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Periphyton composition and diversity in the Kaunas Lagoon and the Nemunas River[1]

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Periphyton is a biological layer found in various substrata in natural waters and consists of bacteria, algae, fungi, protozoa, and small metazoans. It plays an important role in trophic and functional dynamics in freshwater ecosystems.

The Kaunas Lagoon and the Nemunas River are among important freshwater ecosystems in Lithuania. However, little is known about periphytic communities in these freshwater habitats. The aim of this investigation was to determine the taxonomic composition and diversity of periphytic organisms in the Kaunas Lagoon and the Nemunas River.

Periphyton samples were collected from the stones at regular intervals to compare periphytonic community structure and to examine its temporal changes. Totally, 28 taxa of periphyton were collected and identified. Most of the taxa belonged to Bacillariophyta. In all locations the dominant species were diatoms *Navicula lanceolata, Craticula cuspidata, Amphora ovale*. Seasonal assessment of the distribution of periphyton shows that in both water bodies more organisms were found in late summer. The seasonal succession of the periphyton community was more significant in the Nemunas River.

Key words: periphyton, algae, freshwater, Lithuania

INTRODUCTION

Periphyton is a biological layer found in various substrata in natural waters and consists of bacteria, algae, fungi, protozoa, and small metazoans (Hameed, 2003). It plays an important role in trophic and functional dynamics in freshwater

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ecosystems. Periphytonic organisms in freshwater habitats integrate into benthic food webs as prey for larger animals and/or as consumers of bacteria and algae (Schmid-Araya, Schmid, 2000; Schmid, Schmid-Araya, 2006). In our opinion the research of the periphyton in freshwater habitats of Lithuania is still far too limited. Traditionally most hydrobiological studies have focused on phytoplankton (Kasperovičienė, 2001; Hällfors, 2004; Kalytytė, 2007) and less attention is paid to the attached communities regardless of their growth in the most productive littoral zone of aquatic ecosystems (Wetzel, 2001; O'Reilly, 2006). The Kaunas Lagoon and the Nemunas River are among important freshwater ecosystems in Lithuania that differ by hydrobiological characteristic. However, little is known about periphytic communities in these freshwater habitats. The aim of this investigation was to determine the taxonomic composition and diversity of periphytic organisms in the Kaunas Lagoon and the Nemunas River.

MATERIALS AND METHODS

Periphyton sampling locations and its characteristics

Periphyton was investigated in stagnant and flowing freshwater systems: the Kaunas Lagoon and the Nemunas River. Samples were collected at six locations: three locations in the Kaunas Lagoon and three locations in the Nemunas River.

The Kaunas Lagoon (54°51'10'N, 24°10'2'E 54.852778°, 24.167222°) is the largest artificial water body in Lithuania created in 1959 when the Nemunas River was dammed. An average lagoon depth is about 9–12 m, but in deepest locations can reach 22 m. Water level of the Kaunas Lagoon is about 44 m above sea level. The coast shallow near moraine banks are pebbled and the shallow can become silty in the sandy coast. Shores of the lagoon are dominated by mixed and deciduous forests. Periphyton samples were collected at three locations, the

