Phytoplankton community structure of three temporary wetlands on Belene Island (Bulgarian sector of the Danube River)

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Abstract. The phytoplankton community structure and species diversity were studied in comparison with the physical and chemical conditions in three temporary wetlands on Belene Island (the Danube River, Bulgaria) in June 1997, June 1998 and April 2000. A total of 185 taxa were found, including 81 *Chlorophyta*, 27 *Cyanoprokaryota*, 25 *Bacillariophyta*, 24 *Euglenophyta*, 16 *Xanthophyta*, 6 *Pyrrhophyta*, 4 *Cryptophyta*, and 2 *Chrysophyta*. Flagellates, mainly from *Chlorophyta*, *Cryptophyta* and *Euglenophyta*, constituted a significant part of the phytoplankton biomass. The studied wetlands were compared with other basins near the Danube River. The species diversity of phytoplankton (according to Shannon & Weaver, 1949) showed very high values.

Key words: flagellates, phytoplankton, species diversity, temporary wetlands

Introduction

The group of temporary wetlands includes an enormous variety of different water bodies worldwide, each with its own specific features. Williams (1985) had classified these water bodies and their biota and had emphasized the importance of the "degree of predictability that they contain water and on the extent to which the waters occupy discrete basins or are associated with seasonally or unpredictably flooding rivers". The organisms inhabiting these water bodies undergo the influence of a variety of "stressors", of which, according Williams (1985), the more important are: desiccation, chemical variation (variation in ionic proportions), high temperatures, high light intensities, variation in environmental factors (short-term instability and long term unpredictability), and astatic levels.

Knowledge of the structure and functioning of the phytoplankton community in temporary wetlands associated with the Danube River are still scarce and fragmentary. Petkoff (1911) gives the first more detailed data about algal and high swamp flora along the lowland of Danube River. The taxonomic algal composition (including representatives of the phytoplankton and phytobenthos) of different temporary or permanent water basins adjoining the Bulgarian sector of the Danube River were investigated by Draganov & Stoyneva (1992); Stoyneva & Draganov (1994) and Stoyneva (1991, 1994, 1995, 1998).

So far there has been not water chemistry and hydrobiological data available about the three wetlands on Belene Island.

The present work is the first investigation of the temporary wetlands situated on Belene Island, with the aim to study the phytoplankton composition, community structure and species diversity in relation to the complex of physical and chemical variables of the water.

Materials and methods

Description of the studied wetlands

The studied wetlands – Pischene, Murtvo Blato and Dyulova Bara – are located on Belene (Persin) Island, at latitude 43°40' N, longitude 25°10' E, and altitude of 27 m (Fig. 1). Belene Island is the largest isle in the Bulgarian-Romanian sector of the Danube River. Bontschew (1929) reported the approximate dimensions (length 3 km, width 200–600 m) and depth (60–70 cm) of the wetlands. The same author described these wetlands with different names, unpopular nowadays.

We have assigned the studied water basins to the category of intermittent wetlands, which according to the definition of Williams (2000), "contain water or are dry on a more or less predictable annual basis." They originate from the floodplain and have been separated from the Danube River by a dike, encircling the island. Thus their direct connection with the river has been severed and the wetlands are fed only by underground waters and rainfalls. They contain water during the period of high or moderate river levels and during the very hot summer periods (usually at the end of July and August) they periodically dry up completely. The wetlands are strongly overgrown with high aquatic and swamp vegetation and their bottom is covered with a thick layer of mud. The depths of the different wetlands, at the time of sampling, are presented in Table 1.

Physical and chemical conditions

The values of the main physical and chemical factors are given in Table 1. The water is neutral, with relatively high values of oxydability by K2MnO4 and ammonium nitrogen (NH4-N) and with total soluble reactive phosphorus (TP), thus assigning the wetlands to the hypereutrophic category after the classification of Likens (1975). The low N:P mass ratio suggests nitrogen limitation of the phytoplankton.

Field samplings and laboratory treatment

Samplings were carried out three times: on 10–12 June 1997, 02–04 June 1998 and 18–20 April 2000 respectively. The chemical and quantitative phytoplankton

