Dolichospermum planctonicum (Brunnthaler) Wacklin, L.Hoffmann & Komárek		x	x	x				x	x		
Dolichospermum spiroides (Klebhan) Wacklin, L.Hoffmann & Komárek	xx		xx	x	xx			x	xx		x
Gloeotrichia sp.			x				x				
Limnococcus limneticus (Lemmermann) Komárková, Jezberová, O.Komárek & Zapomelová											x
Merismopedia glauca (Ehrenberg) Kützing						x					
Merismopedia punctata Meyen								x			
Merismopedia sp.		x	x			x					
Merismopedia tenuissima Lemmermann					x	xx					x
Microcystis aeruginosa (Kützing) Kützing	xx		x	xx	xx				x	x	x
Microcystis sp.				x				x			
Microcystis wesenbergii (Komárek) Komárek ex Komárek	xx		x	x				x			
Oscillatoria limosa C.Agardh ex Gomont			x	x	xx						x
Oscillatoria sp.				x		x					x

Cyanoprokaryota	SR	BD	RR	ER	NZR	TR	DR	LR	PR	KR	TTR
Planktolyngbya limnetica (Lemmermann) Komárková-Legnerová & Cronberg	x	x	xx		x		x	x		x	x
Planktolyngbya sp.		x									
Planktothrix agardhii (Gomont) Anagnostidis & Komárek			x	x	xx					x	x
Pseudanabaena catenata Lauterborn		x	xx			xx		xx	x		x
Pseudanabaena cf. *galeata* Böcher							x				
Pseudanabaena limnetica (Lemmermann) Komárek	x	xx	x				xx	x	x		
Pseudanabaena mucicola (Naumann & Huber-Pestalozzi) Schwabe	xx			xx			x			x	x
Pseudanabaena sp.	x				x			xx	x		
Raphidiopsis raciborskii (Woloszynska) Aguilera, Berrendero Gómez, Kastovsky, Echenique & Salerno		x	x								
Romeria cf. *elegans* (Woloszynska) Geitler							xx				
Snowella lacustris (Chodat) Komárek & Hindák	x									xx	
Snowella sp.			x								x
Spirullina sp.									*x*		
Synechococcus linearis (Schmidle & Lauterborn) Komárek							x				
Woronichinia naegeliana (Unger) Elenkin										x	

the most abundant. In September, the biomass of cyanoprokaryotes increased to 78.2% and the most common were again *M. aeruginosa* (70%; 5.84 5 mg L^{-1}) and *Ps. mucicola* (4.3%, 0.356 mg.L^{-1}).

In Tsarimir reservoir, in June and July 2019, the share of cyanoprokaryotes in the TPB varied from 36.7 to 51.4% under the dominance of *Merismopedia tenuissima* Lemmermann (2.280-1.602 mg L^{-1}), while the most abundant in August and September was *Pseudanabaena* cf. *catenata* Lauterborn (15-51.4%, 6.92 and 0.340 mg L^{-1}, respectively).

In the Bakurdere reservoir, in June and July 2019, *Pseudanabaena limnetica* (Lemmermann) Komárek was abundant (82.6-97%, 7.21 to 11.7 m gL^{-1}) together with *Aphanizomenon flosaquae* (4.6% - 5.4%, 0.582- 0.441 mg L^{-1}).

In the Radnevo reservoir, in July *Ps. catenata* (18.5%, 0.426 mg L^{-1}), *Aphanizomenon gracile* Lemmermann (10.9%, 0.251 mg L^{-1}) and *Aphanocapsa delicatissima* West & G. S. West (8.1%, 0.187 mg L^{-1}) dominated. *Planktolyngbya limnetica* (Lemmermann) Komárková-Legnerová & Cronberg was the most abundant in August (71.3%, 5.18 mg L^{-1}) and September (53.6%, 7.19 mg L^{-1}).

In July, in Novo Zhelezare reservoir the most abundant were *D. spiroides* (82.4%, 18.81 mg L^{-1}) and *Oscillatoria limosa* C. Agardh ex Gomont (10.1%, 2.295 mg L^{-1}). In August, the contribution of cyanoprokaryotes reached 95% of the TPB and the most abundant were *Planktothrix agardhii* (Gomont) Anagnostidis & Komárek (56.5%, 16.8 mg L^{-1}) and *M aeruginosa* (27.3%, 8.11 mg L^{-1}). In September, *D. spiroides* (23.2%, 3.849 mg L^{-1}), *P. agardhii* (14.4%, 2.387 mg L^{-1}) and *M. aeruginosa* (10.6%, 1.766 mg L^{-1}) dominated.

