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Microphytobenthic communities in the fresh water of Trsteno Arboretum (southern Croatia)

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The microphytobenthos from the fresh water of Trsteno Arboretum consisted of 84 species, mostly diatoms (55 species). There were 15 representatives of *Chlorophyceae* and 10 *Cyanobacteria*, as well as scattered representatives of *Schizomycetes, Xanthophyceae* and *Mycota*. Five diatoms were present throughout the research period: *Achnanthes affinis* Grun., *A. microcephala* Grun., *Cocconeis placentula* Ehr., *Synedra ulna* Ehr., and *Gomphonema dichotomum* Kütz. The maximal number of species was detected during the winter and spring, and the minimum number in autumn. The saprobic index, based on the characteristic species determined in the benthic community (ranging from 1.7 to 2.2) indicated moderate impurity.

Key words: benthic, algae, phytobenthos, saprobic index, fresh water, arboretum, Croatia

Introduction

Trsteno Arboretum consists of cultivated trees and shrubs, primarily olive and laurel. It also contains a wood of Aleppo pines, as well as one of holm oak *(Quercus ilex* L.*)* in various stages of degradation and poorly developed stocks of littoral, thermophilic, pubescent oak *(Quercus pubescens* Villd.*)*. The practice of introducing exotic species in the area goes as far back as to the early 16th century, and has been kept up. In 1960 the Arboterum was declared a protected reserve.

The local flora of Trsteno was published by ADAMOVIĆ (1887, 1911, 1929), and UGRENOVIĆ (1953). However, nothing has been published about the freshwater microphytes in the area.

The main objective of the present research was to determine the species composition of the microphytobenthos in the stream that crosses the Arboretum and the adjoining areas. The appended water qualification is based on the saprobiological characteristics of the species in the microphytobenthic communities.

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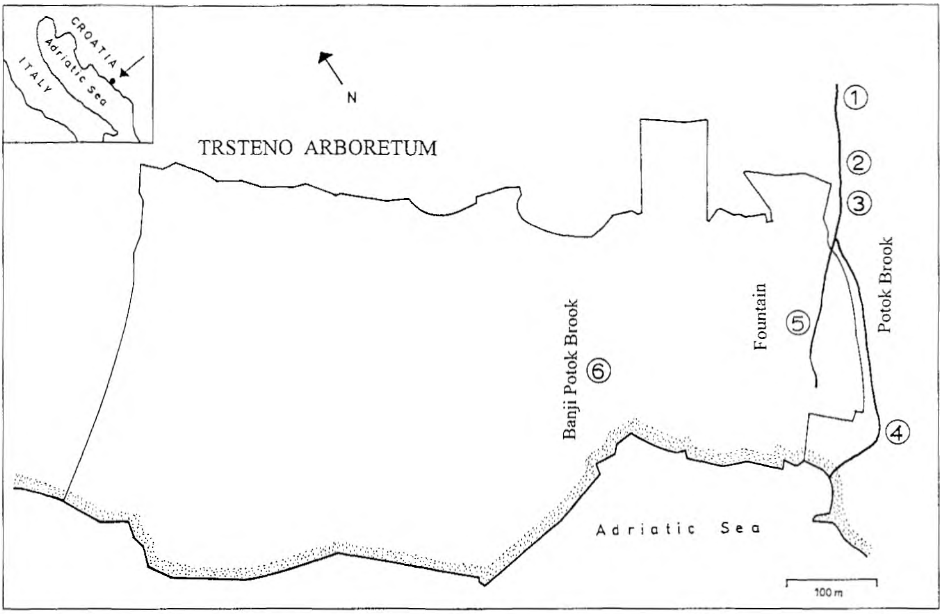


Fig. 1. The research area with sampling sites.

Study area

Trsteno Arboretum (total area: 285 ha) is situated 19 km northwest of Dubrovnik, South Croatia (Fig. 1). There is the strong karstic spring in Trsteno, just above the arboretum. This water is essential for the survival of the old park, while the remaining stream water enters the sea. The area mostly consists of highly permeable Jurassic, Cretaceous and Palaeocene limestones, which have created Mediterranean limestone soils (ŠKORIĆ 1977).

