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CHECKLIST OF ALGAE FROM BULGARIAN THERMAL WATERS

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Abstract. The paper provides annotated Checklist of Bulgarian thermal algae mentioned in the publications on thermo-mineral springs, baths and their effluents and updated according to the last taxonomic considerations. The list contains data on 35 thermal systems and totally 206 taxa from five algal divisions (phyla): Cyanoprokaryota (82), Rhodophyta (4), Ochrophyta (44: 3 - Tribophyceae, 40 - Bacillariophyceae), Chlorophyta (32) and Streptophyta (44). Among them 21 species are of conservation importance according to the Red Lists of Bulgarian macroalgae and microalgae, and of the Red Data Book of R Bulgaria as well. According to their threatened status they are spread in the following groups: *Critically Endangered* (1), *Endangered* (4), *Vulnerable* (6), *Near Threatened* (5) and *Data Deficient* (5). On the background of the increased pace of habitat losses due to capturing of the springs, construction of new modern SPA centers with permanent cleaning of the algae, or usage of springs for heating purposes or as laundries, this Checklist can serve as a basic archive for future investigations of this important ecological group of extremophilic algae.

Key words: cyanoprokaryotes, extremophiles, threatened species, thermal springs, thermophilic algae, vulnerable habitats

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INTRODUCTION

Algae of the thermal springs, their permanent fontal water bodies and effluents form the ecological group commonly named thermophyton. Published data on the species composition of this important group in Bulgaria are quite scattered. The studies started with the papers by PETKOFF (1898, 1904, 1907, 1908, 1908-1909, 1913, 1922, 1925, 1929, 1934, 1934-1935, 1942, 1950A, B) and GUÉRQUIEFF (1906). Later, a few species from thermal waters were mentioned by GEORGIEV (1948), VALKANOV (1955), VODENIČAROV (1967) and SEMERDZHIEV ET AL. (1980). In the Flora of Bulgarian algae (VODENICHAROV ET AL. 1971) included 36 taxa as found in thermal habitats (mainly springs), almost without indication of the localities. Out of them *Aphanocapsa thermalis* Brügger 1863 and *Trichormus thermalis* (V. Vouk) Komárek & Anagnostidis 1989 (Syn. *Anabaena thermalis* V. Vouk 1916) were indicated as "species which have not been found in Bulgaria". Afterwards the studies on the Bulgarian thermophyton continued with the works by STOYNEVA (2003, 2014), STOYNEVA & GÄRTNER (2004) and LUKAVSKY ET AL. (2011). Then GÄRTNER ET AL. (2015) applied combined light microscopical investigation with transmission electron microscopy and biochemical studies of the cell wall composition for identification of a strain of *Chlorella*, collected from Rupite thermal springs. Currently, STRUNECKÝ ET AL. (2018) published the algal composition from the same region, based on polyphasic approach, which unites conventional light microscopy and modern molecular methods. The first summary on the biodiversity of thermal springs from the region of Pirin Mts and its surrounding valleys and kettles was made by PETKOFF (1925). Later on, summaries on the Bulgarian thermophyton were provided in STOYNEVA (2003B, 2014), STOYNEVA & MICHEV (2007) and STOYNEVA & TEMNISKOVA-TOPALOVA (2007). STOYNEVA (2003) made a generalization of the knowledge on temperature limits of distribution of green algae with a summarizing table with the temperatures at which green algal species were documented for Bulgarian thermes. Nowadays STRUNECKÝ ET AL. (2018) published data on temperature of findings and cultivation of some species found in Rupite region.

Data published in all works cited above concern mainly effluents of the thermal springs and baths of Slivnitsa and Opitsvet (kettle Sofiyska Kotlovina), Banki (Lyulin Mt), Sofia (incl. Ovcha Kupel, Knyazhevo) and Zheleznitsa (Vitosha Mt), Pancharevo (gorge Iskurski Prolom), Ravno Pole (plain Sofiysko Pole), Sapareva Banya (Rila Mts), Kyustendil (kettle Kyustendilska Kotlovina of Osogovo Mts), Blagoevgrad, Simitli, Rupite, Marikostinovo and Sveti Vrach (valley Strumska Dolina), Dobrinishte, Ognyanovo (incl. Futovishta), Gotse Delchev, Razlog, Banya (Guliyna Banya) and Bansko (Pirin Mts), Vurshetski Bani and Karlovski Bani (Stara Planina Mts), Hisarya spring complex and Strelcha spring (Sredna Gora Mts), Haskovo (valley Trakiyska Nizina), Malo-Belovo, Draginovo (=Korova), Vetren Dol (=Eli-dere), Narechen and Mihalkovo (Rodopi Mts), as well as the

thermal springs Novata Voda, Svetata Voda and "thermal spring in Yanensko", for which more geographical data are not provided. The UTM map and main abiotic parameters of most studied springs and limits of main hydrothermal formations were given in STOYNEVA (2003) and STOYNEVA & GÄRTNER (2004).

By time the ecosystems of many Bulgarian thermal springs were completely destructed, lost natural habitats or were severely fragmented because of their transformation into balneotherapy and SPA centers, exploitation of springs for heating purposes or their use as carpet or car washing sites. All these events led to biodiversity losses, noted firstly by PETKOFF (1922, 1929) for the thermal complexes of Ovcha Kupel and Malo Belovo, and afterwards confirmed for them and additionally pointed for the springs in the regions Slivnitsa-Opitsvet-Bezden, Zheleznitsa and Rupite (STOYNEVA 2003, 2014; STOYNEVA & GÄRTNER 2004). Therefore, the thermal springs of Zheleznitsa were included in the first Red List of Bulgarian wetlands with the category *Critically Endangered* (MICHEV & STOYNEVA 2005, 2007). Similar is the example with the only geyser in the last 50 years in our country - the one in Sapareva Banya, which was captured for the needs of the heating of the town and practically remained algologically uninvestigated. This geyser, which arose as a result of the earthquake in 1999, and survived in its natural state for less than a year, was also included in the first Red List of Bulgarian wetlands with the category *Vulnerable* (MICHEV & STOYNEVA 2005, 2007). All thermal habitats of Bulgaria were categorized as *Vulnerable* in the Red Book of Bulgarian habitats (BISERKOV ET AL. 2015) and threatened species were included in the Red Lists of Bulgarian macro- and microalgae (TEMNISKOVA ET AL. 2008; STOYNEVA-GÄRTNER ET AL. 2016) and in the Red Data Book of Bulgarian Plants and Fungi (STOYNEVA ET AL. 2015).

Considering the increase of the modern society in balneotherapy and recreation, and the rising pace of construction of SPA centers combined with the development of tourism, we decided to summarize the knowledge on the algal biodiversity of Bulgarian thermal springs. The Checklist provided below shows the algal distribution by springs and is organized according to the recent state-of-art of modern taxonomy. It is supposed to serve as a biodiversity archive and basis for future investigations and nature conservation measures.

MATERIAL AND METHODS

Data were taken from all published sources on the thermophyton biodiversity, issued in the period 1898-2018: PETKOFF (1898, 1904, 1907, 1908, 1908-1909, 1913, 1922, 1925, 1929, 1934, 1934-1935, 1942, 1950A, B), GUERQUIEFF (1906), GEORGIEV (1948), VALKANOV (1955), VODENIČAROV (1967), VODENICHAROV ET AL. (1971), SEMERDZHIEV ET AL. (1980), STOYNEVA (2003), STOYNEVA & GÄRTNER (2004), LUKAVSKY ET AL. (2011), GÄRTNER ET AL. (2015) and STRUNECKÝ ET AL. (2018). Taxonomical updating was done for taxa supplied by descriptions and

indications of taxonomical sources used by the authors (in case of different species understanding by later authors and existence of different synonyms) or for taxa with a single, doubtless taxonomical transformation. For all other species the original writing of the Latin and author names is kept and they are represented included in quotes. Species which need further taxonomic assessment due to deviations from the descriptions noted by the authors, are indicated by asterisk (*) after the site, where deviation was observed. We added taxonomic comments in cases when authors provided cytomorphological data which differ from species diagnosis without noting the differences. The Checklist is organized in alphabetical order in each algal division, with the current algal names checked in AlgaeBase (Guiry & Guiry 2019), in CyanoDB 2.0 (Hauer & Komárek 2019) and in DiatomBase (Kociolek et al. 2018) in addition to the standard taxonomic sources (*e.g.* Geitler 1931, 1942; Gollerbakh et al. 1953; Krammer & Lange-Bertalot 1991, 1997a, b, 2004; Krause 1997; Komárek & Fott 1983; Komárek & Anagnostidis 1999, 2005; Eloranta et al. 2011; Komárek 2013). Threatened status of the recorded algae is provided after Temniskova et al. (2008) and Stoyneva et al. (2015) for macrophytes, and after Stoyneva-Gärtner et al. (2016) for the microalgae.