In June, in the Dushantsi reservoir blooms of the cyanoprokaryotic *Pseudanabaena limnetica* (86.2%, 5.38 mg L^{-1}) were found. In the same reservoir, in July dominated *Anathece clathrata* (West & G. S. West) Komárek, Kastovsky & Jezberová (60%, 5.85 mg L^{-1}), and in August dominant was *Romeria* cf. *elegans* (Woloszynska) Geitler (51%, 4.29 mg L^{-1}).

In Koprinka reservoir, in July the biomass of cyanoprokaryotes reached 32.3% from the TPB with the most abundant *Anathece clathrata* (21%, 0.200 mg L^{-1}) and *Snowella lacustris* (Chodat) Komárek & Hindák (11.3%, 0.110 mg L^{-1}). In August (during the two samplings on 1 August and 29 August) dominated *Snowella lacustris* (48.5-72.2%) with maximum biomass 5.65 mg L^{-1}.

In June, in the reservoir Tsanko Tserkovski in low amounts *P. agardhii* (0.082 mg L^{-1}) and *D. spiroides* (0.042 mg L^{-1}) were identified. In early August, with the development of *Cuspidothrix issatschenkoi* (Usachev) P.Rajaniemi, Komárek, R.Willame, P. Hrouzek, K.Kastovská, L.Hoffmann & K.Sivonen, the percentage of cyanoprokaryotes reached 35% of the TPB, but its biomass was relatively low (0.380 mg L^{-1}). In late August, *Merismopedia tenuissima* (3.87%, 0.67 mg L^{-1}) and *C. issatschenkoi* (4.2%, 0.059 mg L^{-1}) developed, and at the end of September *M. tenuissima* formed 1.82% of the TPB with biomass value …... mg L^{-1}.

In two of the reservoirs monitored in 2019, the representatives of Cyanoprokaryota dominated only once during the four samplings. In Lenovo reservoir, in June 2019, the contribution of cyanoprokaryotes to the TPB reached 96%. The most abundant were *C. issatschenkoi* (63.5%; 2.22 mg L^{-1}) and *A. flosaquae* (26.5%, 0.925 mg L^{-1}). In the reservoir Pyasuchnik, in August 2019, cyanoprokaryotes formed 74% of the TPB with dominance of *D. spiroides* (54.3%, 3.35 mg L^{-1}) and *A. flosaquae* (19.1%; 1.17 mg L^{-1}).

DISCUSSION

In eutrophic Bulgarian reservoirs the representatives of the genera *Aphanizomenon*, *Cylindrospermopsis*, *Microcystis* and *Planktothrix* are among the often reported blooming potentially toxic species (Stoyneva 2016; Stoyneva-Gärtner et al. 2017). In our previous study of lowland reservoirs, the species *A. flosaquae*, *D. spiroides*, *P agardhii* and *M. aeruginosa* dominated in most samples (Dochin in press). According to Stoyneva-Gärtner et al. (2017) *Microcystis wesenbergii* was commonly presented in samples from Bulgarian waterbodies with confirmed cyanotoxins. Later, the toxicity of *M. wesenbergii* was confirmed firstly in Sinyata Reka reservoir, and then in four other waterbodies (Radkova et al.

2020; Stoyneva-Gärtner et al. 2021).

According to a study based on 25 years of investigation (1990-2014), *Microcystis wesenbergii* was found only in the western and eastern part of Bulgaria (Stoyneva 2016). In the autumn of 2015 blooms of *M. wesenbergii* were registered in Koprinka reservoir (Dochin et al. 2017), in June 2018 and in August 2019 it was found as dominant in the reservoir Sinyata Reka (Radkova et al. 2020; Stoyneva-Gärtner et al. 2021). Our data from this study are similar to the results reported by Radkova et al. (2020) and Stoyneva-Gärtner et al. (2021), according to which the contribution of cyanoprokaryotes to the total algal biomass in the same reservoir reached 92-99%, dominated by *M. wesenbergii* in June 2018, and by *Dolichospermum* sp. with less common *M. aeruginosa* and *M. wesenbergii* in August 2019. During the present study, in four samples (from June to September) in the Sinyata Reka reservoir, the biomass of cyanoprokaryotes ranged from 90.5% to 100% of the TPB, with *Dolichospermum* cf. *spiroides* (34.8%), *M aeruginosa* (30.6%), *M wesenbergii* (23.6%) and *Ps. mucicola* (10.1%) as most abundant species, with *M. wesenbergii* found among the dominants at the end of the summer of 2019 (13th September).