The region is influenced Mediterranean, humid climate (BERTOVIĆ 1975, GRAČANIN 1952). The average air temperature of 15.5 °C in the period 1970–1990. The lowest monthly average air temperature of 3.8 °C has been recorded in January-February, and the highest value of 23.8 °C in July (ĐURASOVIĆ and KOVAČEVIĆ 1995–1996).

The investigation was performed in six sites (Fig. 1) in order to analyze the coefficient of floral similarity and saprobiological characteristics of the phytobenthic communities. Site 1 was situated at the source of Potok (the stream), Sites 2 and 3 were in the upper portion of the stream, while Site 4 was defined just before the stream's entry into the sea. Site 5 was placed in a fountain in the old park, and Site 6 in a winterbourne (Banji Potok).

Materials and methods

Seasonal investigation was performed in the period 1995–1996. Samples were taken by scraping the epilithon of rocky surfaces submerged at depths of 10 to 20 cm. Samples were preserved in 4% neutralized formaldehyde (final concentration). The identification of microphyte species was done using a »Standard 20 Microscope« and identification manuals such as: ZABELINA et al. (1951), HINDAK et al. (1978), and HAUSLER (1982). The relative abundance of species, the relative purity and loading were determined by methods according to KNÖPP (1955). Saprobity index was calculated using indicator species and their indices according to WEGL (1983). The coefficient of floral similarity (QS) was calculated according to SØRENSEN (1948).

Results

The microphytobenthos was composed of 84 species. 66% of the total number (Tab. 1) was accounted for by diatoms (*Bacillariophyceae*), 18% by *Chlorophyceae*, 12% by *Cyanobacteria*, 3% by *Xanthophyceae*, and 1% each by *Schizomycetes* and *Mycota*. During the study the following species could be observed as being permanently present: *Achnanthes affinis* Grun., *A. microcephala* Grun., *Cocconeis placentula* Ehr., *Synedra ulna* Ehr., and *Gomphonema dichotomum* Kütz.

The maximal number of species and relative frequency of individuals were detected during the winter-spring period, while the autumn was characterised by the lowest values (Figs. 2 a-b).

The *Schizomycetes* were represented by the *Cladothrix dichotoma* Cohn., permanently and exclusively found in samples from Sites 2 and 3. The maximum abundance of this species was reached in autumn. In the same period, the fungus *Fusarium aquaeductum* Lagerhaim was detected, indicating increased organic pollution. The number of species of *Chlorophyceae*, *Cyanobacteria* and *Xanthophyceae* was observed to be maximal during spring. Their abundance decreased rapidly towards the colder months (Fig. 3). Diatoms were dominant throughout the investigation, with the maximum in winter.

The following species showed a relative frequency ≥5: *Tribonema minus* Hazen, and *T. viride* Pasch. (Xanthophyceae); *Scenedesmus quadricauda* Bréb., and *Cladophora glomerata* Kütz. (Chlorophyceae); *Cocconeis placentula* Ehr. *Synedra ulna* Ehr., *Navicula minima* Grun., *Gomphonema olivaceum* Kütz., and *G. acuminatum* var. *coronatum* Cl. (Bacillariophyceae).

In the lower portion of Potok, species with low relative frequencies (=2), indicating lower water quality, were as follows: *Cladothrix dichotoma* Cohn., *Navicula ryncho-cephala* Kütz., *Nitzschia palea* W. Sm., *N. dissipata* Grun., and *Stigeoclonium tenue* Kütz.

The saprobic index, ranged from 1.7 to 2.2 (moderate impurity), and the relative purity was calculated to be between 86 and 100 percent (Tab. 2).

The coefficient of floral similarity ranged from 89 to 94%. The lowest value was observed when comparing the spring and winter periods (QS = 17%), the largest discrepancy between sites was found in the case of Site 1 and Site 5 (QS = 12%). The highest index of similarity was detected in spring and summer at Sites 2 and 3 (QS = 58%).

