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Studies on cyanoprokaryotes of the water bodies along the Bulgarian Black Sea Coast (1890-2017): a review, with special reference to new, rare and harmful taxa

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Abstract: The report presents a review of the studies on cyanoprokaryotes from Bulgarian coastal wetlands carried out in the period 1890-2017. The biodiversity of cyanoprokaryotes in coastal water basins (their phytoplankton and phytobenthos) was evaluated and analyzed by wetlands types with emphasis on the new and peculiar taxa described. The conservation status of the recorded species follows the Red List of Bulgarian microalgae. Special attention is paid to the occurrence of cyanoblooms, cyanotoxins and toxic species, as well as to the invasive and alien species.

Key words: biodiversity, harmful blooms, invasive species, new species, threatened species, toxic algae

Introduction

The peculiar prokaryotes named Cyanoprokaryota (Cyanobacteria, Cyanophyta or Blue-green algae) are the only nitrogen-fixing organisms which produce also oxygen through photosynthesis. Highly recognized before for their great potential as providers of ecosystem services, during the last decades they got a lot of negation due to their potential toxicity, keystone role in many harmful blooms and general assuming hazardous for human and ecosystem health (Meriluoto et al. 2017, Stoyneva-Gärtner et al. 2017 and references therein). Therefore, the knowledge on these organisms in coastal wetlands, which are of outsized importance to human welfare due to their high productivity and great potential for commercial activity (MEA 2005), but are also amongst the most threatened of the world's main habitat types (Ramsar Guidelines… 2006), is of primary importance.

This is especially valid of the Bulgarian coastal physico-geographical region for two reasons: 1) it is connected with the very peculiar Black Sea (featured by lack of real tides, low halinity levels of 16-18‰ and significant anoxic layer well below the surface waters); 2) it is a part of Bulgaria – a Balkan country, well-known for its rich biodiversity with many species and habitats of high conservation significance (Peev 2015). Therefore, the aim of the present paper is to evaluate the degree of knowledge on cyanoprokaryote biodiversity, abundance and harmful blooms in the lotic and non-lotic water bodies along the Bulgarian Black Sea coast.

Material and methods

The study covers the Bulgarian Black Sea coastal region, which is 378 km in length (starting from the cape Sivriburun on the Romanian border at the North and finishing on the mouth of Rezovska reka on the border with Republic of Turkey on the South) and is 10 to 40-50 km wide, as it is defined in Stoyneva & Michev (2007) by the border of breeze'

influence. The paper aims on outlining the knowledge on cyanoprokaryotes on the background of the general algal biodiversity in Bulgarian coastal water bodies, analysed in Dimitrova et al. (2018). Therefore, it follows the general structural model of the cited paper, as well as all the methods described there in detail with wetlands identification number and conservation status taken from Michev & Stoyneva (2007). The terminology related with alien and invasive species follows Kokocinski et al. (2017). The abbreviations used are: **CP** – cyanoprokaryote, **CPs** – cyanoprokaryotes, **WBs** – water bodies and **RLBMiA** for the Red List of Bulgarian microalgae (Stoyneva-Gärtner et al. 2016), **EX** – extinct, **CR** – critically endangered, **VU** – vulnerable and **EN** – endangered water body.

Results

I. CP data on lotic water bodies

I.1. CP data on coastal rivulets and streams

Petkoff (1919), Valkanov (1935), Mihailova-Neikova (1961), Vodeničarov (1962) and Kirjakov (1985) published ten CPs from Dyavolska reka, Fakiyska reka, Provadiyska reka, Reka Izvorska, Reka Mladezhka and Veleka, and from the "mouths of coastal rivers" as well. They comprise 17% of all 58 algae known from the coastal rivulets. Valkanov (1935) observed "blue coloration" of Provadiyska reka during abundant development of *Chroococcus* sp., which remained for years the only "quantitative" information on the group. The later quantitative data on Ropotamo showed that CPs comprised < 20% of the average phytoplankton numbers and <1% of the biomass (Stoyneva 2003, Pavlova et al. 2007).

I.2. CP data on coastal canals

The new taxon *Oscillatoria geminata* f. *subsalsa,* described by Petkoff (1943) from the canal of Varnensko ezero, was the single CP reported from the total of 16 taxa found in the coastal canals (i.e. only 0.06% of their algal diversity).

I.3. CP data on cold-water springs

Petkoff (1938) published *Phormidium irriguum* (Kütz. ex Gom.) Anagn. et Kom. and *Microcoleus autumnalis* (Gom.) Strun., Kom. et Joh. from the karst spring complex Devnenski izvori, and Lepsi (1926) reported *Oscillatoria* spp. from the springs of Kavarna. These three CPs comprised 10% of all algae known from these coastal WBs.

II. CP studies in lentic and other non-lotic water bodies

II.1. CP studies in coastal lakes and tuzlas

Data on recent CPs of nine coastal lakes, namely Durankulak (IBW0216, CR), Shablensko Ezero (IBW0219, CR), Ezeretsko ezero (IBW0233, CR), Varnensko ezero (IBW0203, CR), Beloslavsko ezero (IBW0227, CR), Pomoriysko ezero (IBW8614, VU), Ezero Vaya (IBW0191, CR), Ezero Uzungeren (IBW0710, VU) and Mandrensko ezero (IBW0810) were given by Petkoff (1919, 1938, 1943), Valkanov (1935, 1936, 1937), Markoff (1935, 1939), Stundl (1937), Paspalew (1943), Cvetkov (1955, 1962), Sashev & Angelov (1959), Mihailova-Neikova (1961), Vodeničarov (1962), Ivanov et al. (1964), Petrova (1961, 1967, 1968a, b), Tsvetkov (1958), Vodenitscharow (1964), Vodenicharov et al. (1971), Petrova-Karadjova (1974, 1975), Valkanov et al. (1978), Naidenov (1981, 1998), Saiz (1981), Moncheva (1991), Chipev & Vassilev (1994), Vassilev et al. (1998, 2015), Beshkova (1998), Kirichova et al. (1998), Stoyneva (1998a, b, 2000a, b, 2002, 2003, 2008, 2010, 2014, 2015), Belkinova et al. (2003, 2014), Mladenov et al. (2003), Pavlova et al. (2006, 2007, 2013a, b, 2014, 2015), Cheshmedjiev et al. (2010), Dimitrova et al. (2014a, b), Stoyanov (2014), Stoyneva et al. (2015), Stoyanov et al. (2013, 2016), Stoyneva-Gärtner et al. (2017). Some "lake" algae have been reported also from stomachs of different fishes (e.g. 4 from 18 taxa in Mihailova-Neikova 1961). In total, more than 115 CPs were found in the lakes, i.e. they represented about 30% of their algal diversity. Varnensko ezero was the second locality of the newly described *Oscillatoria geminata* f. *subsalsa* (Petkoff 1943). Amongst the algae found, two were of conservational importance: *Cyanobacterium diachloros* (Skuja) Kom., Kop. et Cep. and *Oscillatoria annae* Van Goor. They were included in the RLBMiA and comprised 6% of all threatened taxa found in the lakes.