The genus *Microcystis*, and *M aeruginosa* in particular, are among the most often reported toxin producers in Bulgaria (Stoyneva-Gärtner et al. 2017, 2021; Radkova et al. 2020). *Microcystis aeruginosa* is among the most abundant species in the reservoirs Vucha and Ovcharitsa (Teneva et al. 2010; Belkinova et al. 2014). The potential toxins producers are identified in the Kavaka reservoir among the most abundant species *M. aeruginosa*, *M. wesenbergii*, *Dolichospermum spiroides* and *Aphanizomenon flosaquae* (Dochin & Ivanova 2017b). In 2019, *Aphanizomenon flosaquae* was found among the dominants in the Troyan (44.3%) and Kirilovo reservoirs - 46.2% (Dochin in press). Similar data are reported from the investigation of the reservoirs Kardzhali (Dochin & Iliev 2019), Vucha and Acheloy (Belkinova et al. 2014), Dospat (Dochin & Stoyneva 2014; 2016), Tsankov Kamuk (Dochin & Ivanova 2017a) and Batak (Dochin et al. 2018). In 2019, *Cuspidothrix issatschenkoi* was registered among the dominants in the reservoirs Pustren (25%) and Mechka (40%), and *Dolichospermum spiroides* (38.3%) in the Daskal Atanasovo reservoir (Dochin in press). The latter species was found in the reservoirs of Kurdzhali and Dospat (Dochin & Stoyneva 2014).

According to the data from the present study, *Planktolyngbya limnetica* dominated in the whole Radnevo reservoir in August 2019. In 2015, in the Tsankov kamuk reservoir was identified *Planktothrix agardhii* (Dochin & Ivanova 2017a). In 2019, this species co-dominated together with *Raphidiopsis raciborskii* (Woloszynska) Aguilera, Berrendero Gómez, Kastovsky, Echenique & Salerno in the reservoirs Malazmak and Kirilovo (Dochin in press). The common blooms of the blue-green *Pseudanabaena mucicola* and *Gloeotrichia* cf. *echinulata* were recorded during the autumn in 2017 in Kurdzhali reservoir (Dochin & Iliev 2019). In the current study in 2019, the same species was registered among the most abundant in the reservoirs Sinyata Reka and Ezerovo. The possible risks of dominance of *Pseudanabaena limnetica* and the possibility of producing cyanotoxins in reservoirs are discussed by Vasconselo & Pereira (2001) and Maršálek et al. (2003). According to Long et al. (2017) this species is less toxic than other cyanoprokaryotes. According to our study, *Ps. limnetica* was among the most abundant species throughout the summer of 2019 at Bakurdere reservoir and in June 2019 in Dushantsi reservoir. *Snowella lacustris*, which dominated in August in the reservoir Koprinka, was reported among the most widespread species in the reservoirs Kurdzhali and Tsankov Kamuk (Dochin & Stoyneva 2014; Dochin & Ivanova 2017a). According to our previous study, *Anathece clathrata* was identified among the dominants in the reservoirs Kurdzhali and Dospat, and *Aphanizomenon gracile* was recorded in the reservoir Kurdzhali (Dochin 2019). The same species was reported to cause blooms in European lakes (Mischke & Nixdorf 2003; Stoyneva 2003; Kokocinski et al. 2009; Napiorkowska-Krzebietke 2015).

CONCLUSION

The identified intense blooms of cyanoprokaryotes can serve as a reason for further comprehensive monitoring of the reservoirs in Bulgaria.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest regarding the publication of this article.

References

Belkinova D., Padisák J., Gecheva G. & Cheshmedjiev S. 2014. Phytoplankton based assessment of ecological status of Bulgarian lakes and comparison of metrics within the water framework directive. - Applied Ecology and Environmental Research 12 (1): 83-103.

Bláha L., P. Babica & Maršálek B. 2009. Toxins produced in cyanobacterial water blooms – toxicity and risks. - Interdisciplinary Toxicology 2 (2): 36–41.

Deisinger G. V. 1984. Leit faden zur Best immung der planktischen Algen der Karntner Seen und ihrer Biomasse, Karntner Insitut fur Seenforschung, 65 pp.

Dochin K. 2019. Functional and morphological groups in the phytoplankton of large reservoirs used for aquaculture in Bulgaria. - Bulgarian Journal of Agricultural Science 25 (1): 166–176.

Dochin K. The dominance of invasive algae *Raphidiopsis raciborskii* in lowland reservoirs in Bulgaria. - Bulgarian Journal of Agricultural Science (in press).