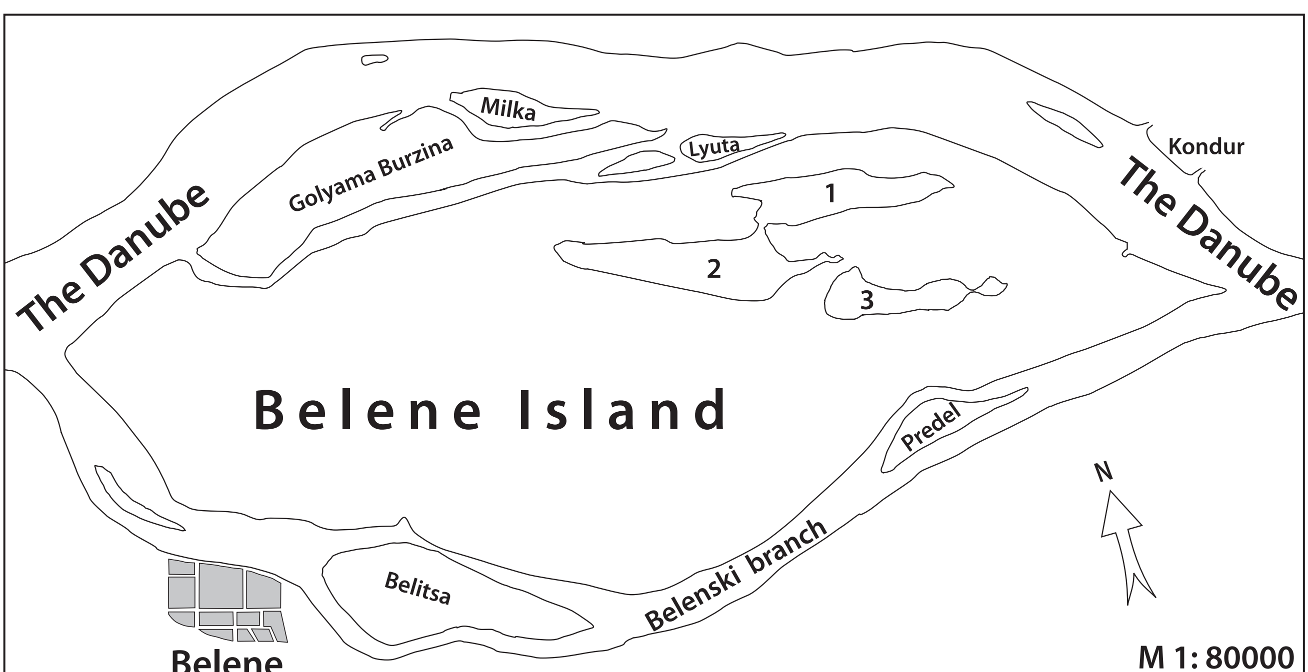

Fig. 1. Scheme with location of the three studied wetlands: Murtvo Blato (1), Pischene (2), Dyulova Bara (3).

Table 1. Physical-chemical variables and quantitative parameters of the phytoplankton.

Wetlands	Murtvo Blato			Pischene			Dyulova Bara		
Month, Year	VI 1997	VI 1998	VI 2000	VI 1997	VI 1998	VI 2000	VI 1997	VI 1998	VI 2000
Temperature, °C	26.0	25.0	17.2	18.0	26.0	17.5	23.0	20.0	16.0
Depth, cm	100	60	150	80	50	140	80	30	100
pH	7.5	7.5	7.2	7.1	7.4	7.3	7.2	7.2	7.2
Oxygen, mg l^{-1}	10.08	8.35	2.88	0.24	8.14	3.28	5.12	1.44	4.80
Oxygen, %	126.2	103.0	30.9	2.6	101.8	35.3	61.1	16.3	50.2
Oxydability, mgO_2 l^{-1}	14.08	11.04	16.96	20.80	17.80	23.36	19.20	25.28	19.20
Alkalinity, mgeqv l^{-1}	1.90	2.10	7.40	3.60	6.10	7.00	4.64	5.30	8.70
Ca^{2+}, mg l^{-1}	22.04	58.12	138.28	54.11	70.14	70.14	64.13	42.08	116.23
Mg^{2+}, mg l^{-1}	12.16	35.26	46.21	15.81	51.07	48.64	14.59	53.50	52.29
NH_4-N, mgN l^{-1}	0.19	0.14	0.17	0.54	0.25	0.16	0.10	0.20	0.11
NO_3-N, mgN l^{-1}	0.03	0.15	0.16	0.17	0.15	0.30	0.11	0.13	0.10
PO_4-P, mgP l^{-1}	0.01	0.17	0.06	0.22	0.48	0.09	0.02	0.42	0.06
TP, mgP l^{-1}	0.04	0.20	0.09	0.25	0.51	0.12	0.04	0.45	0.08
Si, mg l^{-1}	0.86	0.76	2.88	1.71	5.52	4.61	1.79	6.57	3.33
N:P ratio*	23.00	1.90	5.60	3.30	0.85	5.20	11.00	0.81	3.70
Number of species (from quantative samples only)	16	12	13	17	15	13	21	20	14
Numbers, individuals** $.10^3$ l^{-1}	443	343	361	357	599	248	122	6327	238
Biomass, mg l^{-1}	3.99	1.38	0.33	2.25	2.10	0.26	1.11	55.65	0.28
Shannon-Weaver index ($\overline{H}$)	3.46	3.25	2.46	2.07	2.60	2.70	3.81	2.06	3.07

*** – sum of the three soluble inorganic forms of nitrogen (NH_4-N, NO_2-N, NO_3-N) and total dissolved phosphorus were used for calculation**
**** – cells, colonies, filaments**

samples (0.5 l) were taken simultaneously by scooping from the surface at an open area, behind the zone of macrophytes. Qualitative phytoplankton samples (by handnet of 45 μ mesh size) were taken from different points and integrated as one sample for each of the wetlands. The phytoplankton samples were fixed with formalin at a final concentration of 4 %.