Quantitative data on lake phytoplankton and its structural parameters were scarce (e.g. Saiz 1981, Vassilev 1994, Beshkova 1998, Chipev & Vassilev 1994, Vassilev et al. 1998, Stoyneva 1997, 2002, Dimitrova et al. 2014a). The few comparative data show the multiple increase of phytoplankton numbers and biomass with raised role of CPs (Petrova 1967, 1968b, Petrova-Karadjova 1974, Beshkova 1998, Stoyneva 2000, 2002, Dimitrova et al. 2014a, b, Stoyneva-Gärtner et al. 2017), which indicates the negative trends in the development of the shallow coastal lakes, most of which are threatened (for details see Dimitrova et al., 2018).

Tuzlas are peculiar natural hyperhaline coastal lowland WBs situated on the Black Sea shore. After

the transformation of Pomoriyska tuzla (IBW8613, EX), Bulgaria has only three such WBs: Shablenska tuzla (IBW0218, EN), Nanevska tuzla (IBW0217, EN) and Balchishka tuzla (IBW0213, EN). Petkoff (1919, 1943), Ivanov et al. (1964), Draganov et al. (1984), Stoyneva (2003) and Kožuharov et al. (2001) reported 21 CPs, which represented 66% of the algal biodiversity in these WBs.

II.2. CP studies of the coastal swamps

Only *Anabaena oscillarioides* Bory ex Born. et Flah. was recorded by Petkoff (1919) in the swamp complex Blata do Kazul-Kyoy (IBW5367). This single CP represented 3% of the total algal diversity of coastal plateau and mountain swamps.

Data on the CPs of 11 coastal lowland swamps and swamp complexes, namely Alepu (IBW0177, CR), Arkutino (IBW0187, EN), Blata do Topola (IBW0214), Blato Punchevo (IBW0880), Blato Stomoplu (IBW0186, CR), Blattse do Tzarevo (IBW4540), Chengene-Skele (IBW0715, VU), Poda (IBW0193), Orlovo Blato (IBW0242, EN), Sindelsko-Sultanlarsko Blato (IBW0195, EX) and Velyov Vir (IBW0711) were provided by Petkoff (1907, 1919, 1938), Vodeničarov (1962), Vodenitscharow (1964), Naidenow (1967), Kiriakov (1974, 1981), Stoyneva (2000, 2002, 2003, 2014, 2015), Pavlova et al. (2007), Stoyanov (2014), Stoyneva et al. (2015), Stoyanov et al. (2016), Stoyneva-Gärtner et al. (2017). These works contain data on about 90 CPs (i.e. 33% of their algal diversity), with one new taxon described by Petkoff (1938) - *Lyngbya contorta f. duplo-latior.*

II.3. CP studies of the coastal river effluents

Data on CPs from the effluents of the small coastal rivers Ropotamo and Veleka have been published by Petkoff (1907, 1931) and Vodenicharov et al. (1971). Amongst the 45 algae found, five were CPs. *Aphanocapsa rivularis* f. *major* described by Petkoff (1931) and *Aphanocapsa testacea* (A.Br. ex Kütz.) Näg. were included in the RLBMiA.

II.4. CP studies of coastal fountains and watermills and their outfalls

Two CPs (*Phormidium subfuscum* var. *joaninum* Gom., *Microcoleus autumnalis*) were found by Petkoff (1919) in a fountain and a watermill with their outfalls in the region of Kavarna. The new taxon *Phormidium favosum* f. *tenuior* was described by Petkoff (1943) on the basis of material brought by A. Valkanov from a coastal fountain, for which no additional description was provided. CPs comprised 25% of the total algal diversity in these WBs.

II.5. CP studies in the salines

Data on CPs from five costal salt-productive complexes - Burgaski solnitsi (IBW8804), Solnitsi nad Gelareto (IBW0551, EX), Starite solnitsi nad Balchik (IBW0213, EX), Pomoriyski solnitsi (IBW8805) and Sozopolski solnitsi (IBW8145, EX) and on the effluents below the stone-salt productive factory of Provadia were given by Petkoff (1919, 1943), Caspers (1952), Komárek (1956), Ivanov et al. (1964), Vodenitscharow (1964), Vodenicharov et al. (1971), Temniskova-Topalova (1977), Vassilev (1994), Stoyneva (1997, 2003, 2010, 2014, 2015), Chipev & Vassilev (1994), Pavlova et al. (1998), Vassilev et al. (1998), Pavlova et al. (2007), Stoyanov (2014), Stoyneva et al. (2015), Stoyanov et al. (2016), Stoyneva-Gärtner et al. (2017). Data on four CP species from the extinct Sozopolski solnitsi, Balchishki solnitsi and Solnitsi nad Gelareto were provided by Petkoff (1919, 1943): *Lyngbya confervoides* Ag. ex Gom., *Coleofasciculus chthonoplastes* (Thur. ex Gom.) Sieg., Johans. et Friedl, *Phormidium thwaitesii* Umez. et Watan. and *Spirulina subsalsa* Oerst. ex Gom. *L. confervoides* developed in masses on the bottom of Pomoriyski solnitsi and in combination with *C. chtonoplastes* in Sozopolski solnitsi (Petkoff 1919). More recently about 20 CPs were documented for the saltworks of Burgaski solnitsi and Pomoriyski solnitsi with quantitative data and structural parameters of their phytoplankton communities (Vassilev 1994, Chipev & Vassilev 1994, Stoyneva 1997, 2010, Pavlova et al. 1998, Vassilev et al. 1998). *Phormidium bulgaricum* (Kom.) Anagn. et Kom. was described by Komárek (1956) from the canals of the complex wetland Atanasovsko ezero. Afterwards it was reported from more sites of Bulgarian Black Sea coast (Chipev & Vassilev 1994, Vassilev et al. 1998, Dimitrova et al. 2014b, Stoyanov 2014, Stoyneva 2014, Stoyanov et al. 2016) and included in the RLBMiA..

In the effluents of stone-salt factory of Provadiya Petkoff (1938) found abundant development of *Kamptonema laetivirens* (H. Crouan et P. Crouan ex Gom.) Strun., Kom. et Smarda and discovered a special form of *Oscillatoria tenuis* f. *tergestina* (Rabenh. ex Gom.) Elenk. without outlining it as a new taxon.