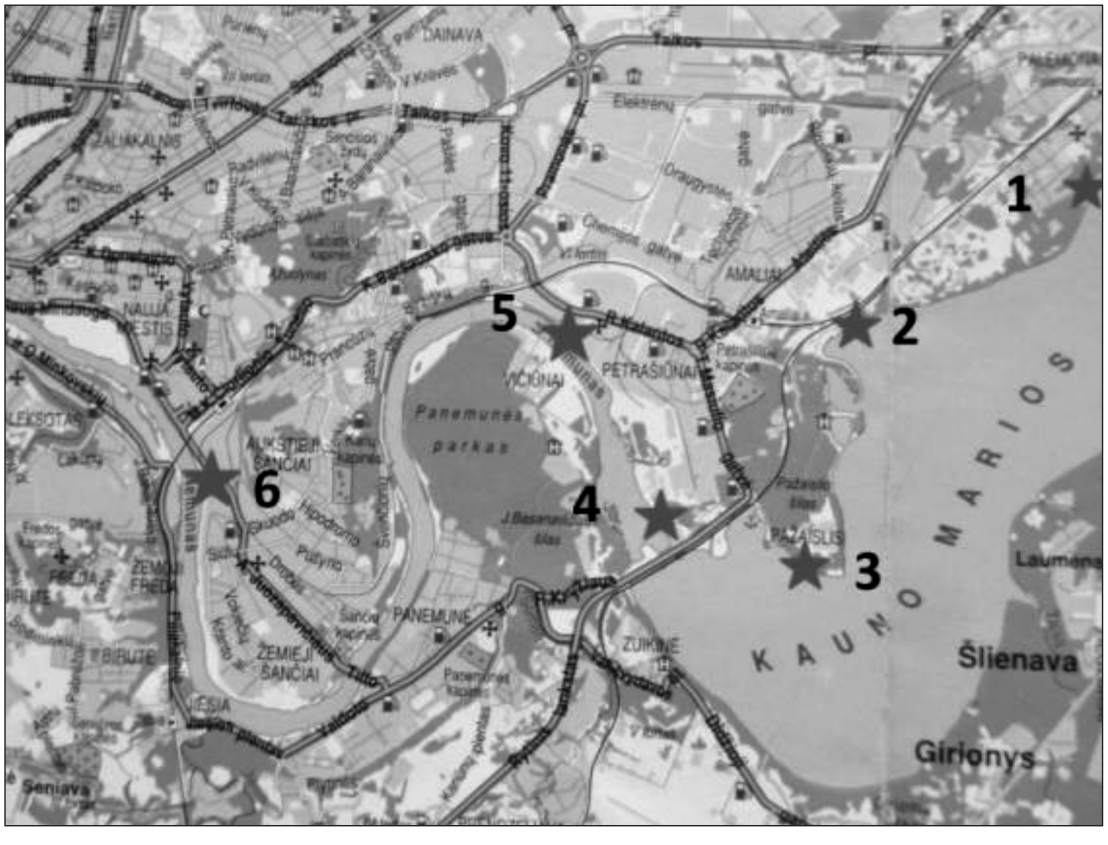

Fig. 1. Periphyton sampling locations in the Kaunas Lagoon and the Nemunas River

Table 1. Periphyton sampling time, pH and temperature

Sampling locations	pH				Temperature			
	June	July	August	September	June	July	August	September
1(lagoon)	8.1	8.4	8	7.8	19	24	18	16
2(lagoon)	8.2	8.2	7.8	7.9	20	23	20	16
3(lagoon)	8.3	8.1	7.9	7.8	16	23	19	17
4(river)	7.8	7.6	7.6	7.6	19	21	20	16
5(river)	7.7	7.4	7.4	7.5	19	20	21	16
6(river)	7.5	7.7	7.4	7.5	18	21	19	16

distance between locations was about 3 km (Fig. 1).

The Nemunas River (55°04'00, 13'N 22°35'50, 92'E – 53°58'29, 43'N 23°54'46, 18'E) is the largest river in Lithuania, its length is 937 km and depth – from 1.5 to 5 m. Periphyton samples were collected at three locations, the distance between locations was about 4 km (Fig. 1).

Accurate periphyton sampling time, water temperature and pH are shown in Table 1.

Periphyton was collected with scalpel from natural substrates – stones, in 40 cm depth of littoral zone. Samples were transported to laboratory for analysis in 2 hour period after they had been collected. Identification of specimens was based on the keys of Mažeikaitė (2003); Patterson (2003); Kelly et al. (2005). Taxonomic nomenclature was adopted according to the most recent checklists (Mather et al., 2010; Andrejić et al., 2012; Baykal Özer et al., 2012).

Relative abundance of species (p_i) was calculated by:

$$p_i = n_i/N \times 100\%$$

where n_i is a number of individuals of a periphyton species found in the studied sample, N is the total number of individuals of all periphyton species found in the sample. Species that had $p_i > 5\%$ were considered as dominant (Durska, 2001). In order to analyze periphyton organisms diversity, species richness (S) and Shannon-Wiener's (H) diversity indices were calculated for each site.