For each species the distribution by thermal systems (altogether 35) is provided. When details on the exact spring or bath basin are not described by the author, we note the whole thermal spring complex, but when the exact name of the spring or bath in a region with more springs is pointed by the author, it is given for the relevant taxon in brackets after the name of the complex. When available, data on algal abundance, are provided in brackets as translation of the original authors texts. The indication "in thermal springs" follows the text in the Flora of Bulgarian algae (Vodenicharov et al. 1971).

RESULTS

The species list provided below contains 205 taxa of algae, found in Bulgarian thermal springs or their effluents during a period of 120 years. They belong to five algal divisions (phyla) and twenty-one of them are of conservation significance according to the Red Lists of Bulgarian macro- and microalgae and Bulgarian Red Data Book.

Division Cyanoprokaryota

***Aphanothece elabens* (Brébisson ex Meneghini) Elenkin 1938** (Syn. *Microcystis elabens* (Brébisson) Kützing 1846) - Bansko

***Aphanothece stagnina* (Sprengel) A. Braun in Rabenhorst 1863** – Bansko

***Aphanothece* sp.** – Rupite

***Beggiatoa alba* Trevisan 1893** – Sapareva Banya (spills of the main spring; abundant)

***Calothrix thermalis* Hasngirg ex Bornet & Flahault 1886** – Pancharevo (dominant together with *Gloeocapsa gelatinosa* in a mat on a concrete wall). In our opinion,

this species needs taxonomic reconsideration since the dimensions provided by LUKAVSKY ET AL. (2011, p. 8) are smaller ("Cells width 4 μm, filaments width 5 μm, including yellow coloured mucillage sheath, bearing heterocysts, basal, transparent. The end of filament rounded,width 3 μm, emerging from sheath") than the dimensions in the species description provided by GEITLER (1930-1932: filaments 8-10 μm wide, cells 5-8 μm wide), GOLLERBAKH ET AL. (1953: filaments 9.5-16.5 μm wide at the basis, then 7-11.5 μm wide; trichomes at the basis 5.5-13 μm wide and then 4.5-9.5 μm wide; heterocytes 4.5-11.5 μm ...or more or less cylindrical, 5.5-8 μm wide and 9-23 μm long) and KOMÁREK (2013: filaments (8)9-16.5 μm wide at the basis, mostly 7-11.5 μm in the middle, trichome 5.5-13 μm wide at the basis and 4.5-9.5 μm at the middle, heterocytes 4.5-11.5 (23) x (4.5)5.5-8.5 (11.5) μm). More, the species ends with a hair-like protrusion, which is not mentioned by LUKAVSKY ET AL. (2011). *Endangered* in the Red List of Bulgarian microalgae [EN - A4 B3 C4 D3 E1 F4 G4 T23].

***Chlorogloeopsis* sp.** - Rupite

"Chroococcales" - Haskovo

***Chroococcus membraninus* (Meneghini) Nägeli 1849** – Blagoevgrad (Shafa Banya), Simitli, Dobrinishte, Ognyanovo, Banya (Guliyna Banya), Marikostinovo, Sveti Vrach (abundant). The text in Bulgarian Flora obviously is a summary of previous findings: "in thermal springs. Valleys of the rivers Mesta and Struma".

***Chroococcus thermalis* (Meneghini) Nägeli 1849** (Syn. *Chroococcus turgidus* var. *thermalis* (Meneghini) Rabenhorst ex Hansgirg 1892) – Blagoevgrad (Shafa Banya), Simitli, Dobrinishte, Ognyanovo, Banya (Guliyna Banya), Marikostinovo, Sveti Vrach. The text in Bulgarian Flora obviously is a summary of previous findings: "in effluents of thermal springs in Simitli and Petrich region".

***Chroococcus turgidus* (Kützing) Nägeli 1849** – Bansko

***Cyanobacterium aponinum* I. Moro, N. Rascio, N. LaRocca, M. DiBella & C. Andreoli 2007** - Rupite

***Chroococcus* sp.** – Rupite

***Desertifilum* sp.** - Rupite

***Geitlerinema splendidum* (Greville ex Gomont) Anagnostidis 1989** (Syn. *Oscillatoria splendida* Greville ex Gomont 1892) – Malo Belovo, "...in thermal springs. Belovo, Vitosha Mt, Razlog and Sofia regions", Rupite

***Gloeocapsa gelatinosa* Kützing 1843** (as "*Gloeocapsa gelatinosa* (Meneghini) Kützing 1843") – Pancharevo. *Vulnerable* in the Red List of Bulgarian microalgae [VU - A4 B3 C4 D3 E1 F2 G1 T18].

***Gloeocapsa kuetzingiana* Nägeli ex Kützing 1849** – Hisarya (fountain Tinkova Cheshma)

***Gloeothece fuscolutea* (Nägeli ex Kützing) Nägeli 1849** (Syn. *Gloeocapsa*

fuscolutea Nägeli ex Kützing 1849 as *Gloeocapsa fusco-lutea*) - Bansko

"*Gloetrichia rufescens*" (?*Rivularia rufescens* Nägeli ex Bornet & Flahault 1886 as *Rivularia rufescens* (Näg.) Born. et Flah. according to Gollerbakh et al. 1953. *Endangered* in the Red List of Bulgarian microalgae [EN - A4 B4 C4 D3 E1 F4 G4 T24]) – Karlovski Bani

***Gomphosphaeria aponina* Kützing 1836** – Bansko

***Hapalosiphon pumilus* Kirchner ex Bornet & Flahault 1887** (Syn. *Hapalosiphon fontinalis* Bornet 1889 as "*Hapalosiphon fontinalis* (Ag.) Born.") – "sometimes in thermal springs…Pirin, Rila"

***Heteroscytonema crispum* (Bornet ex De Toni) G. B. McGregor & Sendall in G. B. McGregor 2018** (Syn. *Scytonema crispum* Bornet ex De Toni 1907 as "*S. crispum* (Ag.) Born."; *Scytonema cincinnatum* Thuret ex Bornet & Flahault 1886 as "*S. cincinnatum* Thur.") – Malo Belovo (extremely abundant). Petkoff (1929) indicated for Malo Belovo "*Scytonema crispum* f. *pauciramosa*" as "abundant before 1890 and already progressively disappearing in 1929" in addition to the abundant *Scytonema cincinnatum* Thuret (which was included for the same site in this and in his earlier paper – Petkoff (1908-1909). Both species – *S. crispum* and *S. cincinnatum* were given by Komárek (2013, p. 82) as separate taxa, but with unclear relations, considered as synonyms by several authors. The synonymizing of both species under the new generic name *Heteroscytonema* (McGregor 2018; Sendall & McGregor 2018) was accepted in AlgaeBase. Since f. *pauciramosa* is not discussed in the standard taxonomic literature and in AlgaeBase, and Petkoff (1929) did not provide an author name, we believe that with this naming he noted findings of more rarely ramificated thalli in addition to the typical ones. Therefore, in this Checklist we refer both taxa to *H. crispum*. *Endangered* in the Red List of Bulgarian microalgae [EN - A4 B3 C4 D3 E1 F2 G4 T21].

***Homoeothrix juliana* (Bornet & Flahault ex Gomont) Kirchner 1898** (as "*Homoeothrix juliana* (Menegh.) Kirchner") – "…also in thermal springs. Vitosha." The combination *Homoeothrix juliana* (Menegh.) Kirchner according to the basionym *Calothrix juliana* Bornet et Flahault was used in Vodenicharov et al. (1971) after Geitler (1930-1932, p. 575).