II.6. CP studies in the coastal lowland reservoirs and microreservoirs

Data on CPs from the coastal lowland reservoirs and microreservoirs Aheloy (IBW3032), Mandra (IBW1720, EN), Poroy (IBW3038), Studena voda (IBW2883) and Yasna polyana (IBW2887) were given by Petrova (1967, 1968a, b), Petrova-Karadjova

(1974), Ivanov et al. (1980), Kirjakov (1985), Moneva & Vodenicharov (1988), Pavlova et al. (2006, 2007, 2013), Cheshmedjiev et al. (2010), Stoyanov et al. (2013, 2016), Belkinova et al. (2014), Stoyanov (2014), Stoyneva et al. (2015), Stoyneva-Gärtner et al. (2017). There ca. 50 CPs were found, which comprised 25% of the algal diversity of the reservoirs.

Petrova (1968b), Petrova-Karadjova (1974) and Ivanov et al. (1980) evaluated the seasonal phytoplankton dynamics (expressed in cell numbers) in the reservoir Mandra in the periods 1964-1966, 1967-1970 and 1964-1967.

II.7. CP studies in coastal park lakes

Vodeničarov (1962) found *Microcystis pulverea* f. *irregularis* (Peters.) Elenk. and *Aphanothece stagnina* (Spreng.) A. Br. in the small garden lakes of the Balchik Palace. These two CPs comprised 70% of the algal flora of coastal park lakes.

II.8. CP studies in industrial water bodies

In the water collectors and in the plankton of purification WBs of the refinery Neftochim-Burgas of the Poda region Simeonov (1980, 1985) and Kirjakov (1998) recorded 71 algae, 11 of which (i.e. 15%) were CPs, mostly non-heterocytous filamentous species.

II.9. CP studies in coastal temporary pools and puddles

Petkoff (1919, 1938), Temniskova-Topalova (1977), Starmach (1969) and Kiriakov (1974) reported 13 CP taxa from small coastal temporary pools with fresh, brackish or even "salty" water. This comprises 12% of the algal flora of these WBs. Starmach (1969) denoted the community of CPs in the sea-side pools in Bulgaria as *Lyngbyetum aestuarii diatomosum*. The similar co-existence of CPs and diatoms was noted by Petkoff (1919) for the sand pools below Primorsko with mass development of *Merismopedia* species.

II.10. CP studies in coastal lithotelms

Draganov et al. (1984) and Georgiev et al. (1985) published 28 CPs found in the coastal lithotelms, most of which with mixohaline waters. This comprised 77% of all 36 taxa reported for these small WBs. Amongst them was *Gloeocapsopsis crepidinum* (Thur.) Geitl. ex Kom. from the RLBMiA.

III. Comparative CP studies in different types of coastal water bodies

Petrova (1968a, b) and Petrova-Karadjova (1974) made comparisons between the phytoplankton composition and dynamics of different coastal bodies of fish importance with noting the role of CPs. Stoyneva (2000, 2003) and Pavlova et al. (2007) provided data on purposive comparative studies of the role of different algal groups in diverse coastal WBs with outlining the significance of CPs and documentation of rare steady-state assemblages with participation of CPs as keystone species in the shallow coastal lake Vaya. More recently, Stoyneva-Gärtner et al. (2017) showed the problems related with increased CP amounts on the background of the total algal abundance and cyanotoxins as serious risk factors for human and ecosystem health. Stoyneva (2015) proved the taxonomic richness of the algae (incl. CPs) along the Bulgarian Black Sea coast in relation with the important bird migration route *Via Pontica* (Michev et al. 2012). She described different vectors for algal distribution (incl. water birds as notable transporting agents for CPs and other algae with mucilage sheaths) with a special attention to the spread of both invasive and alien CPs in the coastal wetlands. The exotic CPs like *Anabaena attenuata* Kiss., *Anabaenopsis knipowitschii* (Usach.) Kom., *A. nadsonii* Woron., *A. cunningtonii* Tayl., *Nodularia spumigena* f. *littorea* (Kütz.) Elenk., *Planktolyngbya circumcreta* (G. S. West) Anagn. et Kom., *P. undulata* Kom. et Kling, *Pseudanabaena papillaterminata* (Kiss.) Kukk, *Raphidiopsis curvata* Fr. et Rich, *Woronichinia fremyi* (Kom.) Kom. et Hind., etc. occurred in single specimens or in very low amounts and never caused water blooms, most probably due to the significant differences in the morphometry and chemical features of the Bulgarian coastal WBs with the African and Asian lakes, from which most of them originated (op. cit.). By contrast, the invaders like *Cylindrospermopsis raciborskii* (Wol.) Seen. et Subba Raju, the debatable *Raphidiopsis mediterranea* Skuja and *Microcystis wesenbergii* (Kom.) Kom. developed and produced blooms in stressed and frequently disturbed WBs (op. cit.). The analysis of CP studies, published during the last 15 years even revealed *C. raciborskii* as the second species with widest distribution in the country (Stoyneva-Gärtner et al. 2017).

IV. Newly described taxa, general data and checklists of CPs from different coastal water bodies without their exact indication

Petkoff (1906, 1919) mentioned *Anabaena oscillarioides* Bory ex Born. et Flah. and *Oscillatoria princeps* Vauch. ex Gom. from the Black Sea coastal region without detailed description of the localities. Vodeničarov (1962) noted the frequent summer development of *Nodularia harveyana* Thur. ex

Born. et Flah. and *N. spumigena* Mert. ex Born. et Flah. in "coastal swamps, lakes, river mouths with brackish or freshwater". The Flora of Bulgarian algae (Vodenicharov et al. 1971) also contains general broad information on 58 CPs amongst 132 algae widely, or frequently distributed along the coastal line, for most of which the occurrence in standing (fresh or brackish) waters is pointed. Only *Merismopedia affixa* Richt. and *M. mediterranea* Näg. were included in the RLBMiA.