RESULTS

Twenty nine periphyton taxa were found in the Kaunas Lagoon and the Nemunas River. Due to the lack of clear morphological criteria many of the found individuals were identified to genus. Based on the results, 12 species and 12 genera of periphyton in a stagnant water body, the Kaunas Lagoon, were collected (Table 2). Twelve species and 11 genera were collected and identified in flowing water body, the Nemunas River (Table 3). A list of all taxa found, together with their relative abundance per sample is given in Table 2 and Table 3.

DISCUSSION

After the analysis of the data, we established the same dominant diatoms in comparable proportions during the study period in the Kaunas Lagoon and the Nemunas River: *Navicula lanceolata* (*Bacillariophyta*), *Craticula cuspidata* (*Bacillariophyta*) and *Amphora ovale* (*Bacillariophyta*) (Figs. 2 and 3). The diversity of periphyton organisms in the Kaunas Lagoon (H = 1.79) was slightly higher than in the Nemunas River (H = 1.77). Both values are about 1.7 and it means that the species are rather evenly distributed. However, there are some species that are found with only few organisms or very high numbers.

During the investigation period a seasonal change of periphyton organisms was observed.

In June the Kaunas Lagoon was dominated by *Amoebae* sp. and diatoms: *Navicula lanceolata, Craticula cuspidata, Amphora ovale*. After a

Table 2. Periphyton composition and relative abundance in the Kaunas Lagoon (p_i – relative abundance of species, n_i – a number of individuals of a periphyton species found in the studied sample)

Genus / species	1st location		2nd location		3rd location	
	n_i	p_i	n_i	p_i	n_i	p_i
Chlorophyta						
Cosmarium sp.	123	3.2	3	0.08	3	0.07
Cosmarium subprotumidum	3	0.08	–	–	–	–
Pediastrum boryanum	1	0.03	13	0.35		
Scenedesmus communis	178	4.62	181	4.92	23	0.56
Actinastrum aciculare	2	0.05	–	–	1	0.02
Bacillariophyta						
Amphora ovale	636	16.52	190	5.16	422	10.22
Cocconeis sp.	55	1.43	71	1.93	161	3.9
Craticula cuspidata	1170	30.4	1691	45.95	972	23.53
Cymbella aspera	5	0.13	–	–	2	0.05
Navicula lanceolata	1187	30.84	670	18.21	1936	46.87
Pinnularia viridis	–	–	99	2.69	–	–
Pinnularia acrosphaeria	73	1.9	15	0.41	16	0.39
Biddulphia sp.	1	0.03	–	–	–	–
Cymatopleura solea	1	0.03	–	–	–	–
Didymosphenia sp.	11	0.29	–	–	–	–
Rhoicosphenia abbreviata	276	7.17	538	14.62	395	9.56
Synedra sp.	45	1.17	48	1.3	11	0.27
Flagillaria sp.	–	–	3	0.08	–	–
Gomphonema sp.	–	–	2	0.05	–	–
Ciliophora						
Paramecium sp.	6	0.16	4	0.11	53	1.28
Vorticella sp.	8	0.21	5	0.14	1	0.02
Rhizopoda						
Amoeba sp.	–	–	38	1.03	–	–
Euglenophyta						
Euglena sp.	65	1.69	107	2.91	132	3.2
Rotifera						
Rotifera	3	0.08	2	0.05	3	0.07
Total number of organisms	3 849	100	3 680	100	4 131	100
H (Shannon index)	1.79		1.71		1.53	
S (species richness)	20		18		15	

Table 3. Periphyton composition and relative abundance in the Nemunas River (p_i – relative abundance of species, n_i – a number of individuals of a periphyton species found in the studied sample)