***Jaaginema geminatum* (Meneghini ex Gomont) Anagnostidis & Komárek 1988** (Syn. *Oscillatoria geminata* Menegh). The name and synonym are provided after Komárek & Anagnostidis (2005). Obviously, the writing of the name as *Jaaginema geminatum* (Schwabe ex Gomont) Anagnostidis & Komárek 1988 in AlgaeBase is a technical mistake. - Blagoevgrad (Shafa Banya), Simitli, Dobrinishte, Ognyanovo, Banya (Guliyna Banya), Marikostinovo, Sveti Vrach. The text in Bulgarian Flora obviously is a summary of previous findings: "In thermal springs... Valleys of Struma and Mesta…". *Near Threatened* in the Red List of Bulgarian microalgae [NT - A3 B4 C3 D2 E1 F1 G1 T15].

***Jaaginema kuetzingianum* (Nägeli in Kützing) Anagnostidis et Komárek 1988**

(Syn. *Oscillatoria kuetzingiana* Nägeli in Kützing as "*Oscillatoria amphibia* Ag. var. *kützingiana* (Näg.) Geitl.") – Haskovo (baths)

***Jaaginema pseudogeminatum* (G.Schmid) Anagnostidis & Komárek 1988** (Syn. *Oscillatoria pseudogeminata* G. Schmid 1914) – Simitli, Marikostinovo, Sveti Vrach, Hisarya

***Kamptonema cortianum* (Meneghini ex Gomont) Strunecký, Komárek & J. Smarda 2014** (Syn. *Oscillatoria cortiana* Meneghini ex Gomont 1892 as "*Oscillatoria cortiana* Menegh. (Syn. *O. formosa* Bory f. *latior* Petkoff)") – "in thermal springs... Rila". The synonymy with *O. formosa* Bory f. *latior* Petkoff needs further checking due to lack of any comments in VODENICHAROV ET AL. (1971).

***Kamptonema okenii* (C. Agardh ex Gomont) Strunecký, Komárek & J. Smarda 2014** (Syn. *Oscillatoria okenii* C. Agardh ex Gomont 1892 as "*Oscillatoria okeni* Ag.") – Pancharevo*, "In thermal springs... Lovech and Sofia regions"

***Leibleinia epiphytica* (Hieronymus) Compère 1985** – Pancharevo (filaments twisted around *Phormidium corium* Gomont ex Gomont 1892). According to LUKAVSKY ET AL. (2011) this species has *Schizothrix calcicola* (C. Agardh) Gomont as a synonym requires its further taxonomic reconsideration.

***Leptolyngbya boryana* (Gomont) Anagnostidis & Komárek 1988** – Rupite

***Leptolyngbya compacta* (Hansgirg ex Hansgirg) Komárek in Anagnostidis 2001** - Rupite

***Leptolyngbya fragilis* (Gomont) Anagnostidis & Komárek 1988** (Syn. *Phormidium fragile* Gomont 1893) – Pancharevo* (extremely abundant)

***Leptolyngbya geysericola* (J. J. Copeland) Anagnostidis 2001** - Rupite

***Leptolyngbya tenerrima* (Hansgirg) Komárek in Anagnostidis 2001** (Syn. *Oscillatoria tenerrima* [Kützing 1843, nom. inval.] ex Prain 1905, *Lyngbya tenerrima* [Kützing] Hansgirg ex Hansqirg as "*O. tenerrima* Kütz., *L. tenerrima* (Ktz) Hansq. α var. *genuina* (Ktz) Hnsq.") – Draginovo, Haskovo (in masses, in the springs)

***Leptolyngbya tenuis* (Gomont) Anagnostidis & Komárek 1988** (Syn. *Phormidium tenue* Gomont 1892, also as "*Phormidium tenue* (Menegh.) Gom.") – Ognyanovo, "in... thermal springs...Region of Gotse Delchev and Sofia region"

***Leptolyngbya valderiana* (Gomont) Anagnostidis & Komárek 1988** (Syn. *Phormidium valderianum* Gomont 1892 as "*Phormidium valderiae* (Delp.) Geitler") – Hisarya. In GEITLER (1930-1932, p. 1011) *Leptothrix valderiae* Delp. is pointed as synonym of *Phormidium valderianum* (Delp.) Gom. The name *Phormidium valderiae* (Delp.) Geitl. is used in GOLLERBAKH ET AL. (1953, p. 486).

***Leptothrix ochracea* Kützing 1843**: 198, nom. inval. – Marikostinovo

***Lyngbya aestuarii* Liebman ex Gomont 1892** (as "*Lyngbya aestuarii* (Martens) Liebmann") – "... more rare in thermal springs. Sozopol and Burgas regions".

Lyngbya major **Meneghini ex Gomont 1892** – "...in thermal springs. Black Sea coastal region."

Lyngbya martensiana **Meneghini ex Gomont 1892** - "...and in thermal springs. Plovdiv and Trun regions". According to LUKAVSKY ET AL. (2011) this species pointed for Bulgarian thermal springs in VODENICHAROV ET AL. (1971) coincides with *Lyngbya thermalis*, found by them in Pancharevo. Since *L. thermalis* and *L. martensiana* are listed as separate taxonomic entities in AlgaeBase and standard taxonomic literature on Cyanoprokaryota, and LUKAVSKY ET AL. (2011) have not checked the original material used by VODENICHAROV ET AL. (1971) we do not synonymize both species in this Checklist. More, the description of *L. martensiana* Menegh., provided in Bulgarian Flora is on conformity with its smaller dimensions to the description of *L. martensiana* in GEITLER (1930-1932) and KOMÁREK & ANAGNOSTIDIS (2005) in comparison with *L. thermalis* in the text by GEITLER (1930-1932) and KOMÁREK & ANAGNOSTIDIS (2005).

Lyngbya thermalis **Kützing ex Gomont 1892**: 152, nom. inval. – Pancharevo. See the notes on *L. martensiana*.

Mastigocladus laminosus **Cohn ex Kirchner 1898** (Syn. *Hapalosiphon laminosus* Hansgirg ex Bornet & Flahault 1886) – Guliyna Banya (abundant), Pancharevo, Sofia, Kazichane, Zhelznitsa, Ravno Pole, Strelcha, Gradeshnitsa, Rupite and Sandanski, and without locality included in the Algal flora of Bulgaria (VODENICHAROV ET AL. 1971). According to LUKAVSKY ET AL. (2011, p. 10) "VODENICHAROV ET AL. (1971) did not list *Mastigocladus laminosus*, but they mentioned *Hapalosiphon fontinalis* in the thermal waters of the Pirin and the Rila ranges. Maybe *Mastigocladus* was not recognised, since there are no drawings of the species". In fact, *Mastigocladus laminosus* as *Hapalosiphon laminosus* was first reported for Guliyana Banya by PETKOFF at temperature of 56°C (1925, p. 37, p. 103) and then was included in Bulgarian Algal Flora (VODENICHAROV ET AL. 1971, p. 96-97) as "representative found in Bulgaria" without pointing the exact location), while in the same flora *H. fontinalis* (Ag.) Born. was included as "sometimes found in thermal waters" (op. cit., p. 95-96). *M laminosus* was presented with a *Vulnerable* status in the Red List of Bulgarian microalgae [VU - A2 B3 C4 D3 E1 F2 G4 T19].

Microcoleus autumnalis **(Gomont) Strunecky, Komárek & J. R. Johansen in Strunecky et al. 2013** (Syn. *Phormidium autumnale* Gomont 1892) – Vurshets, Rupite (rarely found; mentioned also as *Microcoleus* sp.)

Merismopedia glauca **(Ehrenberg) Kützing 1845** - Malo Belovo (abundant)

Merismopedia tranquilla **(Ehrenberg) Trevisan 1845** (Syn. *Merismopedia punctata* Meyen 1839) – "....in thermal springs. Pirin Mt, Plovdiv region, Rila Mt, Black Sea coastal region."