Dochin K. & Iliev I. 2019. Functional classification of phytoplankton in Kardzhali reservoir (Southeast Bulgaria). - Bulgarian Journal of Agricultural Science 25 (2): 385–395.

DOCHIN K. & IVANOVA A. 2017A. The phytoplankton in Tsankov Kamak reservoir. - Bulgarian Journal of Animal Husbandry 54 (1): 35-49.

DOCHIN K. & IVANOVA A. 2017B. Seasonal changes of phytoplankton in a small shallow dam lake part of the protected area Nature 2000. - Bulgarian Journal of Animal Husbandry 54 (1): 50-62.

DOCHIN K. T. & STOYNEVA M. P. 2014. Effect of long-term cage fish-farming on the phytoplankton biodiversity in two large Bulgarian reservoirs. - Berichte des Naturwissenschaftlichen-Medizinischen Vereins Innsbruck 99: 49-66.

DOCHIN K. T. & STOYNEVA M.P. 2016. Phytoplankton of the Dospat Reservoir (Rhodopi Mts, Bulgaria) – indicator of negative trend in reservoir development due to long-term cage fish farming. - Annual of Sofia University, Faculty of Biology, Book 2 – Botany 99: 47-60.

DOCHIN K., IVANOVA A. & ILIEV I. 2017. The phytoplankton of Koprinka Reservoir (Central Bulgaria): species composition and dynamics. - Journal of BioScience and Biotechnology 6 (1): 73-82.

DOCHIN K., KUNEVA V. IVANOVA A. & ILIEV I. 2018. Current state of phytoplankton in Batak reservoir (Southwestern Bulgaria). - Bulgarian Journal of Agricultural Science 24 (4): 686-697.

GUIRY M. D. & GUIRY G. M. 2021. AlgaeBase, World-wide electronic publication, National University of Ireland, Galway. http://www.algaebase.org; searched on 25 February 2021.

KOKOCINSKI M., DZIGA D., SPOOF L., STEFANIAK K., JURCZAK T., MANKIEWICZ-BOCZEK J. & MERILUOTO J. 2009. First report of the cyanobacterial toxin cylindrospermopsin in the shallow, eutrophic lakes of western Poland. - Chemosphere 74: 669–675.

LONG S., HAMILTON P. B., YANG Y., MA J., CHOBET O. C., CHEN C., DANG A., LIU Z., DONG X. & CHEN J. 2017. Multi-year succession of cyanobacteria blooms in a highland reservoir with changing nutrient status, Guizhou Province, China. - Journal of Limnology 77 (2): 232-246.

MARŠÁLEK B., BLÁHA L. & BABICA P. 2003. Analyses of microcystins in the biomass of *Pseudanabaena limnetica* collected in Znojmo reservoir. - Czech Phycology, Olomouc 3: 195-197.

MERILUOTO J., BLAHA L., BOJADZIJA G., BORMANS M., BRIENT L., CODD G. A., DROBAC D., FAASSEN E. J., FASTNER J., HISKIA A., IBELINGS B. W., KALOUDIS T., KOKOCINSKI M., KURMAYER R., PANTELIĆ D. QUESADA A., SALMASO N , TOKODI N., TRIANTIS T. M., VISSER P. M. & SVIRČEV Z. 2017. Toxic cyanobacteria and cyanotoxins in European waters – recent progress achieved through the CYANOCOST Action and challenges for further research. - Advances in Oceanography and Limnology 8 (1): https://doi.org/10.4081/aiol.2017.6429.