Genus / species	1st location		2nd location		3rd location	
	n_i	p_i	n_i	p_i	n_i	p_i
Chlorophyta						
Cosmarium sp.	10	1.22	–	–	–	–
Pediastrum boryanum	5	0.61	–	–	2	0.05
Scenedesmus communis	50	6.08	14	0.71	142	3.87
Bacillariophyta						
Amphora ovale	71	8.64	108	5.51	1396	38.06
Cocconeis sp.	92	11.19	15	0.77	174	4.74
Craticula cuspidata	100	12.17	264	13.48	148	4.03
Cymbella aspera	6	0.73	–	–	11	0.3
Navicula lanceolata	395	48.05	1040	53.09	1224	33.4
Pinnularia viridis	16	1.95	14	0.71	–	–
Pinnularia acrosphaeria	11	1.34	44	2.25	30	0.82
Cymatopleura solea	–	–	–	–	1	0.03
Rhoicosphenia abbreviata	45	5.47	226	11.54	39	1.06
Synedra sp.	13	1.58	128	6.53	196	5.34
Flagillaria sp.	–	–	3	0.15	8	0.22
Gomphonema sp.	–	–	4	0,2	–	–
Melosira varians	–	–	–	–	11	0.3
Lauderia sp.	–	–	–	–	167	4.55
Ciliophora						
Paramecium sp.	6	0.73	9	0.46	–	–
Rhizopoda						
Amoeba sp.	1	0.12	7	0.36	8	0.22
Arcella sp.	–	–	2	0.1	–	–
Euglenophyta						
Euglena acus	–	–	1	0.05	–	–
Euglena sp.	–	–	78	3.98	108	2.94
Rotifera						
Rotifera	1	0.12	2	0.1	3	0.08
Total number of organisms	822	100	1 959	100	3 668	100
H (Shannon index)	1.77		1.60		1.73	
S (species richness)	15		17		17	

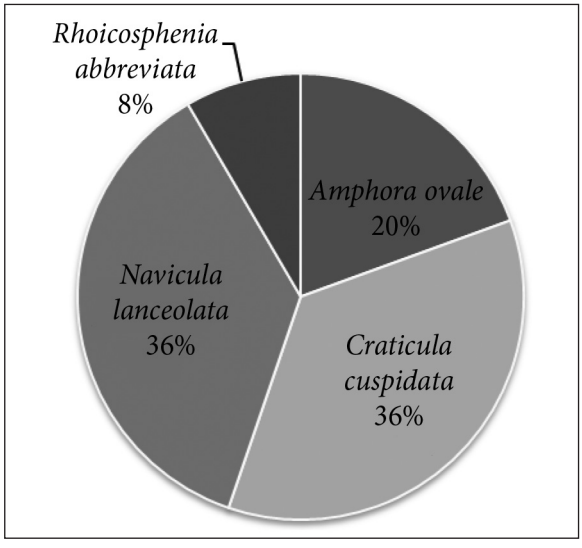

Fig. 2. Dominant species of periphyton in the Kaunas Lagoon

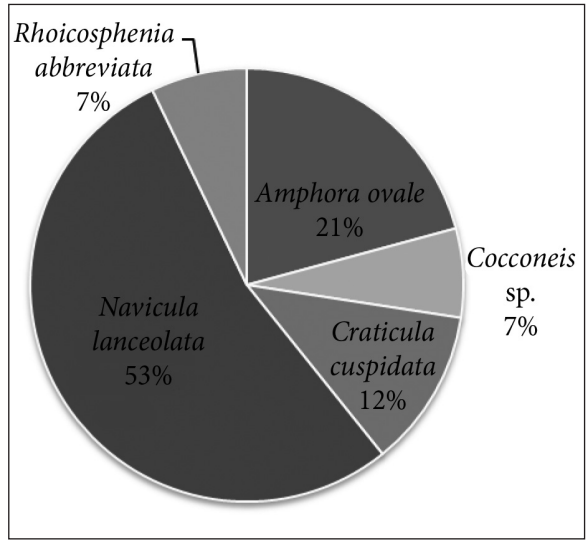

Fig. 3. Dominant species of periphyton in the Nemunas River

month, in July, instead of amoebas *Euglena* sp. dominated. Also, the number of green algae and *Rhoicosphenia abbreviata* diatoms increased. Next month, in August, diatoms *Cocconeis* sp., *Pinnularia* sp. and green algae *Scenedesmus communis* appeared, that were also found in periphyton in September (Fig. 4).