Microcoleus amoenus **(Gomont) Strunecky, Komárek & J. R. Johansen in Strunecky et al. 2013** (Syn. *Oscillatoria amoena* Gomont 1892) – "in thermal springs. Lovech region"

***Microcystis pulverea* (H. C. Wood) Forti 1907** (Syn. *Polycystis pulverea* (Wood) Wolle) - Malo Belovo (in great amounts)

***Microcystis* sp.** - Rupite

***Nostoc linckia* Bornet ex Bornet & Flahault 1886** – Blagoevgrad (Shafa Banya), Simitli, Dobrinishte, Ognyanovo, Banya (Guliyna Banya), Marikostinovo, Sveti Vrach

***Nostoc muscorum* C. Agardh ex Bornet & Flahault 1888** – "... and in thermal springs. regions of Plovdiv, Sozopol, Sofia."

***Nostoc paludosum* Kützing ex Bornet & Flahault 1886** - Bansko

***Nostoc verrucosum* Vaucher ex Bornet & Flahault 1886** - Narechen

"Nostocales" – Haskovo

***Oculatella* sp.** - Rupite

"**Oscillatoria antiliaria Juerg.**", Cooke Freshw. algae p. 250, pl. 97, fig. 2; (*Oscillatoria antiliiaria* (Jurg.) Hansg. var. *genuinea* Krch. (Hansq. I, c. II, p. 114)" – Sapareva Banya (abundant)

***Oscillatoria arachnoidea* C. Agardh ex Gomont 1892** (Syn. *Beggiatoa arachnoidea* (C. Agardh) Rabenhorst 1865) – Draginovo (quite spread), Haskovo (abundant)

***Oscillatoria curviceps* C. Agardh ex Gomont 1892** - Haskovo

***Oscillatoria princeps* Vaucher ex Gomont 1892** – Blagoevgrad (Shafa Banya), Simitli, Dobrinishte, Ognyanovo, Banya (Guliyna Banya), Rupite, Marikostinovo, Sveti Vrach, Bansko, Haskovo, "... and in thermal springs. Widely distributed species in Bulgaria".

***Oscillatoria proboscidea* Gomont 1892** – Hisarya

***Oscillatoria spiralis* Carmichael ex Gomont 1892** (Syn. *Oscillatoria spiralis* Carmichael 1833) – Sapareva Banya (abundant in the middle basin named Srednoto Topilo)

***Oscillatoria tenerrima* var. *nigricans* Hansgirg ex Drouet 1957** (as "*Oscillaria tenerrima* var. *nigricans* Hansgirg") – Haskovo (abundant in Kutela and other sites)

***Oscillatoria tenuis* C.Agardh ex Gomont 1892** (as "*Oscillatoria tenuis* (Ag.) Hansg." and as "*Oscillatoria tenuis* Ag.") – Kyustendil (lower baths), Svetata Voda (abundant), Sapareva Banya

***Oxynema acuminatum* (Gomont) Chatchawan, Komárek, Strunecky, Smarda & Peerapornpisal 2012** (Syn. *Oscillatoria acuminata* Gomont 1892) – "....in thermal springs"

***Phormidesmis molle* (Gomont) Turicchia, Ventura, Komárková & Komárek 2009** - Pancharevo

***Phormidium ambiguum* Gomont 1892** – "in... thermal springs... Rila, Sofia region, Black Sea coastal region"

***Phormidium breve* (Kützing ex Gomont) Anagnostidis & Komárek 1988** (Syn. *Oscillatoria brevis* Kützing ex Gomont 1892, *Oscillatoria neapolitana* Kützing

ex Gomont 1892) – Ovcha Kupel ("separate filaments between *Symploca*")

***Phormidium carboniciphilum* (Prát) Anagnostidis & Komárek 1988** (Syn. *Oscillatoria carboniciphila* Prát 1929) – Marikostinovo, Mihalkovo

***Phormidium chalybeum* (Mertens ex Gomont) Anagnostidis & Komárek 1988** (Syn. *Oscillatoria chalybea* Mertens ex Gomont 1892) - "in… thermal springs. Black Sea coast"

***Phormidium corium* Gomont ex Gomont 1892** - Pancharevo

***Phormidium favosum* Gomont 1892** (as "*Phormidium favosum* (Bory) Gom.") – ".. and in thermal springs…Lovech, Samokov region"

***Phormidium fragile* Gomont 1893** (as "*Phormidium fragile* (Menegh.) Gom.") – "in…. thermal springs. Sofia region."

***Phormidium papyraceum* Gomont ex Gomont 1892** (as "*Ph. papyraceum* (Ag.) Gom.") – Sapareva Banya

***Phormidium terebriforme* C. Agardh ex Gomont) Anagnostidis & Komárek 1988** (Syn. *Oscillatoria terebriformis* C. Agardh ex Gomont 1892) – Blagoevgrad (Shafa Banya), Simitli, Dobrinishte, Ognyanovo (Futovishta), Banya (Guliyna Banya), Marikostinovo, Sveti Vrach. The text in Bulgarian Flora obviously is a summary of previous findings: "in thermal springs. Valleys of the rivers Struma and Mesta, Sofia region"

***Phormidium uncinatum* Gomont ex Gomont 1892** – Opitsvet, Vurshets, Malo Belovo, "… and in thermal springs. Widely distributed species in Bulgaria".

"*Scytonema mirabile* var. *leprieurii* (Mont.) Born. et Flah." – Bansko (rare, in the spring effluents). This variety is not included in AlgaeBase and in Komárek (2013), and in the opinion of Geitler (1930-1932) had not to be separated from the main species *Scytonema mirabile*. Gollerbakh et al. (1953) included *Scytonema mirabile* f. *leprieurii* (Mont.) Kossinsk. as a form typical for thermal springs. In his notes, Petkoff (1925) provided description of the form compared to the main species. He noted also that this form was found in thermal springs in Italy with outermost thin and colorless layer of the mucilage sheath as a main difference with the typical species.

***Spirulina subsalsa* Oersted ex Gomont 1892** – "in thermal springs"

***Spirulina subtilissima* Kützing ex Gomont 1892** – Haskovo, Malo Belovo (extremely abundant), "in sulphur springs. Village Belovo, Razlog region, … Rodopi Mts, Stara Planina Mts"

***Spirulina thermalis* Meneghini ex Kützing 1847** (as "*Spirulina subtilissima* Kuetz. var. *thermalis* (Menegh.) Kabh.") – Haskovo (rare). According to Geitler (1930-1932) the variety *thermalis* with the author Rabenhorst had to be included in the main species *Spirulina subtilissima*. Komárek & Anagnostidis (2005) had included *Spirulina thermalis* Meneghini ex Kützing 1847 among the unrevised species. Currently, in AlgaeBase (2019) this species without any synonym was included as an entity that is currently accepted taxonomically but with a lower "Taxonomic note": "Unrevised species." (Komárek &

ANAGNOSTIDIS 2005: 154). - (25 Feb 2014) - M. D. GUIRY". There is also a "Nomenclature note: Often attributed to "Meneghini ex Gomont" even though it was merely listed as a Species inquirendate by Gomont (1892: 255). - (25 Feb 2014) - M. D. GUIRY". These all, in our opinion, explains the obvious typographic error in the author name "Kabh." provided by PETKOFF (1908) after the name of MENEGHINI in brackets.

***Symploca meneghiniana* Kützing ex Gomont 1892** – Ovcha Kupel (extremely abundant). The text in Bulgarian Flora obviously is a summary of previous findings: "In thermal springs, on wet walls. Sofia region".

***Symploca thermalis* Gomont 1892** – Pancharevo (dominated in some samples). Endangered in the Red List of Bulgarian microalgae [EN - A4 B3 C4 D3 E1 F4 G4 T23]

***Synechococcus bigranulatus* Skuja 1933** – Rupite (rarely observed)

***Synechocystis aquatilis* Sauvageau 1892** – Blagoevgrad (Shafa Banya), Simitli, Dobrinishte, Ognyanovo, Banya (Guliyna Banya), Marikostinovo, Sveti Vrach. The text in Bulgarian Flora obviously is a summary of previous findings: "....in thermal waters. Along the valleys of the rivers Mesta and Struma".