Discussion

The species composition and diversity of epilithic organisms in Trsteno were not significantly different from those in other freshwater streams in Croatia such as: Veliki Potok Stream, Bliznec and Medveščak (PLENKOVIĆ-MORAJ 1995, 1996, 1997), or the Žrnovnica River (BONACCI et al. 1998). The lowest frequencies of species were caused by oxygen

Tab. 1. List of epilithic species and their relative abundance in the Trsteno Arboretum, during 1995–1996. s=index of saprobity

		Season Site Year: 1995, 1996																						
TAXON	s	Spring						Summer					Autumn						Winter					
		1	2	3	4	5	6	1	2	3	4	5	1	2	3	4	5	6	1	2	3	4	5	6
SCHIZOMYCETES																								
Cladothrix dichotoma Colun.	2.4		-,1	-,1					1, -	1, 2				3, -	4, 3					1, 1	2, 2			
CYANOPHYCEAE																								
Chroococcus turgidus Naeg.	1.8		1, -									-, 1			1, -		1, -							
Gloeocapsa polydermatica Kutz.	1.2	1, -											1, -											
Homoeothrix varians Geitl.	1.0	1, 1	2, 0	2, 2																				
Lyngbya margaretheana Menegh.	2.0	1, -						1, -																
Merismopedia punctata Meyen.	1.9			1, -			0, 2			2, 0		1, -												
Oscillatoria bornetii Zukal	1.2	3, 2				-, 1																		
Phormidium inundatum Kutz.	1.4	1, 1			1, -					1, -			1, -						-, 1					
Ph. retzii Gom.	1.5	2, 2			3, 2	1, -	1, -	1, 2	1, 2	1, 1			-, 1										-, 1	1, -
Ph. molle Gom.	2.0					2, 0	2, 2		-, 1						1, -									1, -
Scytomena myochrous Ag.	1.2	-, 1	3, 0		2, -		3, 2	-, 1					1, -						-, 1					
BACILLARIOPHYCEAE																								
Achnanthes lanceolata Grun.	2.2	1, 1	1, -		1, 1		-, 1	1, 1			-, 1	-, 1		-, 1		-, 1	1, 1	-, 1	1, 1	1, 1	1, 1	1, 1		1, 1
A. microcephala Grun.	2.0	1, 1	1, -	1, 3	1, 1	1, 1	-, 1	-, 1	1, -	1, -	1, -	1, 1	-, 1	-, 1	1, 1	-, 1	1, 1	1, 1	1, -	1, 1	-, 1	-, 1	-, 1	1, 1
A. minutissima Kutz.	2.0	1, 1	2, 1				1, 1	1, 1	1, 1	1, -	1, 1	1, 1		1, -	1, -	1, -	-, 1		1, -	1, -		1, -	1, -	1, 1
A. affinis Grun.	2.0	2, 1	3, 1	1, 4	3, 1	1, 4	1, 2	1, 2	1, 1	1, 2	1, 1	1, 1	1, 1	2, 1	2, 2	1, 1	2, 2	2, 2	1, 1	1, 1	2, 3	3, 2	3, 2	3, 2
Amphipleura pelucida Kutz.	1.3	1, 1			1, 1							1, 1								-, 1				1, -
Amphora ovalis Kutz.	1.7					1, 1	1, 1																	1, 1