V. Studies of CP blooms, toxic CPs and cyanotoxins in different coastal water bodies

The occurrence of toxic blooms in Bulgarian coastal lakes was firstly linked with the haptophyte *Prymnesium parvum* Cart. (for details see Dimitrova et al., 2018). Concerning CPs, much earlier Petkoff (1919) outlined the abundance of *Dolichospermum flos-aquae* (Bréb. ex Born. et Flah.) Wackl., Hoffm. et Kom. in Beloslavsko ezero vs. its rarity in Durankulak. Valkanov (1936) described the yellow colour of the Vaya waters in summer during six consecutive years (1930-1936), caused by mass development of *Nodularia spumigena.* However, the regular occurrence of summer strong and long-lasting cyanophycean blooms was outlined as a typical event for some of coastal lakes only in the middle of the last century (e.g. Cvetkov 1955, Tsvetkov 1958). Summarising the studies on Mandrensko ezero, Mihailova-Neikova (1961: 122) wrote that despite that phytoplankton "is not very rich", "as far as quantity is concerned, blue-green algae prevailed" with *Anabaenopsis arnoldii* Apt. amongst the mass forms (dominants). Petrova (1961) paid special attention to the first recorded bloom of this species in Varnensko ezero in September 1952 (12,97‰ halinity) but noted that the alga occurred earlier (August 1946) in the lake in smaller amounts and then appeared again in August 1954. Petrova (1967) was the first who discussed toxic phytoplankton with a special attention to cyanoprokaryotes blooms and their potential harmful effect on fish production in our coastal lakes. Petrova (1968a) and Petrova-Karadjova (1975) described the strong bloom of *A. arnoldii* in Vaya with a mortality of *Cyprinus carpio, Mugil cephalus* and *Sander lucioperca* in 1962. At that time, cyanotoxin investigations were not carried out, but according to the authors the strongest fish-kills coincided with the spots of the highest algal concentrations. Petrova (1968a) predicted the future permanent mass development of this species in Vaya and its eventual role as a causative agent of fish losses. However, it was not detected in the "toxic" samples from Bulgarian WBs collected in the period 2000-2015 (Stoyneva-Gärtner et al. 2017) and recent summaries on cyanotoxins also do not include it as a toxin-producing alga (Meriluoto et al. 2017). According to Sashev & Angelov (1959), the summer fish kills in extremely shallow (50-60 cm) Vaya waters with temperatures of 25-30 °C, were due to lack of oxygen. In 1966, *A. arnoldii* was found as strongly blooming in Vaya, while in the other coastal lakes (Beloslavsko ezero, Shablensko ezero and Durankulak) its development was not abundant (Petrova 1967). From Vaya Petrova-Karadjova (1974) reported also on *Aphanizomenon flos-aquae* Ralfs ex Born. et Flah. bloom in 1967, *Microcystis aeruginosa* (Kütz.) Kütz. bloom in 1968 and a mass development of both species in 1969. In the eu-hypertrophic lake Vaya Stoyneva (2003) registered CP blooms with a two weeks period of dominance without biomass change of *Microcystis wesenbergii*, *Aphanizomenon gracile* Lemm. and *Dolichospermum spiroides* (Kleb.) Wackl., Hoffm. et Kom. in August–September 2001, three weeks dominance of *M. wesenbergii, Aph. flos-aquae* and *D. spiroides* in August–September 2001 and a four weeks dominance of *M. wesenbergii* and *A. gracile* in August–September 2002. In the same lake Pavlova (2007) and Pavlova et al. (2006, 2007) detected microcystins, which were on conformity with finding of representatives of toxic genera *Microcystis, Aphanizomenon*, etc., confirmed later by Dimitrova et al. (2014a). Dimitrova et al. (2014b) noted the main role of CPs in forming of total phytoplankton biomass of Vaya with strong peaks in summer periods of 2004-2006, with *Planktothrix agardhii* (Gom.) Anagn. et Kom. as most frequently occurring species. Petrova-Karadjova (1975) indicated blooms of *Microcystis aeruginosa* and *Aphanizomenon flos-aquae* as a common feature of the lakes Vaya, Mandra and Durankulak. Dimitrova et al. (2014a) noted *Dolichospermum affine* (Lemm.) Wackl., Hoffm. et Kom., *Anabaenopsis elenkini* Mill., *Microcystis aeruginosa, M. flos-aquae* (Wittr.) Kirchn., *M. viridis* (A. Br.) Lemm. and *M. wesenbergii* amongst the 30 common species in the algal flora of Vaya, Shabla, Ezerets, and Durankulak. The significance of CPs in both phytoplankton abundance and composition in these WBs with high trophicity in 90s of 20th century was described in detail by Stoyneva (2000, 2002). Before these works, the eutrophic character of Durankulak with long-lasting CP blooms (incl. *M. aeruginosa*, *Pseudanabaena mucicola* (Naum. et Hub.-Pest.) Schw., *Aph. flos-aquae, D. spiroides* and *Anabaena contorta* Bachm.) was outlined by Naidenov (1981) and Saiz (1981). The last author reported on a

single bloom of *Dolichospermum scheremetieviae* (Elenk.) Wackl., Hoffm. et Kom. in the summer of 1978 vs. *Aph. flos-aquae*, which bloomed "every year". Cheshmedjiev et al. (2010) and Belkinova et al. (2014) reported "second degree" bloom of *M. aeruginosa* (2.65 mg l^{-1}) in 2009. Beshkova (1998) and Naidenow (1998) noted summer-autumn abundance (1992-1994) of *M. aeruginosa* in the lake Shabla. Shabla and Durankulak were the two other coastal lakes (in addition to Vaya) in which the presence of microcystins LR, LA, RR, YR and similar to YR-type was proved by High Performance Liguid Chromatography – HPLC (HPLC-DAD and/or HPLC-MS) and enzyme-linked immunosorbent assay - ELISA (for details see Stoyneva-Gartner et al. 2017). In all these lakes toxic CPs were detected, incl. the invasive CPs discussed above (for details see Stoyneva 2015, Kokocinski et al. 2017, Stoyneva-Gartner et al. 2017).

During the last century CP blooms were not registered in Varnensko ezero (Petrova 1961, Moncheva 1991), only Paspalew (1943) noted the most abundant development of the group with prevalence over diatoms and other algal groups in spring (April). There is no recent evidence for occurrence of harmful cyanoblooms in this large coastal lake with a strong connection with the Black Sea (Stoyneva-Gärtner et al. 2017).

The only data on a positive effect of mass *Microcystis* development in coastal lakes were given by Cvetkov (1962): the colonies which sank to the muddy bottom, served as a good nutritional basis for the larvae of *Pelopia,* in which they comprised >50% of the ingested food.

First data on CP blooms in the reservoirs could be found in Petrova (1968b), Petrova-Karadjova (1974) and Ivanov et al. (1980). The last two works outlined the summer CP blooms of *Aphanizomenon flos-aquae* and *Microcystis aeruginosa* in the reservoir Mandra (which was built on the basis of the former coastal lake Mandrensko ezero). The summer CP bloom in 1967 was interrupted through opening of the reservoir gateways to the Black Sea, preventing the potential harm on fishes (Petrova-Karadjova 1974). Petrova (1968b) mentioned a problem in the heating power station of the Chemical factory of Burgas caused by the strong summer cyanobloom in the reservoir Mandra. Later Ivanov et al. (1980) pointed on the general increase of algal abundance after 1972 with blooms of *A. flos-aquae* and *M. aeruginosa* and Moneva & Vodenicharov (1988) noted the blooms of *Anabaenopsis arnoldii* and *Arthrospira* af. *platensis* in the summer period of 1988. The assessment of Stoyneva-Gärtner et al. (2017) showed that toxic species and blooms were detected in the reservoirs Aheloy, Mandra and Poroy, microcystins were found in Mandra, while their purposive sampling in Yasna polyana showed negative results in accordance with the earlier predicted lack of strong cyanoprokaryote blooms in Yasna polyana (Angelov 1968).