***Thermoleptolyngbya albertanoae* Sciuto & Moro 2016** - Rupite

DIVISION OCHROPHYTA

CLASS TRIBOPHYCEAE

***Tribonema bombycinum* (C. Agardh) Derbès & Solier in Castagne 1851** (Syn. *Conferva bombycina* C. Agardh 1817) – Knyazhevo (as "*Conferva bombycina* var. *genuina*"), Bansko (abundant). Most probably, here is to be referred also "*Conferva bombycina* (Ag.) Lagerh. var. *pallida* Kuetz." found in Malo Belovo.

***Vaucheria geminata* (Vaucher) De Candolle in Lamarck & De Candolle 1805** – Opitsvet (extremely abundant), Vurshets, Malo Belovo

***Vaucheria sessilis* (Vaucher) De Candolle in Lamarck & De Candolle 1805** – Opitsvet (extremely abundant)

CLASS BACILLARIOPHYCEAE

***Amphora affinis* Kützing 1844** (Syn. *Amphora ovalis* var. *affinis* (Kützing) Van Heurck 1885 as "*Amphora ovalis* var. *affinis* Kütz.") – Blagoevgrad (Shafa Banya - rare), Simitli, Dobrinishte, Ognyanovo, Banya (Guliyna Banya), Marikostinovo, Sveti Vrach

***Amphora ovalis* (Kützing) Kützing 1844** - Razlog

"*Amphora ovalis* var. *tenuis* Kützing" – Malo Belovo

***Brachysira exilis* (Kützing) Round & D. G. Mann 1981** (Syn. *Navicula exilis* Kützing 1844) – Blagoevgrad (Shafa Banya), Simitli, Dobrinishte, Ognyanovo, Banya (Guliyna Banya), Marikostinovo, Sveti Vrach, Bansko

***Caloneis amphisbaena* (Bory) Cleve 1894** (Syn. *Navicula amphisbaena* Bory in J. V. Lamouroux et al. 1827) – Blagoevgrad (Shafa Banya - abundant)

Cocconeis thwaitesii **W. Smith 1853** – Bansko (abundant)

Craticula cuspidata **(Kutzing) D. G. Mann in Round, R. M.Crawford & D. G. Mann 1990** (Syn. *Navicula cuspidata* (Kutzing) Kutzing 1844) - Marikostinovo

Ctenophora pulchella **var.** *lanceolata* **(O'Meara) Bukhtiyarova 1995** (Syn. *Synedra pulchella* var. *lanceolata* O'Meara 1875) – Dobrinishte. *Data Deficient* in the Red List of Bulgarian microalgae.

Cymatopleura elliptica **(Brébisson) W. Smith 1851** – Bansko, Malo Belovo (not evenly distributed but abundant in some sites)

Cymbella aspera **(Ehrenberg) Cleve 1894** (Syn. *Cymbella gastroides* (Kützing) Kützing 1844) - Razlog

"*Cymbella* **sp."** – Haskovo

Diatoma vulgaris **Bory 1824** (as "*Diatoma vulgare* Bory") – Malo Belovo

"Diatomaceae" – Opitsvet

Diploneis elliptica **(Kützing) Cleve 1894** (Syn. *Navicula elliptica* Kützing 1844) - Blagoevgrad (Shafa Banya - rare), Simitli, Dobrinishte, Ognyanovo, Banya (Guliyna Banya), Marikostinovo, Sveti Vrach, Bansko

Epithemia adnata **(Kützing) Brébisson 1838** (Syn. *Cystopleura zebra* (Ehrenberg) Kuntze 1891) – Blagoevgrad (Shafa Banya - rare), Dobrinishte, Guliyna Banya, Bansko (rare)

Epithemia turgida **(Ehrenberg) Kützing 1844** (Syn. *Cystopleura turgida* (Ehrenberg) Kuntze 1891) – Dobrinishte

Epithemia turgida **var.** *westermannii* **(Ehrenberg) Grunow 1862** (Syn. *Cystopleura turgida* var. *westermannii* (Ehrenberg) De Toni 1892) – Dobrinishte ("abundant on *Oedogonium* together with E. adnate")

Gomphonema acuminatum **Ehrenberg 1832** (Syn. *G. acuminatum* var. *laticeps* (Ehrenberg) Grunow in van Heurck 1880 as "*G. acuminatum* var. *laticeps* (Ehr.) V H") – Malo Belovo

Gomphonema constrictum **Ehrenberg in Kützing 1844** – Malo Belovo

Gomphonema ventricosum **W. Gregory 1856** – Malo Belovo

Iconella hibernica **(Ehrenberg) Ruck & Nakov in Ruck et al. 2016** (Syn. *Campylodiscus hibernicus* Ehrenberg 1845). According to the "Status of name" in the species page in Algaebase (http://www.algaebase.org/search/species/detail/?species_id=r89bfc8cbc8b4d99a) "This name is of an entity that is currently accepted taxonomically". However, in the "Taxonomic notes" to the same species on the same page of Algaebase it is written: "Combination also proposed by E. C. Ruck, T. Nakov, A. J. Alverson & E. C. Theriot, 2016: 155, appendix A, but it is invalid: format of online material not qualifying as effective publication. [INA] - (9 Oct 2016) - Salvador Valenzuela Miranda" – Bansko, Malo Belovo

"*Navicula appendiculata* **var.** *budense* **Grun."** (In Zabelina et al. (1951; p. 345) *Navicula appendiculata* is synonym of *P.innularia appendiculata* (Ag.) Cl. and additionally is included *P. appendiculata* var. *budense* Grun.) - Ognyanovski

Bani (Futovishta)

***Navicula amphigomphus* var. *amphigomphus* Ehrenberg 1843** (Syn. *Navicula iridis* var. *amphigomphus* (Ehrenberg) van Heurck 1880) - Bansko

"*Navicula nobilis* (Ehr.) Kütz." (most probably *Pinnularia nobilis* (Ehrenberg) Ehrenberg 1843, Syn. *Navicula nobilis* Ehrenberg 1841; *Data Deficient* in the Red List of Bulgarian microalgae) – Blagoevgrad (Shafa Banya), Simitli, Dobrinishte, Ognyanovo, Banya (Guliyna Banya), Marikostinovo, Sveti Vrach

***Neidium affine* (Ehrenberg) Pfitzer 1871** (Syn. *Navicula affinis* Ehrenberg 1843) – Marikostinovo. *Vulnerable* in the Red List of Bulgarian microalgae [VU - A3 B3 C4 D3 E1 F1 G2 T17]

***Nitzschia sinuata* (Thwaites) Grunow 1880** – Bansko (rare)

***Pinnularia appendiculata* (C. Agardh) Schaarschmidt 1881** (Syn. *Navicula appendiculata* (C. Agardh) Kützing 1844) – Ovcha Kupel

***Pinnularia major* (Kützing) Rabenhorst 1853** (Syn. *Navicula major* (Kützing) Ehrenberg 1838) – Malo Belovo

***Pinnularia viridis* (Nitzsch) Ehrenberg 1843** (Syn. *Navicula viridis* (Nitzsch) Ehrenberg 1832) – Blagoevgrad (Shafa Banya), Simitli, Dobrinishte, Ognyanovo, Banya (Guliyna Banya), Marikostinovo, Sveti Vrach, Bansko, Haskovo

***Pinnularia* sp.** – Marikostinovo

***Pleurosigma spenceri* (Bailey ex Quekett) W. Smith 1856** - Ovcha Kupel

***Rhoicosphenia abbreviata* (C. Agardh) Lange-Bertalot 1980** (Syn. *Rhoicosphenia curvata* (Kützing) Grunow 1860) - Malo Belovo

***Stauroneis phoenicenteron* (Nitzsch) Ehrenberg 1843** – Bansko. *Vulnerable* in the Red List of Bulgarian microalgae [VU - A3 B3 C4 D3 E1 F1 G2 T18]

***Staurosirella mutabilis* (W. Smith) E. Morales & Van de Vijver in Morales et al. 2015** (Syn. *Odontidium mutabile* W. Smith 1856) – Bansko (abundant)

"*Suriraya ovalis* var. *ovata* Kütz." – Blagoevgrad (Shafa Banya - rare), Simitli, Dobrinishte (rare), Ognyanovo, Guliyna Banya