Caloneis silicula Cl.	1.8						1, -						1, -					1, -					-, 1	
Ceratoneus arcus Kutz.	1.4	2	1, -		-, 1	1, 1	1, 1	-, 1		1, -			1, -	1, -	1, -			1, 1		-, 1	1, -			1, 1
Cocconeis placentula Ehr.	1.6	2, 3	4, 3	1, 3	-, 3	4, 5	1, 1	2, 1	1, 1	2, 1	1, 1	1, 1	2, 2	2, 2	1, 2	2, 2	1, 1	1, 1	1, 1	1, 1	1, 1	2, 2	2, 2	3, 2
C. pediculus Ehr.	1.7				-, 1		4, 2		-, 1			1, -		1, -					1, -				1, 1	
C. placentula var. *euglypta* Cl.	1.6			1, 2		3, 3		1, 1			1, 1													
Cyclotella comta Kutz.	1.2	-, 1			1, 1					1, 1						-, 1	1, -				1, -			
C. kuetizingiana Thw.	1.5				-, 1			1, -				-, 1			1, -		1, -		1, -		1, -		1, -	
Cymbella ventricosa Kutz.	2.0		1, 2		1, 2	1, 1	-, 1	1, -		1, 1		1, 1			1, 1		-, 1	-, 1			1, 1	1, 1	1, 1	1, 1
C. affinis Kutz.	1.3	1, 1			3, 2			1, 1	1, 1	1, 1	-, 1	2, -	1, 1				-, 1	-, 1	1, -		1, 1	1, -	1, -	
C. delicatula Kutz.	1.7	1, 1						1, 1					1, 1	-, 1		1, -			1, -		1, -		1, -	
C. laevis Naeg.	1.7	1, 1				1, -			1, 1			1, 1	1, 1		2, 1	1, 1	1, -		1, -	-, 1	1, 1	-, 1	1, -	-, 1
C. lanceolata V.H.	1.6				1, -		-, 1					1, -			1, -		-, 1		1, -	-, 1		-, 1		1, -
C. parva Cl.	1.7				1, -					1, -													1, -	
C. turgidula Gom.	1.7					1, -								1, -			-, 1			-, 1				
Denticula tenuis Kutz.	1.2	1, 1								-, 1					1, 1	1, -		1, -		-, 1				-, 1
Diatoma vulgare Bory.	2.2	-, 1			1, 1		3, 4				1, 1							3, 2			1, 1		1, 1	2, -
D. v. var. *capitulatum* Grun.	1.9						2, 2																	
D. elongatum var. *tenue* V.H.	1.9									2, 2												1, 1	-, 1	1, 1
Diploneis ovalis Cl.	1.4				1, 1		2, 1		1, -			-, 1			1, -		-, 1		-, 1			1, -	-, 1	1, -
Eunotia arcus Ehr.	1.1					2, 2				-, 2	2, 2	-, 1	1, 1	1, 1	1, -			-, 1	1, 1		-, 1	1, 1	1, 1	1, 1
Fragilaria capucina Desm.	1.6		-, 2	1, -	1, 1		1, 1	1, 1	1, 1	1, 1	1, 1	1, -	1, 1			1, -		1, 1		1, 1	1, 1			2, 1
Gomphonema olivaceum Kutz.	2.0	-, 1			3, 2	5, 3	3, 3					1, 1		1, 1		1, 2	1, -	1, -			1, 1		6, 5	2, 1
G. acuminatum Ehr.	1.7					2, 7	1, -	1, -															2, -	
G. a. var. *coronatum* W.Sm.	1.7		-, 1			2, 5											4, 3				2, 3		1, 3	
G. dichotomum Kutz.	1.2	1, 1	-, 1	1, 1	2, 1	4, 2	2, 1	1, 1	1, 1	1, 1	1, 1	1, 1	-, 1	-, 1	1, 1	1, 1	1, 2	2, 2	1, 2	2, 2	1, 1	1, 1	2, 3	1, 1