The field measurement, filtering and fixation of the chemical samples, as well as the methods of laboratory chemical analysis processing according to Golterman & Clymo (1970) and Höll (1970), have been already described by Botev (1998).

Counts were carried out in a haemocytometer chamber of Bürker under a light microscope. The biomass (at ρ=1) was calculated by the method of stereometrical approximations (Rott 1981) based on original measurements of cell dimensions. The basic count unit was individual (cell, colony, filament).

Species diversity was estimated after Shannon & Weaver (1949). The similarity of wetlands was estimated on the basis of quantitative phytoplankton samples by the Steinhaus Coefficient (Legendre & Legendre 1983). For estimation of the relations between phytoplankton and environmental factors, the nonparametric Spearman's Correlation Test was used.

Results

Phytoplankton composition

A total of 185 taxa were found during the investigation period, of them 67 in Pischene, 96 in Murtvo Blato and 119 in Dyulova Bara (Table 2). The taxa were distributed by divisions as follows: 81 *Chlorophyta*, 27 *Cyanoprokaryota*, 25 *Bacillariophyta*, 24 *Euglenophyta*, 16 *Xanthophyta*, 6 *Pyrrhophyta*, 4 *Cryptophyta*, and 2 *Chrysophyta*.

Chlorophyta rated first in relation to the number of species (45 % in Dyulova Bara, 42 % in Murtvo Blato and 28 % in Pischene), as a considerable part of the species found in the qualitative net samples consisted of tychoplanktonic forms. The wetlands differed with respect to proportional distribution of the different algal groups. Thus, both in Dyulova Bara and Murtvo Blato, *Chlorophyta* evidently prevailed over *Cyanoprokaryota*, *Euglenophyta*, and *Bacillariophyta*, the last three divisions being almost equally represented. In Pischene the taxa were more evenly distributed among the four taxonomic divisions mentioned above. Differences between wetlands were registered within *Chlorophyta* too. In Murtvo Blato the desmids were better represented, while in Dyulova Bara the *Chlorococcales* were richer in species. In Pischene, both *Volvocales* and *Chlorococcales* were well represented.

Table 2. Phytoplankton composition in studied wetlands during the sampling period.