In relation to blooms and toxic species distribution, a multivariate analysis on a dataset from 61 chosen WBs (incl. 10 coastal WBs) was run to outline the role of environmental gradients on the spread of CPs. The redundancy analysis outlined clearly the speciality of the group of coastal lakes with a core of CP genera well known for their ability to form water blooms due to presence of gas vesicles, like *Microcystis*, *Anabaena* s.l. (mainly *Dolichospermum*), *Aphanizomenon* s.l., *Cylindrospermopsis* and *Planktothrix,* and of the group of high-coductivity saltworks with the core of smallest coccal non-blooming and non-toxic CPs (Stoyneva-Gärtner et al. 2017). Total phytoplankton biomass, total CP biomass, as well as CP assemblages showed a strong response to the environmental variables, with an expected major influence of total phosphorus (op. cit.). Earlier, the PCA analyses conducted on a group of 19 chosen WBs from the country (incl. 6 coastal WBs) showed clear separation of WBs according to environmental variables (with grouping of shallow eutropic WBs, incl. all coastal WBs) with responses of phytoplankton groups according to their general ecological preferences, where a conspicuous relation of CP biomass with the increase of the total phosphorus concentration, pH and chlorophyll a was detected (Stoyneva et al. 2015). The last work provided conclusions from careful checking of the indices and parameters with their weighted values, used in the Bulgarian legislation documents with special attention to the "percentage representation of CPs". It was underlined that, when estimated according to the Water Framework Directive (Annex V), this index influences and often distorts the final result due to the fact that it is generally lower in comparison with the realistic situation and does not take into account many exotic and invasive species (e.g. *C. raciborskii, R. mediterranea*), which were detected as forming 'blooms' in some of our WBs (op. cit.).

Data on CP blooms in coastal fish ponds are extremely scarce. Petrova-Karadjova (1974) and Ivanov et al. (1980) mentioned briefly a harmful *Microcystis*-bloom with a strong fish kill of *Cyprinus carpio* with significant economic damages, which happened in the summer of 1978 in the State

fishery near Dolno Ezerovo (IBW0868). According to these authors the bloom appeared after a technical accident, which led to the "invading" of blooming water from the reservoir Mandra. This information needs an additional checking since these fishponds are situated on the western coast of the lake Vaya.

Discussion

In total, 80 works issued in the period 1890-2017 contain information on CPs from more than 90 different lotic and non-lotic WBs situated along the Bulgarian Black Sea Coast, which comprises 48% of the 168 algological works aimed on the coastal region (Dimitrova et al., 2018). In agreement with the conclusions on the general algal biodiversity in Bulgarian coastal WBs (op.cit.), it has to be outlined that because all the studies analyzed were quite different in aims, details and sampling design and because during the last century most of the coastal WBs underwent serious changes of their hydrological regime, the credible comparisons of the species composition and abundance are extremely difficult, if possible at all. But, despite of the unsufficient character of many data, it is possible generally to conclude that coastal Bulgarian WBs contain rich CP flora (ca. 330 taxa), from which with 3 forms were described as new for science, one form was noted as having significant peculiarities and eight threatened CPs were included in the RLBMiA.

However, most of the works issued during the period 1890-2017 were in Bulgarian language (47) and were published in local journals or conference proceedings, which make them quite invisible for the world scientific community. Therefore, this review can serve as a good starting point for designing future studies, in which all the accumulated data could be used as a comparative basis and as a useful tool for biomonitoring and restoration of our coastal wetlands. This is of outsized importance taking into account both their threatened status of generally extremely vulnerable shallow WBs and detected negative trends of the increasing role of CPs in algal communities with development of toxic and invasive species, which are serious risk factors for the human and ecosystem health in Bulgaria.

References

Angelov A. 1968. Prognose für die Entwicklung Biologischer Prozesse beim Neuprojektierten Stausee "Jasna Poljana" – Bezirk Burgas. Godishnik na Sofiyskiya univeristet, BF, Kniga 1 – Zoologiya, fiziologiya I biohimiya na zhivotnite 61: 73-80. (In Bulgarian)

Belkinova D., Mladenov R. & Kirjakov I. 2003. Species composition of the phytoplankton in the Mandra Dam. Nauchni Trudove na Suyuza na uchenite (Plovdiv) 3: 81-88. (In Bulgarian)

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

Beshkova M. 1998. Phytoplankton of the coastal lakes Shabla and Ezerets (Northeastern Bulgaria) during the period 1992-1994. In: Golemansky V. V. & Naidenov W. T. (Eds): Biodiversity of Shabla lake system. Sofia: "Prof. Marin Drinov" Acad. Publ. House, pp. 25-38.

Caspers H. 1952. Untersuchungen über die Tierwelt von Meeressalinen an der bulgarischen Küste des Schwarzen Meeres. Zoologischer Anzeiger 148: 243-259.

Cheshmedjiev S., Belkinova D., Mladenov R., Dimitrova-Dyulgerova I. & Gecheva G. 2010. Phytoplankton based assessment of the ecological status and ecological potential of lake types in Bulgaria. Biotechnology and Biotechnological Equipment SE 24: 14-25.

Chipev N. & Vassilev V. 1994. Structural dynamics and production in phytoplankton assemblages from Lake Pomorie. In: Black Sea'94 International Conference, 12-17 September 1994, Riviera Holiday Club, Varna, Bulgaria, pp. 85-88.

Cvetkov L. 1955. Die Chironomidenfauna der Bulgarischen Schwarzmeerseen. Izvestiya na Zoologicheskiya institut s Muzey – BAN 4/5: 215-249. (In Bulgarian)

Cvetkov L. 1962. Sur la prolifération quantitative des Chironomides et la productivité des bassins de pisciculture. Izvestiya na Zoologicheskiya institut s Muzey – BAN 12: 172-196. (In Bulgarian).

Dimitrova R. E., Nenova E. P., Uzunov B. A., Shihiniova M. D. & Stoyneva M. P. 2014a. Phytoplankton abundance and structural parameters of the critically endangered protected area Vaya Lake (Bulgaria). Biotechnology & Biotechnological Equipment 28 (5): 871-877.