Tab. 1. – continued

		Season Site Year: 1995, 1996																						
TAXON	s	Spring						Summer					Autumn						Winter					
		1	2	3	4	5	6	1	2	3	4	5	1	2	3	4	5	6	1	2	3	4	5	6
G. d. var. pumillum Grun.	2.2				1, -	4, 1	3, 2			1, -					-, 1	-, 1							1, 1	
G. intricatum	1.2		-, 1			1																	1	
G. i. var. coronatum Kutz.	2.2					3, -										1, 1								1, 1
G. parvulum Grun.	2.1	-, 1			1, 1	2, 3	3, 3		1, 1	1, -	1, 1	2, 1			1, 1								2, 1	
Gyrosigma spenceri Cl.	2.1				1, -	1, -		1, -		-, 1		-, 1		1, 1	1, 1		1, 1			-, 1	1, -	1, 1		
G. accuminatum Rab.	1.7					-, 2						3, 2												
Melosira varians Ag.	2.0										2, 2			2, 1		4, -	-, 1			1, -		1, 1		
Meridion circulare Ag.	1.1	1, 1	2, 1		2, -	1, -	3, 3	1, -				-, 1				-, 1	2, 2			1, -	1, -	-, 1	1, -	3, 2
Navicula gracilis Ehr.	1.7		4, 1		1, 3			1, -	1, 2	1, 2	1, 3	2, 2	1, 1		3, 3					1, 2				1, 1
N. mutica Kutz.	2.0				1, 2							1, 1		-, 1						-, 1		1, 1		1, 1
N. perpusilla Grun.	1.0	1, 1		-, 2							1, -	1, -												
N. pupula Kutz.	1.9			1, 4	1, 1	1, 1	1, 1	1, 1				1, -					-, 1		1, 1		1, 1	1, 1	1, 1	1, 1
N. radiosa Kutz.	2.0		1, 1		2, 2	-, 1	1, 1	1, 1	1, 1	1, 2		3, 4			1, 1		1, 1							
N. minima Grun.	2.2	2, 2	4, 3	2, 5	3, 3	1, 3	1, 1	2, 1	1, 1	1, 1					3, 2			1, 1	1, 1	1, 1	3, 2	3, 2	1, 1	2, 1
Nitzschia palea W.Sm.	2.7				1, 1										-, 1	1, 1	1, 1				1, -			1, -
N. recta Hantzsch	1.7				-, 1		-, 1	1, -	1, -	-, 1	1, 1	1, -	-, 1	-, 1		1, 1		1, 1	1, -	1, 1		-, 1		1, -
N. rhynchocephala Kutz.	2.7			1, -	1, 2							1, 1					-, 1		-, 1		1, -	1, -	-, 1	
N. heufleriana Grun.	1.2	1, 1	-, 1									-, 1							1, -					
Rhoicosphenia curvata Grun.	2.0				1, -							-, 1					-, 1	1, -				-, 1		
Stauroneis anceps Ehr.	1.4	2	1, -	1, -	1, 1		1, -	1, 1		1, -		-, 1	-, 1		1, -			1, 1		-, 1	1, -			1, -
Surirella ovata Kutz.	2.0				-, 1		1, -	1, 1			-, 1				-, 1				1, -				1, -	
Synedra ulna Ehr.	2.0	1, 1	1, 1	1, 1	2, 1	5, 7	3, 4	1, -	1, 1	1, 1	2, 2	3, 3	1, 1	1, 1	1, 1	1, 1	2, 2	1, 1	1, 1	1, 1	1, 1	2, 2	4, 3	2, 1
S. capitata Ehr.	1.5			3, 3			2, 2			-, 1	1, 1				1, 1	-, 1	1, 1					1, 1	-, 1	
XANTHOPHYCEAE																								
Tribonema minus Hazen.	1.6	7, 1	3, 3	1, 4	7, 5	4, 5	3, 4						1, 2											
T. viride Pasch.	1.5			5, 7	1, 3			1, 1																
CHLOROPHYCEAE																								
Ankistrodesmus falcatus Ralfs.	2.1				1, -																		1, -	
Cladophora glomerata Kutz.	2.0	7, 6				7, 1						7, 4												
Closterium aciculare West.	1.7	1, 1			1, -	1, 1						-, 1	-, 1	-, 1										
C. ehrenbergii Menegh.	2.0													-, 1										
Cosmarium botrytis Menegh.	2.3		-, 1			1, 1																	1, -	
C. formosulum Hoff.	1.8	-, 1		-, 1	-, 1																			
C. impressulum Elfv.	1.8											1, -												
Scenedesmus quadricauda Breb.	2.1		-, 1		1, 1	5, 1			1, 1	1, 1		2, 1					1, -						2, 1	
S. q. var. *longispina* Chod.	2.2					3, 2																	2, -	
S. q. var. *papillatus* Chod.	2.2			-, 1		2, 1																		
S. q. var. *spinosus* Chod.	2.2		-, 1		1, 1	2, -																	2, -	
S. acuminatus Chod.	2.2				-, 1	2, -		1, -															1, -	
S. bijugatus Kutz.	2.2			-, 1		2, -							1, -										1, -	
S. obliquus Kutz.	2.2					1, -		1, -															1, -	
Stigeoclonium tenue Kutz.	2.8			3, 1		2, 1								-, 1										
MYCOTA																								
Fusarium aquaeductum Lagerhaim	3.8														1, 2									