In the Kaunas Lagoon water pH was 7.8–8.4 (Table 1). Significant distribution of organisms under pH was not observed. Water temperature ranged from 16 °C to 24 °C (Table 1). The number of organisms and species increased when temperature reached 19 °C.

In June the Nemunas River was dominated by *Paramecium* sp. and *Amoeba* sp., diatoms *Navicula lanceolata, Craticula cuspidata, Amphora ovale, Rhoicosphenia abbreviata, Cocconeis* sp. No heterotrophic protozoans were

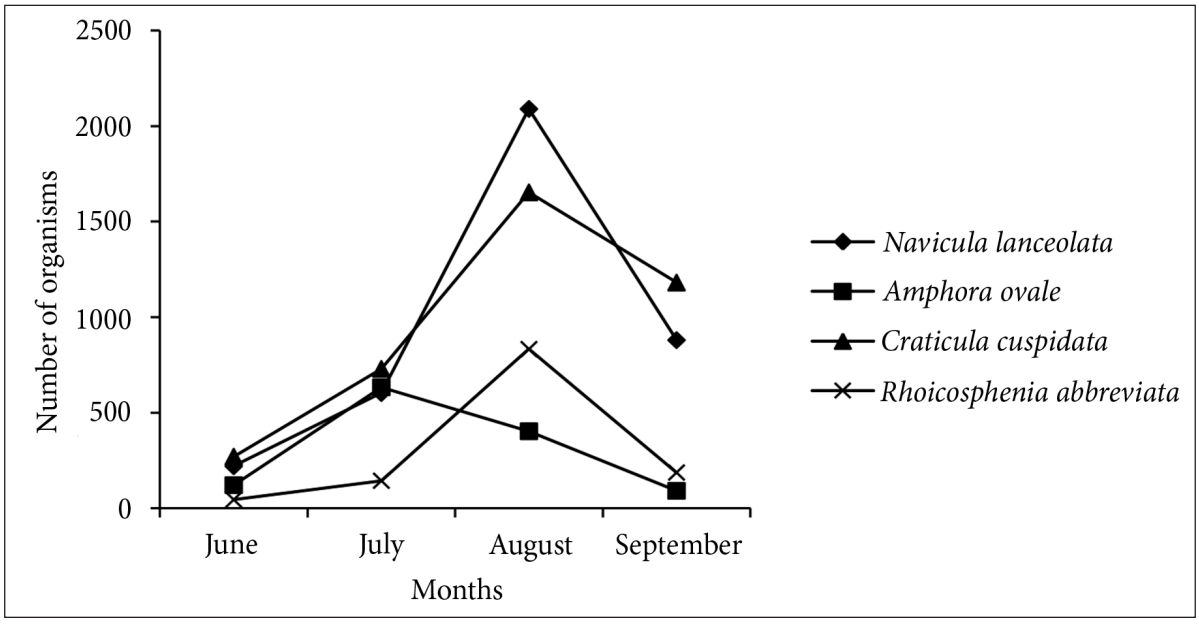

Fig. 4. Seasonal change of the dominant periphyton species in the Kaunas Lagoon

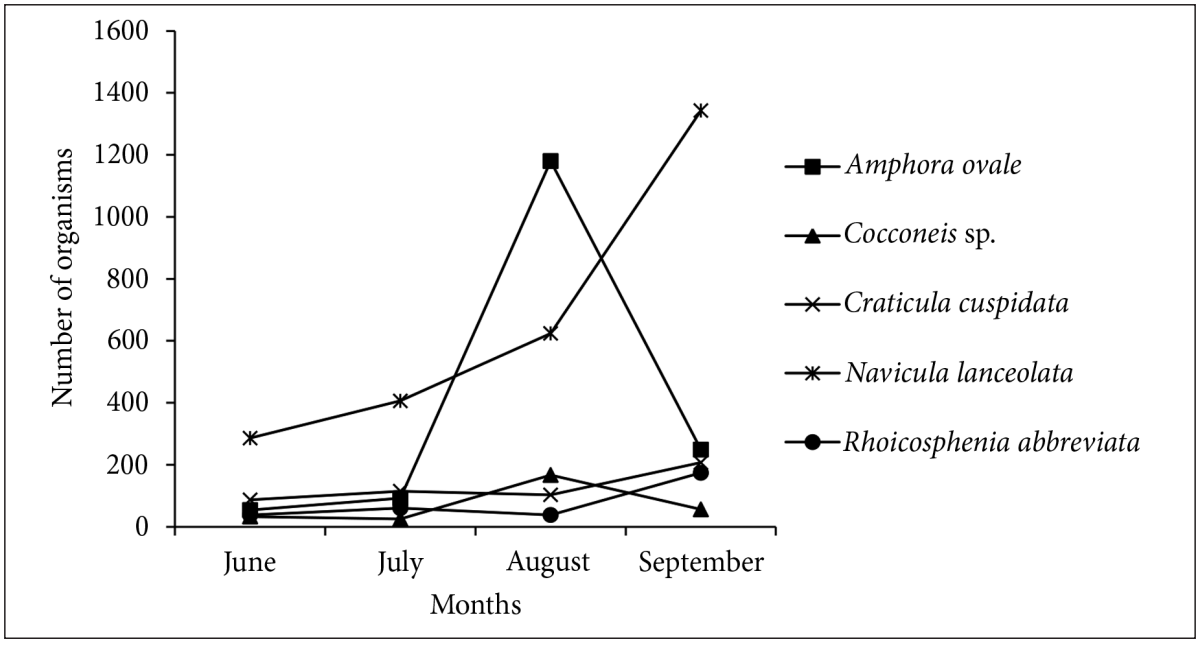

Fig. 5. Seasonal change of the dominant species in periphyton in the Nemunas River

found in July, like in the Kaunas Lagoon. The composition of the dominated species of algae was similar to that in June, also, *Scenedesmus communis* and *Synedra* sp. appeared. The communities of dominant algae remained similar in August and September. In addition, *Euglena* sp. was found (Fig. 5).

In the Nemunas River water pH was 7.4–7.8. The preliminary data suggest that organisms were most abundant when pH was 7.5. Water temperature ranged from 16 °C to 21 °C. Organisms were most abundant when temperature was 19 °C.

Summarizing the distribution of periphyton in different months, we see that abundance of dominant periphyton species in the Kaunas Lagoon is gradually rising, when water temperature rises, and reaches the peak in late summer, when water temperature is 19 °C. (Fig. 4; Table 1). Seasonal distribution of species in the Nemunas River was more significant than in the lagoon. (Fig. 5). The abundance