Dimitrova R. E., Nenova E. P., Uzunov B. A., Shihiniova M. D. & Stoyneva M. P. 2014b. Phytoplankton composition of Vaya Lake (2004-2006). Bulgarian Journal of Agricultural Science, Supplement 1: 165-172.

Dimitrova P. H., Stoyneva-Gärtner M. P., Uzunov B. A. & Gärtner G. 2018. Review of the algological studies of Black Sea coastal water bodies with special reference to the newly described and threatened species. Acta Zoologica Bulgarica, Supplement 11: 27-42.

Draganov S. J., Georgiev B. B., Mileva E. K. & Georgieva I. L. 1984. Blue-green algae of the Northern and Central Parts of the Bulgarian Black Sea Coast. Hidrobiologiya 20: 51-64. (In Russian).

Georgiev B. B., Georgieva I. L. & Draganov S. J. 1985. Algal benthos in Sozopol Aquatoria I. Hidrobiologiya 20: 51-64. (In Bulgarian).

Guidelines for the rapid ecological assessment of biodiversity in inland water, coastal and marine areas 2006. Gland, Switzerland: Ramsar Technical Report 1: 1-55.

Ivanov K., Rozhdestvenski A., Sotirov B. & Vodenicharov D. 1964. The Lakes in Bulgaria. Trudove na Instituta po

hidrologiya i meteorologiya 16: 1-241. (In Bulgarian)

Ivanov L., Rojdestvenski A., Marinov T., Petrova-Karadjova V., Kounsulov A. & Mitev S. 1980. On the hydrochemical conditions, nutritive base and fish stocks in Mandra Dam. Izvestiya na Instituta po ribni resoursi - Varna 18: 9-70. (In Bulgarian)

Kiriakov I. 1974. Beitrag zur Algenflora Bulgariens. III. Nauchni trudove Plovdivski universitet "Paisiy Hilendarski" 12 (4): 23-30. (In Bulgarian)

Kiriakov I. 1981. A contribution to the algal flora of Bulgaria. IV. Nauchni trudove Plovdivski universitet "Paysiy Hilendarski" 19 (4): 109-120. (In Bulgarian)

Kirichova J. R., Belkinova D. S. & Mladenov R. D. 1998. Investigations on the variability of *Anabaenopsis arnoldii* var. *indica* Ramanathan (1938) (Cyanobacteria). Plantarum 34 (6): 65-73.

Kirjakov I. 1998. Notes on the ecology and morphology of *Calycomonas pascheri* (Van Goor) Lund (Chrysophyta, Chromulinales). Nauchni trudove Plovdivski universitet "Paisiy Hilendarski" 34 (6): 5-12 (In Bulgarian).

Kirjakov I. K. 1985. Beitrag zur Algenflora Bulgariens. VII. Nauchni trudove Plovdivski universitet "Paisiy Hilendarski" 23 (1): 17-24 (In Bulgarian).

Kokociński M., Akçaalan R., Salmaso N., Stoyneva-Gärtner M. P. & Sukenik A. 2017. Expansion of alien and invasive cyanobacteria. In: Meriluoto J., Spoof L. & Codd J. (Eds): Handbook of Cyanobacterial Monitoring and Cyanotoxin Analysis. Chichester, West Sussex: John Wiley & Sons, Inc., pp. 28-40.

Komárek J. 1956. Some interesting blue-green algae from Bulgarian coast of Black Sea near Burgas. Acta Universitatis Carolinae Biologica 2 (1): 91-123. (In Russian)

Kožuharov D., Topalova J., Botev I., Stoichev S., Andreev S., Stoyneva M. & Vladimirov V. 2001. Anthropogenic effect on the successive changes in Balchishka Touzla: Hydrobiological Assessment. 3rd Black Sea International Conference ''Environmental Protection Technology for Coastal Areas', Varna, 6-8 June 2001, pp. 56-60.

Lepsi J. 1926. Über die Protozoenfauna einiger Quellen der Dobrudscha. Archiv für Hydrobiologie 17: 751-771.

Markoff V. N. 1935. Biochemische Prozesse bei der Moorbildung im Pomorie /Anchialo/ See. Godishnik na Sofiyskiya universitet, Meditsinski fakultet 14: 445-472. (In Bulgarian)

Markoff V. N. 1939. Biochemische Prozesse bei der Moorbildung im Pomorie (Anchialo) See. Zentralblatt für Bakteriologie 100: 277–288.

Meriluoto J., Spoof L. & Codd J. (Eds): Handbook of Cyanobacterial Monitoring and Cyanotoxin Analysis. Chichester, West Sussex: John Wiley & Sons, Inc. 548 p.

Michev T. M. & Stoyneva M. P. (Eds) 2007. Inventory of Bulgarian Wetlands and their Biodiversity. Part 1: Non-Lotic Wetlands. Sofia: Publ. House Elsi-M. 364 p. + CD supplement

Michev T. M., Profirov L. A., Karaivanov N. P. & Michev B. T. 2012. Migration of soaring birds over Bulgaria. Acta Zoologica Bulgarica 64 (1): 33–41.

Mihailova-Neikova M. 1961. Hydrobiological research of the Mandra Lake with regard to its importance as a fishing ground. Godishnik na Sofiyskiya universitet, BGGF, Kniga 1 – Biologiya (Zoologiya) 53: 57-123. (In Bulgarian)

MEA (Millennium Ecosystem Assessment) 2005. Ecosystems and Human Well-being: Synthesis. Washington, DC: Island Press. 155 p.

Mladenov R. D., Belkinova D. & Kirjakov I. 2003. Taxonomical diversity of the phytoplankton in the Mandra Lake. Trudove na Suyuza na uchenite (Plovdiv) 3: 89-95. (In Bulgarian)

Moncheva S. 1991. The phytoplankton of Varna Lake - A Syndrom of anthropogenic pollution. In: Sbornik Vtora nauchna konferentsiya 'Ratsionalno usvoyavane i zashtita na prirodnite resursi vuv Varnenskiya region', Varna, pp. 79-87. (In Bulgarian)

Moneva D. & Vodenicharov D. 1988. Bloom of the water in the Lake of Mandra caused by blue-green algae. In: Natsionalna nauchna sesiya na mladite nauchni rabotnitsi na tema 'Ekologiya I opazvane na prirodnata sreda', Plovdiv, 24-25.11.1988, pp. 26-28. (In Bulgarian)

Naidenov W. 1998. Struktur und Horizontalverteilung des Zooplanktons in zwei Küstenseen am Schwarzen Meer in Nordostbulgarien (Schabla-See und Ezerets-See). In: Golemansky V. V. & Naidenov W. T. (Eds): Biodiversity of Shabla Lake System. Sofia: Prof. Marin Drinov Academic Publ. House, pp. 51-68.