"*Suriraya spiralis* Ktz" (most probably *Surirella spiralis* Kützing 1844, which is currently regarded as a synonym of *Iconella spiralis* (Kützing) E. C. Ruck & T. Nakov in Ruck et al. 2016. According to the "Status of name" in the species page in Algaebase (http://www.algaebase.org/search/species/detail/?species_id=161230) "This name is of an entity that is currently accepted taxonomically". However, in the "Taxonomic notes" to the same species on the same page of Algaebase it is written: "Combination also proposed by E. C. Ruck, T. Nakov, A. J. Alverson & E. C. Theriot, 2016: 155, appendix A, but it is invalid: format of online material not qualifying as effective publication. [INA] - (9 Oct 2016) - Salvador Valenzuela Miranda"; *Vulnerable* in the Red List of Bulgarian microalgae [VU - A3 B3 C4 D4 E1 F1 G3 T20]) – Bansko (rare)

"*Surirella biseriata* (Ehr.) Bréb. f. *minor obtusa* V. Heurck" and **"*Suriraya biseriata* Breb. f. *minor obtusa* V. Heurck"** (According to Algaebase (http://www.

algaebase.org/search/species/detail/?species_id=32189) *Surirella biseriata* Brébisson in Brébisson & Godey 1835: 53, pl. VII [7] (as '*Surirella* (*Suriraya*) *biseriata*') has the homotypic synonyms *Surirella biseriata* Brébisson 1835 and *Suriraya biseriata* (Brébisson) Pfitzer 1871, and is currently regarded as a synonym of *Iconella biseriata* (Brébisson) Ruck & Nakov in Ruck et al. 2016. According to the "Status of name" in the page of the last species in Algaebase (http://www.algaebase.org/search/species/detail/?species_id=161635). "This name is of an entity that is currently accepted taxonomically". However, in the "Taxonomic notes" to the same species on the same page of Algaebase it is written: "Combination also proposed by E. C. Ruck, T. Nakov, A. J. Alverson & E. C. Theriot, 2016: 155, appendix A, but it is invalid: format of online material not qualifying as effective publication. [INA] - (9 Oct 2016) - Salvador Valenzuela Miranda") - Malo Belovo

***Surirella minuta* Brébisson ex Kützing 1849** (Syn. *Surirella ovalis* var. *ovata* (Kützing) Van Heurck 1885 and *Suriraya ovalis* var. *ovata* (Kützing) Gutwinski 1899 as "*Suriraya ovalis* var. *ovata* Kütz.") – Blagoevgrad (Shafa Banya - rare), Simitli, Dobrinishte (rare), Ognyanovo, Banya (Guliyna Banya), Marikostinovo, Sveti Vrach, Haskovo

***Surirella ovalis* Brébisson 1838** (Syn. *Suriraya ovalis* (Brébisson) Pfitzer 1871 as "*Suriraya ovalis* Bréb." – Blagoevgrad (Shafa Banya - rare)

***Ulnaria ulna* (Nitzsch) Compère 2001** (Syn. *Synedra ulna* (Nitzsch) Ehrenberg 1832) – Marikostinovo, Malo Belovo ("some forms")

Division Chlorophyta

***Bulbochaete* sp. st.** - Bansko

***Chaetomorpha herbipolensis* Lagerheim 1887**: commented in Stoyneva & Gärtner (2004) – Opitsvet (abundant; not found in 2002). *Data Deficient* in the Red List of Bulgarian macroalgae

***Chaetophora elegans* (Roth) C. Agardh 1812** (as "*Chaetophora elegans* (Roth) Ag. f. *genuina* (Roth) Hansg.") – Malo Belovo

***Chlorella vulgaris* Beyerinck [Beijerinck] 1890** - Rupite

"Chlorococales": commented in Stoyneva & Gärtner (2004) – Haskovo (Haskovski Mineralni Bani)

***Cladophora glomerata* (Linnaeus) Kützing 1843**: the material from Hisarya commented in Stoyneva & Gärtner (2004) – Vurshets, Hisarya (Tinkova Cheshma, Havuz Dere)

***Cladophora fracta* (O. F. Müller ex Vahl) Kützing 1843** – "..thermal springs... Balchik region, Varna region... Vitosha Mt"

***Cladophora* sp. I**: commented in Stoyneva & Gärtner (2004) – Hisarya (Chair Banya)

***Cladophora* spp.** – Opitsvet, Ovcha Kupel

***Coelastrum proboscideum* Bohlin in Wittrock, Nordstedt & Lagerheim 1896** –

Bansko (rare)

***Draparnaldia acuta* (C. Agardh) Kützing 1845** (Syn. *Draparnaldia glomerata* var. *acuta* C. Agardh 1824) – Malo Belovo

***Gloeocystis vesiculosa* Nägeli 1849** - Bansko

***Hydrodictyon reticulatum* (Linnaeus) Bory 1824** – Sapareva Banya, Ognyanovski Bani (Futovishta), Karlovski Bani

***Neglectella solitaria* (Wittrock) Stenclová & Kastovsky in Stenclová et al. 2017** (Syn. *Oocystis solitaria* Wittrock in Wittrock & Nordstedt 1879; *Oocystella solitaria* (Wittrock in Wittrock et Nordstedt) Hindák 1988) – Bansko (rare)

***Oedogonium capillare* Kützing ex Hirn 1900** – Malo Belovo

"*Oedogonium cardiacum* (Hass.) Wittr. f. *thermalis* Petkoff" (*Oedogonium cardiacum* Wittrock ex Hirn 1900 is an entity that is currently accepted taxonomically, but f. *thermalis* is not included in AlgaeBase) – Ovcha Kupel. The text in Bulgarian Flora obviously is a summary of previous findings: "Sofia region".

***Oedogonium concatenatum* Wittrock ex Hirn 1900** – "in ... thermal springs. Vitosha Mt, Sofia region"

***Oedogonium intermedium* Wittrock ex Hirn 1900**: commented in Stoyneva & Gärtner (2004) – Hisarya (spring Samodivsko Kladenche)

***Oedogonium* spp. st.**: commented in Stoyneva & Gärtner (2004) – Dobrinishte, Malo Belovo, Opitsvet, Zheleznitsa

***Palmella mucosa* Kützing 1843**: commented in Stoyneva & Gärtner (2004) – Bansko

***Pediastrum boryanum* var. *vagum* (A. Braun) Chodat** (Syn. *P vagum* A. Braun): not included in AlgaeBase, commented in Stoyneva & Gärtner (2004) - Bansko

***Pithophora roettleri* (Roth) Wittrock 1877** (Syn. *Pithophora kewensis* Wittrock 1877; *Pithophora oedogonia* (Montagne) Wittrock 1877): commented in Stoyneva & Gärtner (2004) – Hisarya (spring Samodivsko Kladenche; "uncaptured spring of Hisarya with temperature about 30°C")

***Pithophora* sp.**: commented in Stoyneva & Gärtner (2004) – Hisarya

***Pseudopediastrum boryanum* (Turpin) E. Hegewald in Buchheim et al. 2005** (Syn. *Pediastrum boryanum* (Turpin) Meneghini 1840) – Malo Belovo (abundant)

***Rhizoclonium hieroglyphicum* (C. Agardh) Kützing 1845**: commented in Stoyneva & Gärtner (2004) - Zheleznitsa, Opitsvet

***Scenedesmus bijugatus* var. *seriatus* Chodat 1902** – Bansko (quite often)

***Scenedesmus quadricauda* (Turpin) Brébisson in Brébisson & Godey 1835** – Draginovo, Haskovo (abundant)

***Sphaerellocystis ampla* (Kützing) Nováková 1964** (Syn. *Gloeocystis ampla* (Kützing) Rabenhorst 1863) – Bansko (abundant)

***Stauridium tetras* (Ehrenberg) E. Hegewald in Buchheim et al. 2005** (Syn.

Pediastrum tetras (Ehrenberg) Ralfs 1845) – Bansko (quite often)

***Stigeoclonium thermale* A. Braun in Kützing 1849**: commented in Stoyneva & Gärtner (2004) – Hisarya, Zheleznitsa, Opitsvet, "mainly, preliminary in thermal springs"