of *Scenedesmus* sp., *Synedra* sp. and *Cocconeis* sp. started to decrease in late summer and was changed by *Craticula cuspidata* and *Rhoicosphenia abbreviata* which started to increase in September. The most significant change was observed in *Navicula lanceolata* diatoms, which also started to increase in late summer, but differently with higher abundance than the previous species. It could be due to rising water temperature and increasing number of algae. Many organisms were also found in September, although water temperature was only 16 °C. It is because of dead organisms that were left on the substrate. It might also show the increased river pollution this month because *Navicula lanceolata* are more often found in polluted water. At the same time a significant reduction of *Amphora ovale* diatoms was observed. Fallen temperature and water contamination may be a possible reason, too.

Assessment of the seasonal distribution of periphyton shows that in both water bodies organisms were more abundantly found in late summer. During the first summer months heterotrophic protists *Amoeba* sp. and *Paramecium* sp. were found more abundantly, while in July autotrophic / mixotrophic *Euglena* sp. increased.

The analysed results showed that dominant algae species in lagoon and river were similar, namely *Navicula lanceolata, Craticula*

cuspidata, Amphora ovale. The quantity and composition of other protists were different (Figs. 2 and 3). *Euglena* sp., *Paramecium* sp., *Vorticella* sp., *Amoeba* sp. dominated in the lagoon. *Vorticella* sp. was never found in the Nemunas River, only *Arcella* sp. was detected.