Taxa	Murtvo Blato	Pischene	Dyulova Bara
1	2	3	4
Cyanoprokaryota			
Anabaena constricta (Szafer) Geitler	+	+	
A. inaequalis (Kütz.) Bornet & Flahaut	+		
A. oscillarioides Bory			+
A. sphaerica Bornet & Flahaut		+	+
A. variabilis Kütz.	+		
Anabaena sp. *ster.* 1		+	
Anabaena sp. ster. 2			+
Aphanothece saxicola Nägeli			+
A. stagnina (Spreng.) A. Braun			+
Calothrix stagnalis Gomont	+		
Calothrix sp.	+		
Coelosphaerium kuetzingianum Nägeli	+		+
Cylindrospermum stagnale (Kütz.) Bornet & Flahaut	+	+	
Gloeotrichia natans (Hedw.) Rabenh.			+
Gloeotrichia sp.			+
Gloeocapsa limnetica (Lemmerm.) Hollerb.	+		
Gomphosphaeria lacustris Chodat	+	+	+
Lyngbya aestuarii (Mert.) Liebm.	+		+
Lyngbya sp.	+	+	
Microcystis pulverea (Wood) Forti		+	+
Nodularia spumigena Mert.	+	+	+
Nostoc sphaericum Vaucher	+		
Oscillatoria limosa Agardh			+
O. proboscidea Gomont			+
Oscillatoria sp.	+	+	+
Phormidium ambiguum Gomont		+	
Spirulina platensis (Nordst.) Geitler			+
Euglenophyta			
Astasia sp.		+	+
Euglena acus Ehrenb.		+	+
E. oxyuris Schmarda	+		
E. pascheri Swirenko		+	
E. tripteris var. *crassa* Swirenko			+
Euglena spp.	+	+	+
Lepocinclis sp.	+	+	+
Phacus acuminatus Stokes		+	+
Ph. caudatus Hübner		+	
Ph. curvicauda Swirenko	+	+	
Ph. fominii Roll	+		+
Ph. lismorensis Playfair		+	+
Ph. longicauda (Ehrenb.) Dujard.	+	+	+
Ph. longicauda f. *vix-tortus* Kisselev			+
Ph. mirabilis Pochm.	+		
Ph. nordstedtii Lemmerm			+
Ph. orbicularis Hübner	+	+	+
Ph. pyrum (Ehrenb.) Stein	+		
Trachelomonas hispida (Perty) Stein em. Deflandre	+	+	
T. hispida var. duplex Deflandre			+
T. intermedia Dangeard		+	
T. oblonga Lemmern	+	+	+
T. volvocina Ehrenb.	+	+	
T. volvocinopsis Swirenko	+		
Pyrrhophyta			
Ceratium cornutum (Ehrenb.) Clap. & Lachm.	+	+	
Peridinium bipes Stein	+	+	
P. cinctum Ehrenb.	+		
P. cinctum f. *westii* (Lemmern) Lefèvre			+
P. umbonatum Stein			+
Peridinium sp.	+	+	+
Chrysophyta			
Dinobryon divergens Imhof	+		+
Synura sp.	+	+	+
Xanthophyta			
Characiopsis anas Pascher	+		
Ch. pyriformis (A. Braun) Borzi	+		+
Isthmochloron lobulatum (Nägeli) Skuja			+
Ophiocytium arbuscula (A. Braun) Rabenh.			+
O. cochleare A. Braun	+		
O. gracillipes (A. Braun) Rabenh.	+		+
O. ilkae (Istv.) Heering			+
O. parvulum A. Braun			+
Ophiocytium sp.			+
Tribonema affine West			+
T. angustissimum Pascher	+		
T. gayanum Pascher	+	+	+
T. minus Hazen	+		
T. utriculosum (Heering) Hazen	+		
T. viride Pascher	+		
Tribonema sp.			+
Bacillariophyta			
Asterionella formosa Hassall	+		
A. gracillima (Hantzsch) Heib.		+	
Aulacoseira granulata (Ehrenb.) Simonsen			+
A. granulata var. *angustissima* (O. Müll.) Simonsen			+
A. italica (Ehrenb.) Simonsen	+		+
Cocconeis placentula Ehrenb.		+	+
C. placentula var. *intermedia* (Hérib. & Perag.) Cleve		+	
Diatoma vulgaris Bory	+		
Epithemia turgida (Ehrenb.) Kütz.	+	+	
Eunotia bilunaris (Ehrenb.) Mills			+
E. pectinalis (Dillwyn) Rabenh.		+	
Eunotia sp.		+	
Fragilaria capucina Desm.	+	+	+
F. intermedia Grunov		+	
Fragilaria cf. *lapponica* Grunov			+
F. ulna (Nitzsch) Lange-Bert.	+	+	+
F. ulna var. *acus* (Kütz.) Lange-Bert.		+	+
Gomphonema olivaceum (Lyngb.) Kütz.		+	+
Hantzschia amphioxys (Ehrenb.) Grunov			+
Navicula sp.			+
Nitzschia acicularis W. Smith	+	+	+
N. sigmoidea (Ehrenb.) W. Smith	+		+
Pinnularia sp.	+	+	+
Rhoicosphenia curvata (Kütz.) Grunov	+		

Table 2. Continuation.