Naidenow W. 1967. Hydrobiologische Untersuchungen der Wasserbecken an der Südlichen Schwarzmeerküste und im Strandzha-Gebirge. I. Cladocera, Calanoida, Cyclopoida. Izvestiya na Zoologicheskiya institut s Muzey - BAN 24: 57-95. (In Bulgarian)

Naidenov W. T. 1981. Struktur und Dynamik des Zooplanktons aus dem See Durankulak. Hidrobiologiya 15: 63-73. (In Bulgarian)

Paspalew G. W. 1943. Beitrag zur Erforschung des Warna- Golfs und des Warna Sees. Sofiyski Uuniversitet, Trudove na Chernomorskata biologichna stantsiya 10-11: 141-144.

Pavlova P., Markova K., Tanev S. & Davis J. S. 1998. Observations on a solar saltworks near Burgas, Bulgaria. International Journal of Salt Lake Research 7: 357-368.

Pavlova V. 2007. Hygiene and Analytical Aspects of Microcystins Occurrence in Surface Water. Ph.D. Thesis. Sofia: National Center of Public Health Protection. 95 p. (In Bulgarian)

Pavlova V., Stoyneva M. & Bratanova Z. 2013a. Cyanoprokaryotes (Cyanobacteria) and cyanotoxins in some Bulgarian reservoirs. Journal of Balkan Ecology 16 (3): 257-260.

Pavlova V., Stoyneva M., Bratanova Z. & Karadjova I. 2013b. Cyanobacteria and cyanotoxins – health aspects and security requirements for the air transportation. In: Proceedings of the Scientific Conference "Actual problems of security", 16-18.10.2013, Vol. 8. Veliko Turnovo: Publishing Complex of NVU „Vasil Levski", pp. 96-100. (In Bulgarian)

Pavlova V., Babiča P., Todorova D., Bratanova Z. & Maršalek B. 2006. Contamination of some reservoirs and lakes in Republic of Bulgaria by microcystins. Acta Hydrochimica and Hydrobiologica 34: 437-441.

Pavlova V., Stoyneva M., Babica P., Kohoutek J. & Bratanova Z. 2007. Microcystins contamination and cyanoprokaryote blooms in some coastal Bulgarian wetlands. In: Conference Preprint Book, BULAQUA 2007, Sofia, June 2007, pp. 221-226.

Pavlova V., Stoyneva M., Georgieva V., Donchev D., Spoof L., Meriluoto J., Bratanova Z. & Karadjova I. 2014. New records of microcystins in some Bulgarian water bodies of health and conservational importance. Journal of Water Resources and Protection 6: 446-453.

Pavlova V., Stoyneva-Gärtner M., Uzunov B., Bratanova

Z., Lazarova A. & Karadjova I. 2015. Microcystins -LR, -YR and -RR in six Bulgarian water bodies of health and conservational importance (2012-2014). Journal of Water Resources and Protection 7: 1375-1386.

Peev D. (Ed.) 2015. Red Data Book of the Republic of Bulgaria. Vol. 1. Plants and Fungi. Sofia: BAS & MoEW. 881 p.

Petkoff S. 1906. Sur la flore algologique déau douce de Bulgarie. In: Wettstein R.v., J. Wiesner and A. Zahlbruckner (Hrsgs), Wissenschaftliche Ergebnisse des Internationalen Botanischen Kongressses Wien 1905. Jena: Verlag Von Gustav Fischer, pp. 354-369.

Petkoff S. 1907. Contribution to the flora of the southern nook of the Bulgarian Black Sea coast. Periodichesko spisanie na Bulgarskoto knizhovno druzhestvo v Sofia 48 (3-4): 191-216. (In Bulgarian)

Petkoff S. 1919. Materiaux pour la flore algologique du littoralbulgare de la Mer Noire. Spisanie na BAN 17: 25-134. (In Bulgarian)

Petkoff S. 1931. Note supplementaire a la flore algologique d'eau douce sur les côtes Bulgares de la Mer Noire. Izvestiya na Bulgarskoto botanichesko druzhestvo 4: 103-115.

Petkoff 1938. La flore aquatique et le dessechement de la plaine marecageuse entre le lac de Devna et le village de Soultanlar et leur importance pour celle-ci. Spisanie na BAN 57: 43-86. (In Bulgarian)

Petkoff S. 1943. Encore quelques especes d'Algues d'eau douce, marine et saumatre appartenant a la flore algologique des cotes bulgares de la mer Noire. Izvestiya na Bulgarskoto botanichesko druzhestvo 9: 52-56.

Petrova V. 1961. Le Phytoplankton du Lac de Varna. Izvestiya na Tsentralniya nauchnoizsledovatelski institut po ribovudstvo i ribolov – Varna, BAN 1: 183-219. (In Bulgarian)

Petrova V. 1967. Dynamique saisonniere et annuelle du phytoplancton dans les lacs du littoral bulgare ayant une importance economigue de peche. Izvestiya na Centralniya nauchnoizsledovatelski institut za ribno stopanstvo i okeanografiya – Varna, BAN 8: 131-154. (In Bulgarian)

Petrova V. 1968a. Distribution et floraison des cyanophycees *Anabaenopsis arnoldii* Apt. dans les lacs le long du littoral bulgare de la mer Noire. Izvestiya na Nauchnoizsledovatelskiya institut za ribno stopanstvo i okeanografiya – Varna 9: 85-88. (In Bulgarian)

Petrova V. 1968b. Phytoplankton as main trophic link in the Bulgarian coastal lakes with commercial fishing importance. Ribno stopanstvo 15 (4): 5-8. (In Bulgarian)

Petrova-Karadjova V. 1974. On the phytoplankton dynamics in Lake Burgas and in Mandra Dam. Izvestiya na Nauchnoizsledovatelskiya institut po okeanografiya i ribno stopanstvo – Varna 13: 35-49. (In Bulgarian)

Petrova-Karadjova V. 1975. Status of algological studies along the Bulgarian Black Sea coast. In: Jordanov D. (Ed.), Problems of Balkan flora and vegetation. Sofia: Izdatelstvo BAN, pp. 104-110. (In Russian)

Saiz D. 1981. Dynamik und Verteilung des Phytoplanktons im See Durankulak. Hidrobiologiya 15: 49-61. (In Russian)

Sashev G. & Angelov A. 1959. Untersuchungen über den Burgas-See (Waja) in Beziehung zur Verbesserung seiner Fischwirtschaftlichen Ausbeutung. Godishnik na Sofiyskiya universitet, BGGF, Kniga 1 – Biologiya 51: 161-210. (In Bulgarian)

Simeonov S. J. 1980. Dynamics of the flora and vegetation depending on the pollution and purification of the water body in the place 'Poda' - Burgas. PhD Thesis. 128 p. (In Bulgarian)

Simeonov S. J. 1985. Species composition of algae in the water collectors in the Poda Area, near Bourgas. Fitologija 29: 45-48. (In Bulgarian)

Starmach K. 1969. Algae of seaside pools near the mouth of the river Batova in Bulgaria. Fragmenta Floristica Geobotanica 15: 513-521.