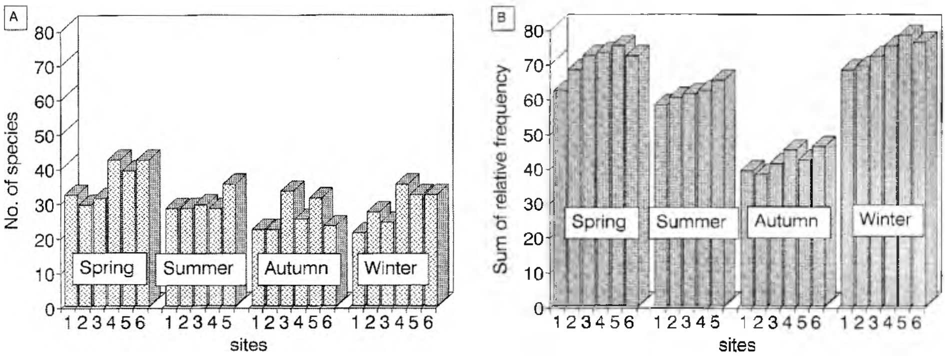
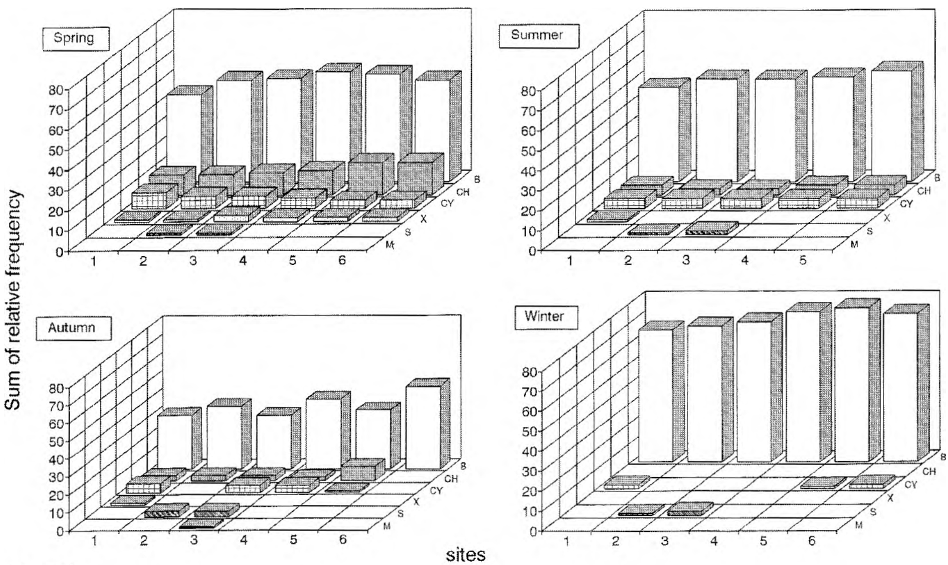


Fig. 2. Number of species (A) and the sum of relative frequencies (B) in epilithon communities (Trsteno arboretum during 1995–1996.)



Legend:
B = Bacillariophyceae; CH = Chlorophyceae; CY = Cyanophyceae; X = Xanthophyceae; S = Schizomycetes, M = Mycota

Fig. 3. Seasonal distribution of epilithic species in phytobenthic communities (Trsteno arboretum during 1995–1996.)

depletion. The low values in winter (except for diatoms) were the direct consequences of community stagnation due to lower water temperature (WACHS 1980).

During the research period, the species permanently present *(Achnanthes affinis* Grun., *A. microcephala* Grun., *Cocconeis placentula* Ehr., *Synedra ulna* Ehr., and *Gomphonema dichotomum* Kütz.*)* showed various abundances. Their increased abundance in spring have already been observed by GESSNER (1955), and their adaptation to various water currents has been confirmed (BACHAUS 1968). Being pioneers in the settlement of new surfaces and

Tab. 2. Water quality in the Trsteno arboretum based on epilithic species as indicators