1	2	3	4
Rhopalodia gibba (Ehrenb.) O. Müll.	+	+	+
Cryptophyta			
Chroomonas sp.		+	
Cryptomonas ovata Ehrenb.		+	
Cryptomonas sp. 1 (large)	+	+	+
Cryptomonas sp. 2 (small)	+	+	+
Chlorophyta			
Euchlorophytina			
Ankistrodesmus falcatus (Corda) Ralfs	+	+	+
A. fusiformis Corda	+		+
Ankyra judayi (G. M. Smith) Fott	+		
A. lanceolata (Korshikov) Fott	+		
Ankyra sp.	+		
Chlamydomonas sp.	+	+	+
Closteriopsis longissima (Lemmerm.) Lemmerm.			+
Coelastrum sphaericum Nägeli			+
Coenocystis planctonica Korshikov	+		
Coenochloris ovalis Korshikov	+		
Crucigenia rectangularis (Nägeli) Gay	+		
Desmatractum indutum (Geitler) Pascher		+	
Dictyospaerium ehrenbergianum Nägeli			+
D. pulchellum Wood	+		+
Elakatothrix lacustris Korshikov			+
Eudorina elegans Ehrenb.		+	+
E. illinoisensis (Kof.) Pascher			+
Gloeocystis polydermatica (Kütz.) Hindák			+
Gonium pectorale Müller			+
Kirchneriella obesa (W. West) Schmidle	+		
Monoraphidium arcuatum (Korshikov) Hindák			+
M. contortum (Thur.) Komárk.-Legn.	+		+
M. griffithii (Berk.) Komárk.-Legn.			+
Oedogonium rufescens Wittr.			+
O. sociale Wittr.			+
Oedogonium sp.	+	+	+
Oocystis elliptica W. West			+
O. lacustris Chodat	+		+
Pandorina morum (Müller) Bory	+	+	+
Pediastrum duplex Meyen		+	
P. tetras (Ehrenb.) Ralfs		+	
Phacotus lenticularis (Ehrenb.) Stein	+	+	+
Pteromonas angulosa Lemmerm.			+
Pteromonas sp.			+
Scenedesmus aculeolatus Reinsch	+		
S. acuminatus (Lagerh.) Chodat	+	+	+
S. acutiformis Schröd.			+
S. armatus Chodat			+
S. communis Hegew.			+
S. costatus Schmidle			+
S. ecornis (Ehrenb.) Chodat	+		+
S. obliquus (Turpin) Kütz.			+
S. obtusus Meyen			+
S. opoliensis P. Richt.		+	
Scenedesmus sp.	+	+	+
Schroederia robusta Korshikov		+	
S. setigera (Schröd.) Lemmerm.			+
Sorastrum spinulosum Nägeli	+		
Tetrachlorella alternans (G. M. Smith) Korshikov			+
T. ornata Korshikov	+		
Tetraedron minimum (A. Braun) Hansg.		+	+
T. triangulare Korshikov	+		+
Ulothrix moniliformis Kütz.			+
Zygnemophytina			
Closterium navicula (Bréb.) Lütkem.			+
C. parvulumm Nägeli			+
Closterium sp.		+	
Cosmarium abbreviatum Racib.	+		
C. angulosum Bréb.	+		
C. blyttii Wille	+		
C. impressulum Elfving			+
C. meneghinii Bréb.	+		
C. ochthodes Nordst.	+		
C. punctulatum Bréb.	+		
C. retusiforme (Wille) Gutw.	+		
C. subgranatum (Nordst.) Lütkem.	+		
C. umbilicatum Lütkem.	+		
C. undulatum Corda	+		+
C. vexatum West		+	+
C. wembaerense Schmidle	+		
Cosmarium sp.	+		
Cosmoastrum gladiosum (Turn.) Pal.-Mordv.	+		
Gonatozygon pilosum Wolle			+
Mougeotia scalaris Hassall			+
Mougeotia sp. *sterilis*	+	+	+
Raphidiastrum lunatum (Ralfs) Pal.-Mordv.			+
Spirogyra sp. *sterilis*	+	+	+
Staurastrum hexacerum (Ehrenb.) Wittr.	+		+
S. manfeldtii Delponte	+		
S. punctulatum Bréb.			+
Staurastrum sp.		+	
Zygnema sp. *sterilis*	+		+

Xanthophyta were presented by only one species (*Tribonema gayanum*) in Pischene, while in Dyulova Bara and Murtvo Bato, 10 and 9 species respectively were found. *Pyrrhophyta*, *Cryptophyta* and *Chrysophyta* were poor in species in all studied wetlands (Table 2).

Phytoplankton community structure on the basis of the biomass

The number of species in quantitative samples ranged from 12 to 21 (Table 1). The wetlands differed considerably in the proportions (to the total biomass) of the main algal groups (Fig. 2), as the differences were strongly expressed in both summer months.

In Dyulova Bara the phytoplankton was clearly dominated by chlorophytes, reaching a very high relative biomass both in 1997 and 1998 (Fig. 2). In 1997, the main contributors to the biomass were *Mugeotia* sp. and *Eudorina elegans*, while in 1998 *E. elegans* alone reached a biomass of 47.93 mg l^{-1} and together with the small coccal green algae caused a bloom of phytoplankton which led to decrease in the species diversity (Table 1).

In Murtvo Blato the phytoplankton community had polydominant structure in the summer of 1997, as the species *Gomphosphaeria lacustris*, *Peridinium umbonatum*, *Ceratium cornutum* and *Tribonema* sp. all had higher relative biomass (Fig. 2). In the summer of 1998 *Phacotus lenticularis*, *Pediastrum duplex* and *Trachelomonas* sp. dominated the phytoplankton (Fig. 2).

In Pischene the most successful algal groups in the summer of 1997 were cryptophytes *(Cryptomonas* spp.) and in the summer of 1998 euglenophytes (*Phacus*, *Euglena*, *Trachelomonas*, *Astasia* spp.). The species diversity index had the lowest values as compared with the other two wetlands (Table 1).

The Steinhaus Similarity Coefficient had very low values in the summer months (Table 3).

Table 3. Values of Steinhaus similarity coefficient between wetlands.

Month Year	Murtvo Blato – Pischene	Murtvo Blato – Dyulova Bara	Pischene – Dyulova Bara	Average
June 1997	0.13	0.06	0.04	0.08
June 1998	0.17	0.02	0.04	0.08
April 2000	0.44	0.22	0.23	0.29
Average	0.25	0.10	0.10	

Differences were smaller in spring (April 2000), when the phytoplankton assembly consisted of the same algal divisions but in different proportions in the distinct wetlands. Thus, in Murtvo Blato the phytoplankton was dominated by *Cryptomonas* spp., in Pischene by *Cryptomonas* spp. plus euglenoids, and in Dyulova Bara by euglenoids plus green algae, mainly *Chlorococcales* (Fig. 2). The Steinhaus Coefficient was significantly higher, and the highest value was registered between the interconnected wetlands Murtvo Blato and Pischene (Table 3).