***Ulothrix zonata* (F. Weber & Mohr) Kützing 1833**: commented in Stoyneva & Gärtner (2004) – Ovcha kupel (on the thalli of *Chara foetida* f. *thermalis* Petkoff, extremely abundant in the spring before its capture), Opitsvet

***Ulothrix zonata* var. *rigidula* (Kützing) Hansgirg 1886** - Simitli

Division Streptophyta

***Chara braunii* C. C. Gmelin 1826** (Syn. *Chara coronata* J. B. Ziz ex G. W. Bischoff 1828): commented in Stoyneva & Gärtner (2004) – Hisarya (Samodivski Izvor and nameless spring in front of the fountain Tinkova Cheshma), Karlovski Bani

"*Chara coronata* Ziz. f. *intermedia* Petkoff (inter f. *humilior* A. Br. et f. *tenuior* A. Br."). (*Chara coronata* J. B. Ziz ex G. W. Bischoff 1828 is currently regarded as a synonym of *Chara braunii* C. C. Gmelin 1826): commented in Stoyneva & Gärtner (2004) – Karlovski Bani

"*Chara foetida* A. Br. α) *subinermis* ß) *longibracteata* A. Br." (? *Chara foetida* var. *subinermis* f. *longibracteata*; *Chara foetida* A. Braun 1834 is currently regarded as a synonym of *Chara vulgaris* Linnaeus 1753): commented in Stoyneva & Gärtner (2004) – Malo Belovo

"*Chara foetida* f. *macrostephana* Wahldst" (*Chara foetida* A. Braun 1834 is currently regarded as a synonym of *Chara vulgaris* Linnaeus 1753): commented in Stoyneva & Gärtner (2004) – Malo Belovo

"*Chara foetida* f. *macroptila*. 2. *Minor, humilior, pauciramosa brevipapillosa*" (*Chara foetida* A. Braun 1834 is currently regarded as a synonym of *Chara vulgaris* Linnaeus 1753): commented in Stoyneva & Gärtner (2004) – Malo Belovo

"*Chara foetida* f. *microptilla* Mig." (*C. foetida* A. Braun 1834 is currently regarded as a synonym of *Chara vulgaris* Linnaeus 1753): commented in Stoyneva & Gärtner (2004) – Malo Belovo

"*Chara foetida* f. *minor*, *humilior*, *pauciramosa brevipapillosa*" (*C. foetida* A. Braun 1834 is currently regarded as a synonym of *Chara vulgaris* Linnaeus 1753) – Malo Belovo

"*Chara foetida* f. *thermalis* Petkoff" (*C. foetida* A. Braun 1834 is currently regarded as a synonym of *Chara vulgaris* Linnaeus 1753): commented in Stoyneva & Gärtner (2004) - Ovcha Kupel (abundant before capture; not found in 2002)

"*Chara fragilis* Dezv. f. *normalis* Mig." (*Chara fragilis* Desvaux in Loiseleur Deslongschamps 1810 is currently regarded as a synonym of *Chara globularis* Thuiller 1799): commented in Stoyneva & Gärtner (2004) – Vetren Dol

"*Chara gymnophylla* f. *thermalis* Petkoff 1934" (*Chara gymnophylla* A. Braun 1835 is currently regarded as a synonym of *Chara vulgaris* var. *gymnophylla* (A. Braun) C. F. Nyman 1884): commented in Stoyneva & Gärtner (2004) including its mentioning as *Chara gymnophylla* f. *pulchella* Mig. – Malo Belovo (extremely abundant in 1913, 1934)

***Closterium acerosum* Ehrenberg ex Ralfs 1848**: commented in Stoyneva & Gärtner (2004) - Dobrinishte (rare)

***Closterium closterioides* (Ralfs) A. Louis & Peeters 1967**: commented in Stoyneva & Gärtner (2004) - Zheleznitsa

***Closterium decorum* f. *minor* Petkoff** – see *Closterium delpontei* (Klebs) Wolle 1885

***Closterium delpontei* (Klebs) Wolle 1885**: commented in Stoyneva & Gärtner (2004) with the proposal that *Closterium decorum* f. *minor* Petkoff 1925 belongs to this species - Bansko (rare). *Near Threatened* in the Red List of Bulgarian microalgae [NT - A4 B3 C4 D1 E1 F1 G1 T15]

"*Closterium digitus*": commented in Stoyneva & Gärtner (2004) as most probably belonging to *Netrium digitus* (Brébisson ex Ralfs) Itzigsohn & Rothe in Rabenhorst 1856; according to AlgaeBase (2019) *Closterium digitus* Ehrenberg 1832: 68, nom. inval. should be regarded as synonym of *Netrium digitus* (Brébisson ex Ralfs) Itzigsohn & Rothe in Rabenhorst 1856) – Marikostinovo

***Closterium ehrenbergii* Meneghini ex Ralfs 1848** – Malo Belovo

***Closterium lanceolatum* Kützing ex Ralfs 1848** – Vurshets, Malo Belovo

***Closterium pritchardianum* W. Archer 1862**: commented in Stoyneva & Gärtner (2004) – Ovcha Kupel. *Near Threatened* in the Red List of Bulgarian microalgae [NT - A3 B4 C3 D2 E1 F2 G1 T16]

"*Closterium*" - Opitsvet

***Cosmarium botrytis* Meneghini ex Ralfs 1848**: commented in Stoyneva & Gärtner (2004) – Bansko (often, even abundant), Malo Belovo ("between the filaments of *Scytonema cincinatum* and *O. splendida*")

"*Cosmarium botrytis* ad var. *paxilosporum* West et West": commented in in Stoyneva & Gärtner (2004) – Bansko* (often, even abundant)

***Cosmarium laeve* Rabenhorst 1868**: commented in in Stoyneva & Gärtner (2004) – Bansko

***Cosmarium meneghinii* Brébisson ex Ralfs 1848** - Bansko

***Cosmarium sexnotatum* Gutw. ad var. *tristriatum* (Luetkemüller) Schmidle**: the species is currently accepted taxonomically, but the variety is not discussed in Algae Base; Petkoff 1925 identified it after "West et G. G, West, p. 228, pl. LXXXVI, fig. 8-9" and provided a description; comments on the description are given in Stoyneva & Gärtner (2004) – Simitli*

***Cosmarium subtumidum* Nordstedt in Wittrock, Nordstedt & Lagerheim 1878**: commented in in Stoyneva & Gärtner (2004) with pointing the similarity

in dimensions with *C. subtumidum* var. *klebsii* (Gutwinski) W. et G. S. West (which is not discussed in AlgaeBase)- Bansko

***Cosmarium tinctum* Ralfs** 1848 – Bansko

***Cosmarium turpinii* Brébisson 1856** – Vurshets

***Cosmarium venustum* (Brébisson) W. Archer in Pritchard 1861** – Bansko (rare)

"*Cosmarium*" – Opitsvet

"*Euastrum binale* f. *secta* Turn." (*Euastrum binale* Ehrenberg ex Ralfs 1848 is currently accepted taxonomically, but f. *secta* Turn. is not included in AlgaeBase) – Bansko (often)

***Euastrum insulare* (Wittrock) J. Roy 1877** - Bansko

***Mesotaenium endlicherianum* var. *grande* f. *brevior* Petkoff 1925**: commented in Stoyneva & Gärtner (2004) – Bansko (rare). *Data Deficient* in the Red List of Bulgarian microalgae.