	Season / Site																						
	Spring						Summer					Autumn						Winter					
Parameters	1	2	3	4	5	6	1	2	3	4	5	1	2	3	4	5	6	1	2	3	4	5	6
Saprobic index	1.7	1.9	1.7	2.1	2.0	1.9	1.9	1.9	2.1	2.0	2.2	1.7	1.9	1.9	2.0	2.1	2.1	1.9	2.0	1.9	2.1	2.0	2.1
Saprobic level	I-II	II	I-II	II	II	II	II	II	II	II	II	I-II	II	II	II	II	II	II	II	II	II	II	II
Saprobic degree	o-b	b	o-b	b	b	b	b	b	b	b	b	o-b	b	b	b	b	b	b	b	b	b	b	b
Relative purity (%)	96	88	100	93	97	100	100	95	93	86	97	100	98	86	88	98	100	96	100	97	94	95	92
Relative loading (%)	4	12	0	7	3	0	0	5	7	14	3	0	2	14	12	2	0	4	0	3	6	5	8

permanent members of epilithic communities, these species are also referred to by MUNTEANU and MALY (1981).

Temperature and the quantity of autochthonous and allochthonous organic input considerably influence the intensified development of *Cyanobacteria* in spring and autumn (KUZNECOVA 1975, VOIGHT and KOSTE 1978). The maximal development of *Cyanobacteria* in spring has already been reported (LAMBERTI and VINCENT 1985, SNOEIJS and PRENTICE 1989). In this period an insignificant increase was observed in the development of *Cyanobacteria* (genera *Phormidium* and *Oscillatoria).* The majority of *Cyanobacteria* found in Trsteno, primarily species from the genera *Gloeocapsa, Scytonema* and *Homoeothrix,* are characteristic species of clean karstic waters (GOLUBIĆ 1957, MARČENKO 1960).

The genus *Scenedesmus* dominated among the species of *Chlorophyceae*, indicating anthropogenic eutrophication (KUZNECOVA 1975). The highest population density of *Chlorophyceae* was recorded in spring, while they were not found in the epilithon during winter.

The presence of the species *Cladothrix dichotoma* Cohn. and *Fusarium aquaeductum* Lagerhaim in Sites 2 and 3 is a reliable indicator of minor organic pollution (HAUSLER 1982).

The high coefficient of floral similarity for the period 1995–1996 indicated a comparable taxonomic composition. The low saprobity index, as well as the high relative purity, indicated good water quality in Trsteno Arboretum.

Conclusion

Eightyfour species of the microphytobenthos were identified in the fresh water stream of Trsteno Arboretum. In comparison with other streams in Croatia, there are no significant differences in the diversity of epilithic species.

The greatest number of species and greatest relative abundance of individuals were established during spring and winter periods. Reduced values of these parameters were obtained during autumn.

There was a permanent presence of the species: *Achnanthes affinis* Grun., *A. microcephala* Grun., *Cocconeis placentula* Ehr., *Synedra ulna* Ehr., and *Gomphonema dichotomum* Kütz. at all investigated sites.

Diatoms were dominant throughout all seasons and sites, their peak density values coming in winter. *Chlorophyceae, Cyanobacteria* and *Xanthophyceae* reached the maximum number of species during spring. Their abundance decreased rapidly during the colder months. The majority of *Cyanobacteria* found in the Potok Brook of Trsteno are characteristic species of clean karstic waters. The highest population density of green algae was recorded in spring, and they were absent from the epilithon during winter.

During the research, the low values of the saprobity index and the high relative purity indicated water of a good quality.

References

ADAMOVIĆ, L., 1887: Građa za floru Dubrovačku. Glas. hrv. Naravosl. društva 1, 161–216.

ADAMOVIĆ, L., 1911: Die Pflanzenwelt Dalmatines. Leipzig.

ADAMOVIĆ, L., 1929: Die Pflanzenwelt der Adrialander. Jena.

BACHAUS, D., 1968: Oekologische Untersuchungen an den Aufwuchsalgen der obersten Donau und ihrer Quellfluesse. II die raeumliche und zeitliche Verteilung der Algen. Arch. Hydrobiol. 24, 24–73.

BERTOVIĆ, S., 1975: Prilog poznavanju odnosa klime i vegetacije u Hrvatskoj. Prir. Istr. JAZU 41, 89–215.