The total phytoplankton numbers and biomass also varied to a great extent, mainly in Dyulova Bara, where the difference between the phytoplankton biomass in the summer of 1998 and in the spring of 2000 was over two orders of magnitude (Table 1).

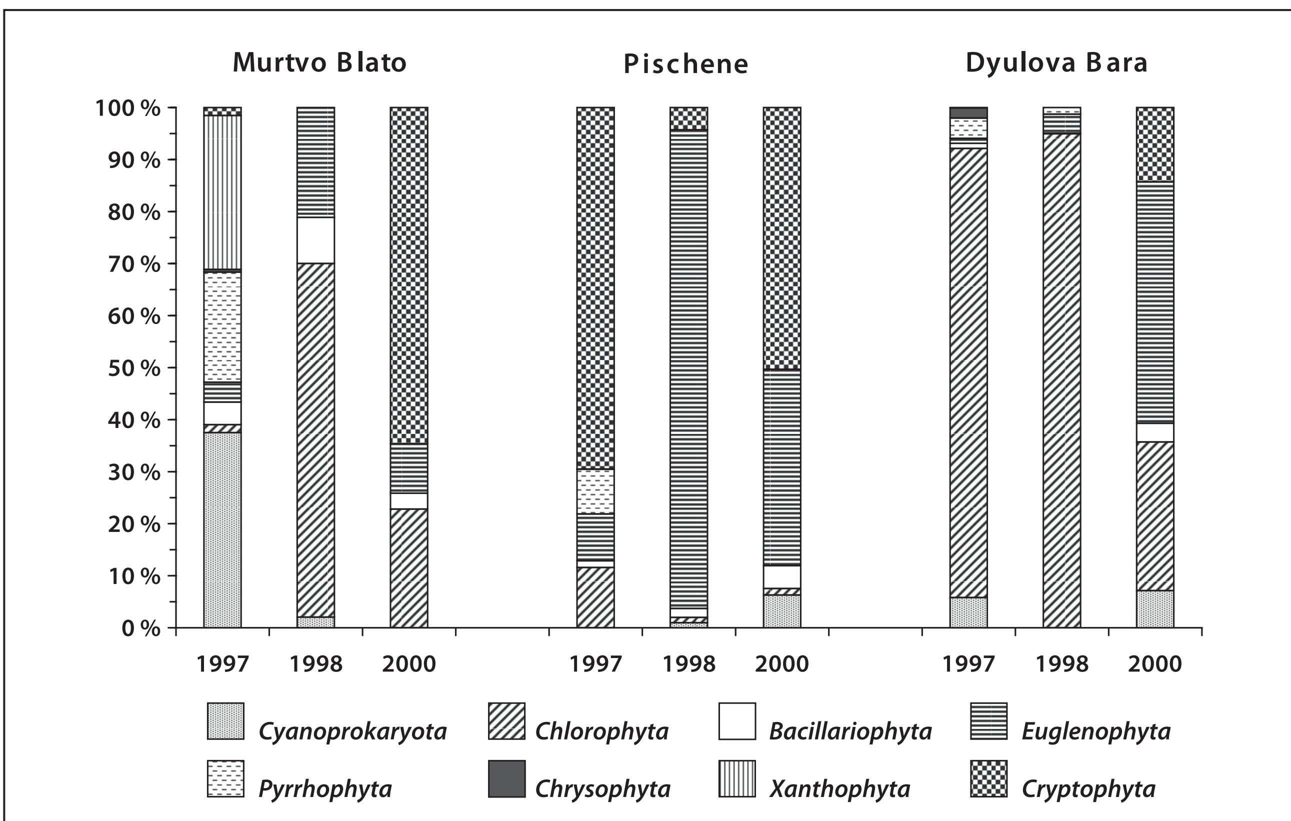

Fig. 2. Percentage of different algal groups to the total biomass.

Highly significant correlation was obtained between the total numbers of phytoplankton and ammonium nitrogen (R_{SP}=0.80, P=0.01, n=9).

Flagellated species constituted a significant part of the phytoplankton assemblages, reaching above 95 % of the total biomass in Pischene (1997, 1998) and in Dyulova Bara of year 1998 (Fig. 3).