MICHEV T. M. & STOYNEVA M. P. 2007. Inventory of Bulgarian wetlands and their

biodiversity. Part 1: Non-lotic wetlands. - Publishing House Elsi-M. 364 pp.+CD.
MISCHKE U. & NIXDORF B. 2003. Equilibrium phase conditions in shallow German lakes: How Cyanoprokaryota species establish a steady state phase in late summer. - Hydrobiologia 502: 123–132.
NAPIÓRKOWSKA-KRZEBIETKE A. 2015. Cyanobacterial bloom intensity in the ecologically relevant state of lakes – an approach to Water Framework Directive implementation. - Oceanological and Hydrobiological Studies 44 (1): 97-108.
PAVLOVA V., STOYNEVA M. & BRATANOVA Z. 2013. Cyanoprokaryotes (Cyanobacteria) and cyanotoxins in some Bulgarian Reservoirs. - Journal of Balkan Ecology 16 (3): 257-260.
RADKOVA M., STEFANOVA K., UZUNOV B., GÄRTNER G. & STOYNEVA-GÄRTNER M. 2020. Morphological and molecular identification of microcystin-producing cyanobacteria in nine shallow Bulgarian water bodies. – Toxins 12 (39); doi:10.3390/toxins12010039
ROTT E. 1981. Some result from phytoplankton intercalibration. - Schweizerische Zeitschrift für Hydrologie-Swiss Journal of Hydrology 43: 34-62.
STOYANOV P., I. TENEVA, R. MLADENOV & BELKINOVA D. 2016. Filamentous cyanoprokaryotes (Cyanoprokaryota/ Cyanobacteria) in standing waters of Bulgaria: diversity and ecology. – Journal of BioScience and Biotechnology 5 (1): 19-28.
STOYNEVA M. P. 2016. Allochthonous planktonic algae recorded during the last 25 years in Bulgaria and their possible dispersal agents. - Hydrobiologia 764: 53–64.
STOYNEVA-GÄRTNER M. P., DESCY J. P., LATLI A., UZUNOV B. A., PAVLOVA V. T., BRATANOVA Z., BABICA P., MARŠÁLEK B., MERILUOTO J. & SPOOF L. 2017. Assessment of cyanoprokaryote blooms and of cyanotoxins in Bulgaria in a 15-years period (2000-2015). - Advances in Oceanography and Limnology 8 (1): 131-152.
STOYNEVA-GÄRTNER M. P., UZUNOV B.A. DESCY, J.-P. GÄRTNER G. DRAGANOVA P.H. BORISOVA C.I. PAVLOVA V. & MITREVA M. 2019. Pilot application of drone-observations and pigment marker detection by HPLC in the studies of Cyano HABs in Bulgarian inland waters. - Marine and Freshwater Research 71: 606–616.
STOYNEVA-GÄRTNER M., K. STEFANOVA J.P. DESCY B. UZUNOV M. RADKOVA V. PAVLOVA M. MITREVA & GÄRTNER G. 2021. *Microcystis aeruginosa* and *M. wesenbergii* were the primary planktonic microcystin producers in several Bulgarian water bodies (August 2019). - Applied Sciences (2076-3417) (11):1. 357-357.
STOYNEVA M. P. 2000. Planktic c green algae of Bulgarian coastal wetlands. - Hydrobiologia 438: 25–41.
STOYNEVA M. 2003. Steady-state phytoplankton assemblages in shallow Bulgarian

wetlands. - Hydrobiologia 502: 169-176.
Svirčev Z., Lalić D. Savić G. B. Tokodi N. Backovic D. D. Chen L. Meriluoto J. & Codd G. A. 2019. Global geographical and historical overview of cyanotoxin distribution and cyanobacterial poisonings. - Archives of Toxicology 93: 2429–2481.
Tasinov O. B., D. G. Vankova, N. F. Nazifova-Tasinova, M. G. Pasheva, Y. D. Kiselova, T. D. Sokrateva, D. L. Ivanov, B. A. Uzunov, M. P. Stoyneva-Gärtner & Ivanova D. G. 2020. Cytotoxicity of water from five Bulgarian wetlands contaminated by toxigenic cyanobacteria and cyanotoxins. - Bulgarian Chemical Communications 52, Special Issue D: 257-262.
Temniskova D. & Stoyneva M. 2011. Algology. Systematic Part. Volume 2. Pensoft, Sofia-Moscow, 513-1040 pp. (In Bulgarian).
Teneva I., D. Basheva T. Mladenova P. Stoyanov D. Belkinova & Mladenov R. 2018. Species composition and toxic potential of cyanobacteria in some Western Rhodopes Dams. - Ecologia Balkanica 10 (2): 11-121.
Teneva I., D. Belkinova I. Dimitrova-Dyulgerova & Mladenov R. 2009. Phytoplankton assemblages and monitoring of cyanotoxins in Trakiets Reservoir. - In: Scientific Researches of the Union of Scientists in Bulgaria - Plovdiv, series B. - Natural Sciences and the Humanities, 5- 6 November 2009, pp. 244-249.
Teneva I., Belkinova D. Dimitrova-Dyulgerova I. Vlaknova M. & Mladenov R. 2010. Composition and toxic potential of Cyanporokaryota in Vacha Dam (Bulgaria). - Biotechnology & Biotechnological Equipment 24/2010/SE, Second Balkan Conference on Biology, Special Edition/On-line 50 years University of Plovdiv, Plovdiv: 26–32.
Vasconcelos V. M. & Pereira E. 2001. Cyanobacteria diversity and toxicity in a wastewater treatment plant (Portugal). - Water Research 35 (5): 1354-1357.

Received 23rd April 2021
Accepted 9th June 2021