***Mougeotia angusta* (Hassall) Czurda 1932** (Syn. *Mougeotia parvula* var. *angusta* (Hassall) Kirchner): commented in Stoyneva & Gärtner (2004) – Bansko. *Near Threatened* in the Red List of Bulgarian microalgae [NT - A4 B3 C4 D1 E1 F2 G1 T16]

***Mougeotia* spp. st.**: commented in Stoyneva & Gärtner (2004) – Zheleznitsa, Opitsvet, Narechenski Bani

***Netrium digitus* (Brébisson ex Ralfs) Itzigsohn & Rothe in Rabenhorst 1856**: commented in Stoyneva & Gärtner (2004); see also "*Closterium digitus*" - Bansko

***Pleurotaenium trabecula* Nägeli 1849**: commented in Stoyneva & Gärtner(2004) – Bansko* (rare)

***Spirogyra columbiana* Czurda 1932**: commented in Stoyneva & Gärtner (2004) – Ovcha Kupel. *Vulnerable* in the Red List of Bulgarian microalgae [VU - A3 B2 C4 D2 E1 F4 G3 T19]

***Spirogyra crassa* (Kützing) Kützing 1843** (as "*Spirogyra crassa* (Kuetz.) Petit.") – Malo Belovo, Ovcha Kupel

***Spirogyra jugalis* (Dillwyn) Kützing 1845**: commented in Stoyneva & Gärtner (2004) – Marikostinovo; *Data Deficient* in the Red List of Bulgarian microalgae

***Spirogyra neglecta* (Hassall) Kützing 1849** – Malo Belovo

***Spirogyra reticulata* Nordst. *forma* Petkoff 1934/35**: commented in Stoyneva & Gärtner (2004) – Vurshets

Spirogyra varians (Hassall) Kützing 1849: commented in Stoyneva & Gärtner (2004) - Bansko

***Spirogyra* spp. st.**: commented in Stoyneva & Gärtner (2004) – Dobrinishte, Svetata Voda, Novata Voda, spring in Yanensko, Hisarya, Narechen, Zheleznitsa, Opitsvet

***Zygnema* spp. st.** – Dobrinishte

***Zygnema* sp. st.** (? *Zygogonium* sp. ster. ad *Zygogonium ericetorum* Kützing 1843): commented in Stoyneva & Gärtner (2004) - Opitsvet

Division Rhodophyta

***Audouinella chalybea* (Roth) Bory 1823** (Syn. *Chantransia chalybea* (Roth) Fries 1825) – Malo Belovo

"*Batrachospermum moniliforme* Roth var. *helminthoides* Sirod" (most probably *Batrachospermum helminthosum* Sirodot 1884, nom. illeg. which is accepted by Eloranta et al. (2011) as a synonym of *Batrachospermum confusum* (Bory 1808) Hassal 1845 emend. Vis et al. 1995; the variety is not included in AlgaeBase) – Malo Belovo (well developed before 1908, completely disappeared before 1929)

***Hildenbrandia rivularis* (Liebmann) J. Agardh 1851** – Malo Belovo (well developed before 1908, progressively disappearing in 1929). *Near Threatened* in the Red List of Bulgarian macroalgae

***Thorea hispida* (Thore) Desvaux 1818** (Syn. *Thorea ramosissima* Bory 1808) – Gotse Declhev (Toplitsi, karst), Malo Belovo (abundant in 1908 but in 1929 mentioned as "completely disappeared since the last 10 years"). *Critically Endangered* in the Red List of Bulgarian macroalgae [CR B1ab(i,ii,iii); C1] and in the Red Data Book of R Bulgaria.

In addition to all taxa enlisted above, Stoyneva (2003) considered species from the unpublished diploma paper of Lukov (1964) and summarized data on 14 taxa from the papers by Petkoff (1900, 1904, 1907, 1908, 1913, 1922, 1934) reported for villages with thermal springs without indication of the exact localities. In the opinion of Stoyneva (2003) it is difficult to refer the last taxa to thermal habitats but they have to be considered in further studies.

Considering the results from the checklist provided above, the order of thermal complexes according to their algal biodiversity is as follows: Bansko – 45, Malo Belovo – 40, Dobrinishte – 22, Marikostinovo – 21, Simitli – 18, Ognyanovo – 15, Rupite – 17, Blagoevgrad (Shafa Banya) – 17, Banya (Guliyna Banya) – 16, Haskovo – 15, Opitsvet -15, Hisarya -14, Sveti Vrach – 14, Pancharevo – 11, Ovcha Kupel – 10, Vurshets – 7, Sapareva Banya – 6, Zheleznitsa – 6, Karlovski Bani – 4, Razlog – 4, Draginovo – 3, Narechen – 3, Gotse Delchev – 2. From each of the other thermal springs only one species was published.

DISCUSSION

Although records on biodiversity of Bulgarian thermophyton are scarce, the results from literature search proved its general richness – 206 taxa from five divisions (phyla): Cyanoprokaryota (82), Rhodophyta (4), Ochrophyta (44: 3 - Tribophyceae, 40 - Bacillariophyceae), Chlorophyta (32) and Streptophyta (44) – **Fig. 1**. This total number of taxa, obtained after the recent taxonomic updates, is on conformity with the total number of "more than 200 species, varieties and forms" pointed by Stoyneva (2003, p. 566). The highest number of cyanoprokaryotes

and important role of green algae, followed by diatoms was already indicated by STOYNEVA (2003) and illustrated by her Figures 1 and 2. Some differences in species distribution and total composition (with presence of glaucophytes in particular) between this paper and the paper by STOYNEVA (2003) come from her considering of some hardly available unpublished data, which were not taken into account in this paper.

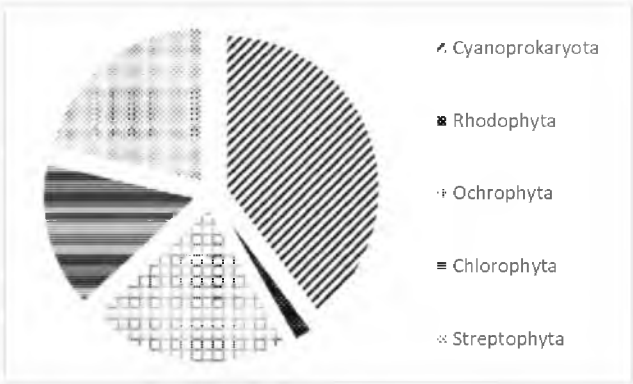

Fig. 1. Taxonomic structure of the algal flora of Bulgarian thermal springs, baths and their effluents. The position of taxonomic groups followes clockwise direction.

Doubtless, the rich algal biodiversity reflects the diversity of thermal spring and system types, which exist in Bulgaria (for details, see STOYNEVA 2003 and STOYNEVA & GÄRTNER 2004). Among all taxa found, there are 21 species of conservation importance: *Critically Endangered* (1), *Endangered* (4), *Vulnerable* (6), *Near Threatened* (5) and *Data Deficient* (5). It is possible to suppose that further more detailed studies with modern polyphasic approach will reveal more rare and threatened species.

The distribution of species by thermal systems outlines the thermal springs of Bansko and Malo Belovo as the richest in algal biodiversity (45 and 40 algae, respectively). Considering the thermal types of VOUK (1923, 1948) it is easily explainable by the cool (chliarithermal) type of these two springs and their effluents – 21°C and 22-23.5°C of the main springs, respectively. Logically, they are followed by the group of springs of eu- and akrothermal waters (30-50 °C and 50-70 °C, respectively) with lowest number of species found in hyperthermal waters (>70 °C). However, this conclusion is quite tentative since for most of the species the exact temperature of finding was not indicated while in most publications the temperature of the main source is given. The same problem was outlined by STOYNEVA (2003) in discussion of the real temperatures of occurrence and limits of distribution of green algae. Additionally, we have to note that most data were based on single samplings at a spot and this is strongly reflected in the results on site biodiversity evaluations. More, 151 taxa (or, 74%) are published as found in one site only and for other 15 taxa (7%) only general distribution in thermal springs was noted without indication of the location. Our results are in accordance with the data of STOYNEVA (2003) that 68% of green algae were documented for one site only.

Many of the species from the Checklist were noted as found in the effluents

of the thermal springs without pointing the exact distance from the source, or temperature difference. Therefore, it is difficult to state that all species listed above are strictly thermal and more detailed investigations in this aspect are needed. More, all algae have been found in a period of 120 years and it is not possible to state that they all occurred at the same time and could be find recently in the thermal spring systems of Bulgaria. However, in the increased pace of habitat losses due to capturing of the springs, construction of new modern spa centers with permanent cleaning of the algae, or usage of springs for heating purposes or as laundries, this Checklist can serve as a basic archive for future investigations of this important ecological group of extremophilic algae.

CONFLICT OF INTERESTS

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

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