Discussion

Comparing the studied wetlands with five other temporary and permanent water basins situated nearby the Danube River, according Draganov & Stoyneva (1992), we have established that in terms of the total numbers of taxa the wetlands on Belene Island are close to the swamp of Garvan village (62 taxa), the little swamp situated between the Srebarna Biosphere Reserve and the Danube River (74 taxa), and the shallow basin on Vardim Island (105 taxa). Considerably wealthier in taxa is Srebarna Lake (Stoyneva 1991; Draganov & Stoyneva 1992; Stoyneva & Draganov 1994; Stoyneva 1998). In respect to the greatest taxonomical richness of *Chlorophyta* and the high contribution of tychoplanktonic species, Belene wetlands are close to all earlier investigated water basins near the Danube River (Petkoff 1911; Stoyneva 1991; Draganov & Stoyneva 1992; Stoyneva & Draganov 1994; Stoyneva 1995). The subject of tychoplanktonic species has been discussed in detail by Stoyneva (1994). Another similarity found out by us was in respect to the low taxonomical contribution of *Pyrrhophyta*, *Chrysophyta* и *Xanthophyta*. There were certain differences in relation to *Cyanoprokaryota*. Despite the low N:P ratio in the studied wetlands as a factor favouring the development of blue-green algae (Bulgakov & Levich 1999; Smith & Bennett 1999), the blue-greens were poorly presented (mainly in respect to the biomass) in the strongly overgrown wetlands on Belene Island. On the contrary, in some shallow, small and not overgrown basins the blue-green algae have rated among the leading groups in taxonomical respect (Stoyneva 1991). This presumes a possible inhibitory influence of macrophytes on the blue-greens in Belene wetlands. There are ample data in current literature in support of such influence (Alliotta & al. 1990; Nakai & al. 1999).

The total phytoplankton numbers and biomass fluctuated between very low values corresponding to the oligotrophic level in spring (at higher water level) and up to hypereurtrophic values (Dyulova Bara in

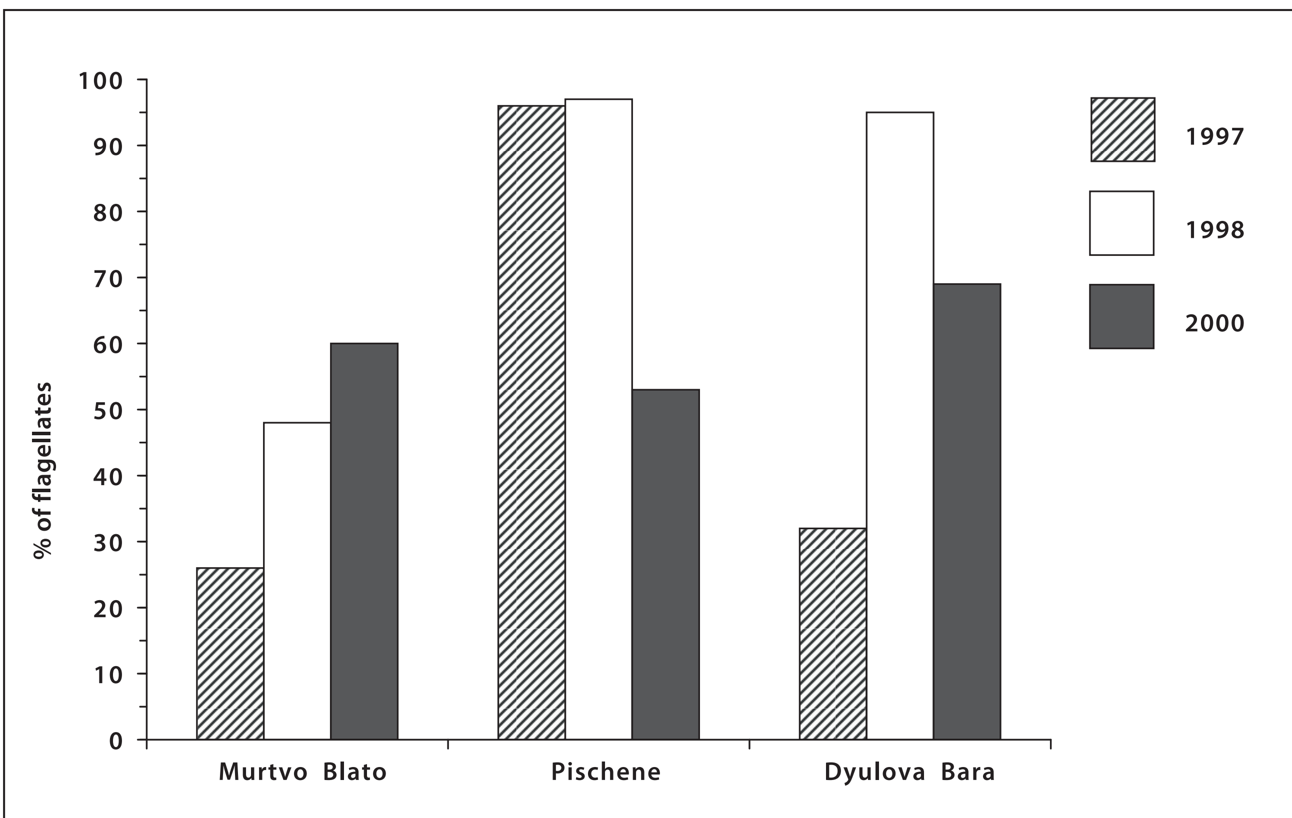

Fig. 3. Percentage of flagellates to the total phytoplankton biomass.