Stoyanov P. S. 2014. Variability, taxonomy and ecology of some filamentous blue-green algae (Cyanoprokaryota). PhD Thesis. Plovdiv University "Paysiy Hilendarski", Faculty of Biology. 173 p. (In Bulgarian)

Stoyanov P., I. Teneva, R. Mladenov and D. Belkinova 2013. Diversity and ecology of the phytoplankton of filamentous blue-green algae (Cyanoprokaryota, Nostocales) in Bulgarian standing waters. Ecologia Balcanica 5 (2): 1-6.

Stoyanov P., Teneva I., Mladenov R. & 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. 1997. Survey on the phytoplankton of the wetland Atanasovsko lake (June - November 1995 and – September 1996). In: Michev T. (Ed.): Ecology and Conservation of Atanasovsko Lake Nature Reserve. Collection of Final Scientific Reports of Experts. Sofia: BSBCP, pp. 18-35.

Stoyneva M. 1998a. On the occurrence of teratological forms in some green chlorococcal algae of genera Scenedesmus, Pediastrum and Tetraedron in Bulgarian natural lowland wetlands. Algologija 8 (4): 351- 359.

Stoyneva M. 2002. Algological Studies of Bulgarian coastal wetlands. II. Quantitative structure of the phytoplankton of Durankulak and Shabla-Ezeretz lakes. Godishnik na Sofiyskiya universitet, BF, Kniga 2 – Botanika 92: 91-109.

Stoyneva M. 2010. Phytoplankton of the wetland Pomorie Lake. In: Radev R., Hiebaum G., Michev T. & Profirov L. (Comp.): Collection of Reports for the Integrated Management Plan for the Protected area Pomorie Lake BG0000152 and Protected area Pomorie BG0000620. Edition of "Zeleni Balkani", pp. 48-60. (In Bulgarian)

Stoyneva M. P. 2000. Algological studies of Bulgarian coastal wetlands. I. Species composition of the phytoplankton of Durankulak and Shabla-Ezeretz lakes. Godishnik na Sofiyskiya universitet, BF, Kniga 2 – Botanika 91: 27-48.

Stoyneva M. P. 2003. Steady-state phytoplankton assemblages in shallow Bulgarian wetlands. Hydrobiologia 502: 169-176.

Stoyneva M. P. 2014. Contribution to the studies of the biodiversity of hydro- and aerobiontic prokaryotic and eukaryotic algae in Bulgaria. DrSc Dissertation. Sofia: Sofia University "St. Kliment Ohridski". 825 p. (In Bulgarian).

Stoyneva M. P. 2015. Allochtonous planctonic algae recorded in Bulgaria during the last 25 years and their possible dispersal agents. Hydrobiologia 764: 53-64.

Stoyneva M. P. & Michev T. M. 2007. Wetlands, wetland types and the Bulgarian wetland classification. In: Michev T. M. & Stoyneva M. P. (Eds): Inventory of Bulgarian wetlands and their biodiversity. Part 1: Non-lotic wetlands. Sofia: Publishing House Elsi-M, pp. 17-43.

Stoyneva M. P., Traykov I. T., Tosheva A. G., Uzunov B. A., Zidarova R. P. & Descy J.-P. 2015. Comparison of ecological state/potential assessment of 19 Bulgarian water bodies based on macrophytes and phytoplankton (2011-2012). Biotechnology and Biotechnological Equipment

29 (1): 33-38.

Stoyneva-Gärtner M. P., Isheva Ts., Ivanov P., Uzunov B. A. & Dimitrova P. 2016. Red List of Bulgarian algae. II. Microalgae. Annual of Sofia University, Faculty of Biology, Book 2 – Botany 100: 15-55.

Stoyneva-Gärtner M. P., Descy J.-P., Latli A., Uzunov B., Pavlova V., Bratanova Zl., 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): DOI: 10.4081/aiol.2017.6320

Stundl K. 1937. Chemisch-Biologische Untersuchungen im Gebiete von Warna, Bulgarien. Annalen der Hydrographie und maritimen Meteorologie 65 (7): 322-330.

Temniskova-Topalova D. 1977. Neue Blaualgen und Grünalgen für die Flora Bulgariens. Godishnik na Sofiyskiya universitet, BGGF 68: 35-39. (In Bulgarian)

Tsvetkov L. 1958. Investigations into the Microbenthos of the Bulgarian Black Sea Lakes. Izvestiya na Zoologicheskiya institut s Muzey - BAN 7: 219-250. (In Bulgarian)

Valkanov A. 1935. Notizen über die Brackwässer Bulgariens.I. Godishnik na Sofiyskiya Universitet, FMF 31: 249-303. (In Bulgarian)

Valkanov A. 1936. Notizen über die Brackwässer Bulgariens. II. Versuch einer Hydrographischen und Biologischen Erforschung derselben. Godishnik na Sofiyskiya Universitet, FMF 32: 209-341. (In Bulgarian)

Valkanov A. 1937. Die Varnaseen. Beitrag zur Hydrographie und Biologie derselben. Izvestiya na Bulgarskoto geografsko druzhestvo 4: 118-139. (In Bulgarian)

Valkanov A., Petrova V., Rozhdestvenski A., Marinov T. & Naidenow W. 1978. Black Sea coastal lakes. In: The Black Sea. Varna: Izdatelstvo Georgi Bakalov, pp. 262-283. (In Bulgarian)

Vassilev V. 1994. On the ecological characteristics of the Lake Pomoriysko. Autoreferat of PhD Thesis. Sofia. 35 p. (In Bulgarian)

Vassilev V. P., Moncheva S. P. & Moneva D. S. 1998. Composition, distribution and dynamics of the phytoplankton in Pomoriysko ezero. Trudove na Instituta po Okeanologiya (Varna) 2: 168-177. (In Bulgarian)

Vodenicharov D., Draganov S. & Temniskova D. 1971. Flora of Bulgaria. Algae. Sofia: Narodna Prosveta. 644 p. (In Bulgarian)

Vodeničarov D. 1962. Beitrag zur Algenflora Bulgariens. IV. Izvestiya na Botanicheskiya institut - BAN 10: 145-159. (In Bulgarian)

Vodenitscharow D. 1964. Beitrag zur Algenflora Bulgariens.V. Nauchni trudove Vish pedagogicheski institut 'Paisiy Hilendarski'- Plovdiv 11 (2): 75-79. (In Bulgarian)