The abundance of rotifers was low in both water bodies – merely a few individuals. Based on the available data, it would not be possible to make conclusions about their distribution or abundance.

Regarding periphyton composition in both water bodies, we can make a preliminary conclusion that periphyton on stones is mainly composed of diatoms, but heterotrophic protists and micro multicellular organisms form a smaller part of periphyton.

Some of the genera / species found in periphyton have indicator features. Pollution tolerant genera *Amphora* sp., *Cocconeis* sp., *Cymbella* sp., *Navicula* sp., *Pinnularia* sp., *Scenedesmus* sp., *Synedra* sp. (Denys et al., 1989; Dickman et al., 1993; Kelly et al., 2005) were found in the Kaunas Lagoon and the Nemunas River. Diatoms like *Amphora* sp. and *Navicula* sp. (Round, 1993) are especially contamination tolerant.

Clean water usually has small amounts of different types of diatoms (Person, 1989). During the study diatoms were found abundantly in July and August in both water bodies. Diversity of algae in contaminated water decreases, however pollution tolerant species like *Navicula* sp. increases. *Navicula* sp. was abundantly found in July, August and September in the lagoon and in the Nemunas River in September.

Green algae such as *Scenedesmus* sp. can survive both in clean and polluted water. *Euglena* sp. is most resistant to pollution, it is commonly found in farm ponds, lagoons where sewage is treated, and other water bodies with high levels of nitrogen (Person, 1989). During this study, higher abundance of *Euglena* sp. individuals was observed in the lagoon in July, August and September. From the Nemunas River, *Euglena* sp. was found only in two locations in August and September.

CONCLUSIONS

The composition of dominant species in periphyton in the Kaunas Lagoon and the Nemunas River was similar: *Navicula lanceolata, Craticula cuspidata, Amphora ovale*. In total, 15 species and 14 genera of periphyton were collected and identified.

12 species and 12 genera of periphyton were identified in a stagnant water body, the Kaunas Lagoon. The number of organisms and species increased when temperature reached 19 °C in July and August.

12 species and 11 genera were found in a flowing water body, the Nemunas River. Organisms were most abundant when temperature was 19 °C in July, August, and similar abundance remained in September when water temperature was only 16 °C.

The dominant genera / species of periphyton found in the studied water bodies are good water contamination indicators and show a low water quality in the Kaunas Lagoon and the Nemunas River.

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PERIFITONO SUDĖTIS IR ĮVAIROVĖ KAUNO MARIOSE IR NEMUNO UPĖJE

Santrauka

Perifitoną sudaro įvairūs prie substrato, esančio po vandeniu, prisitvirtinę organizmai: bakterijos, dumbliai, grybai, protistai ir mikrodaugialąsčiai. Perifitonas yra svarbus normaliai funkcionuojančių gėlavandenių ekosistemų maistiniams ir funkciniams ryšiams.

Kauno marios ir Nemunas yra vieni svarbiausių gėlo vandens telkinių Lietuvoje, tačiau duomenų apie šių telkinių perifitoninius organizmus yra nedaug. Šiam tikslui buvo atliktas tiriamasis darbas, kuriuo siekta nustatyti perifitoninių organizmų įvairovę Kauno mariose ir Nemuno upėje.

Perifitono mėginiai vandens telkiniuose nuo akmenų buvo surenkami reguliariai, kad būtų galima įvertinti perifitono bendrijų pokyčius tiriamuoju laikotarpiu. Iš viso surinkta ir identifikuota 14 perifitoną sudarančių rūšių ir 14 genčių. Kauno mariose ir Nemuno upėje vyravo *Navicula lanceolata*, *Cratícula cuspidata*, *Amphora ovale*. Vertinant perifitono pasiskirstymą sezonų metu, buvo pastebėta, kad perifitoninių organizmų pagausėja vasaros pabaigoje. Ryškesnė sezoninė perifitono bendrijos rūšių kaita nustatyta Nemuno upėje.

Raktažodžiai: perifitonas, rūšinė įvairovė, gėlavandenės ekosistemos