1998) at low water levels in summer. One of the reasons for the low spring values of the biomass might be the increase of water turbidity, because of the great amount of sand found in the samples (which even hindered their processing). Possibly, inert materials in the water inhibit the phytoplankters by clashing with them, or by additionally disturbing the light climate. The highly significant correlation of the total numbers of phytoplankton and NH_4-N is probably related to nitrogen limitation and indicates a likely preference of ammonium as a source of nitrogen by the phytoplankton. Although some authors have found a relationship between the preference of primary producers of one or another form of nitrogen and the stage of successional development of water basins (Kalchev & Tsvetkova 1996), the question on what occasion the algae prefer to take ammonium or nitrate still remains unsolved.

Probably by reason of environmental variability, the phytoplankton structure has shown great differences between the various wetlands. As the changes of environmental conditions happen within a very short time span, the shift of species and changes in their amount are also rapid and to a great extent unpredictable. The Steinhaus Similarity Coefficient has clearly shown, first, a considerably higher similarity between the interconnected Murtvo Blato and Pischene wetlands and, second, very low similarity between the wetlands in the summer months at low depth (Table 3). This can be explained by the fact that in summer the progressive process of desiccation strengthens the differences between the specific features (depths, degree of turbidity, pattern of macrophytes, light climate and others) in the distinct wetlands.

Against the background of significant differences in the taxonomical structure of phytoplankton, we have established that a greater part of the dominant species (mainly *Chlorophyta*, *Euglenophyta* and *Cryptophyta*) are flagellates, with a combination of some morphological, functional and life-cycle adaptive traits increasing their survivability under unfavourable conditions. These traits are as follows: 1) Motility – the success of flagellated species has been usually associated with the oligotrophic, nutrient-limited conditions in stratified water bodies, because of their ability to engage in vertical migration and derive nutrients from deeper layers (Hehmann & Krienitz 1996; Krienitz & Hehmann 1997). Motility in the shallow water basins probably has another meaning: it enables the organisms to move to cooler refuges or near the sediment surface, when temperature and solar radiation reach very high values (Williams 1985), or conversely, to look for a more favourable light climate in case of shading by macrophytes; 2) Ability of switching over from phototrophy to hetero- or mixotrophy. This is typical of many crypto-, pyrrho- and euglenophytes and gives them an advantage over the other species under the conditions of nutrient and/or light limitation; 3) Ability of forming resistant spores or dormant vegetative bodies typical of many cryptomonads (cysts and palmella), euglenophytes (dormant stages and palmella), chlorophytes (palmella at many valvocales), and dinoflagellates (cysts) that contribute to their survival under unfavourable conditions and desiccation.

A juxtaposition of the taxonomical differences of the wetlands and their similarity in relation to flagellates testifies how important the morphological and functional approach (along with the taxonomical one) is in determining the structure of phytoplankton community.

Differences in species diversity were insignificant and did not correspond adequately to biomass fluctuations, insofar as there existed in principle a reverse relationship between diversity and biomass. The Shannon-Weaver Coefficient showed very high values even in comparison with the richest in species shallow lake near the Danube River, the Srebarna Biosphere Reserve, where these coefficients ranged from 0.86 to 3.13 in the period from 1987 to 1995 (Stoyneva 1998). In the wetlands studied by us this coefficient exceeded 2.0 in all cases and approached 3.46 (Table 1). Most likely, the reason for the high species diversity was that under the variable and unstable conditions and under nitrogen limitation none of the species reached a very high degree of relative abundance. Probably the cases of mass development of certain species, as in the case of *Eudorina elegans* in Dyulova Bara, were accidental and unpredictable.

Conclusion

The organisms inhabiting the temporary wetlands are subject to stress in the result of highly changeable and unstable conditions which may be unpredictable. Environmental instability is a probable reason for the large differences in phytoplankton structure between the studied wetlands, more pronounced in the summer period, at low water depth.

In spite of these differences, a common feature of the three wetlands is the high percentage of flagellates among the dominants, belonging mainly to *Chlorophyta*, *Euglenophyta* and *Cryptophyta*. This testifies how important the morphological and functional approach is in understanding the phytoplankton structure.

The studied wetlands resemble the other water basins near Danube River in respect to the leading role of *Chlorophyta* in terms of taxonomical richness. There are some differences in respect to *Cyanoprokaryota* that were represented in lower quantities in the wetlands on Belene Island.

In spite of the unstable conditions and temporary character of the studied wetlands, the species diversity of phytoplankton (according Shannon-Weaver) shows very high values. This high diversity, however, is rather due to the low species dominance, than to the high species number.

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