BONACCI, O., KEROVEC, M., MRAKOVČIĆ, M., ROJE-BONACCI, T., PLENKOVIĆ-MORAJ, A., 1998: Ecologically acceptable flows definition of the Žrnovnica River (Croatia). Regulated Rivers-Res. Menag. 14, 245–256.

ĐURASOVIĆ, P., KOVAČEVIĆ, M., 1995–1996: Delectus seminum. Arboretum Trsteno HAZU, Zagreb.

GESSNER, F., 1955: Die Limnologie des Naturschutzgebietes Seen. Arch. Hydrobiologia 47, 553–624.

GOLUBIĆ, S., 1957: Vegetacija alga na slapovima Krke u Dalmaciji. Rad JAZU 312, 207–259.

GRAČANIN, Z., 1952: Pedološka studija arboretuma Trsteno. Prir. istr. JAZU 25, 227–267.

HAUSLER, J., 1982: *Schizomycetes.* VEB Gustav Fischer Verlag, Jena.

HINDAK, F., CYRUS, Z., MARVAN, P., JAVORNICKY, P., KOMAREK, J., ETTL, H., ROSA, K., SLADEČKOVA, A., POPOVSKI, J., PUNOCHAROVA, J., LHOTSKY, O., 1978: Slatkovodne riasy. Slovenske pedagogicke nakladateljstvo, Bratislava.

KNÖPP, H., 1955: Neuere Untersuchungen ueber die Wikung von Selbstreiningung. Dt. Gewaesser-Kundl. Mitt. Sonderheft., 63–69.

KUZNECOVA, A., 1975: Obšaja ekologija. Biocenologija. Hidrobiologija.Tom. 2. Itogi nauki i tehniki, Moskva.

LAMBERTI, G. A., VINCENT, H. R., 1985: Distribution of benthic algae and microinvertebrates along a thermal stream gradient. Hydrobiologia 128, 13–21.

MARČENKO, E., 1960: Prilog poznavanju vegetacije algi na području slapova Plitvička jezera. Rad JAZU 320, 106–152.

MUNTEANU, I., MALY, E. J., 1981: The effect of current on the distribution of diatoms settling on submerged glass slides. Hydrobiologia 78, 273–282.

PLENKOVIĆ-MORAJ, A., 1995: Diatoms (*Bacillariophyceae*) of the Croatian freshwaters. Acta Bot. Croat. 54, 22–33.

PLENKOVIĆ-MORAJ, A., 1996: Index of Croatian freshwater *Cyanophyceae*. Nat. Croat. 5, 299–315.

PLENKOVIĆ-MORAJ, A., 1997: Index of Croatian freshwater *Chlorophyceae*. Nat. Croat. 6, 67–89.

SNOEIJS, P. J. M., PRENTCE, I. C., 1989: Effects of cooling water discharge on the structure and dynamics of epilithic algal communities in the northern Baltic. Hydrobiologia 184, 99–123.

SØRENSEN, T., 1948: A method of establishing groups of equal amplitude in plant sociology based on similarity of species content and its application to analyses of the vegetation on Danish commons. Biol. Skr. (k. danske Videsk. Sel.) 5, 1–34.

ŠKORIĆ, A., 1977: Tipovi naših tala. Školska knjiga, Zagreb.

UGRENOVIĆ, A., 1953: Trsteno. JAZU, Zagreb.

VOIGHT, M., KOSTE, W., 1978: Die Radertiere Mitteleuropas. Gebruder Borntraeger, Berlin-Stuttgart.

WACHS, B., 1980: Die periphytische Primaeproduktion in einem gestaten Fluss in Abhaengigkeit von der Abwasserbelastung und der Gewasserguete. Muench. Beitr. Abw. Fisch. Flussbiol. 32, 195–224.

WEGL, R., 1983: Index für die Limnosaprobität. Wasser Abwasser 26, 1–175.

ZABELINA, M. M., KISELEV, I. A., PROŠKINA, A. I., ŠEŠUKOVA, V. I. 1951: Opredelitelj presnovodnih vodoroslei SSSR. Diatomovie vodorosli. Gosudarstvenoe izdateljstvo Sovjetskaja nauka, Moskva.