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# ALGAL FLORA OF FOUR DIFFERENT SPRINGS IN SLOVENIA

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## *ABSTRACT*

*Samples were taken seasonally at four different springs in Slovenia: the spring at Medvedje Brdo, the spring in Pohorje, the mineral Rimski vrelec spring, and the thermal Terme Čatež spring in the years 1999, 2000 and 2001. The paper presents the initial research carried out into the algae at the above four springs. The purpose of the investigation was to establish species composition and periphyton abundance. Some physical and chemical parameters were also measured. Altogether, 83 algal taxa were registered, with prevailing Bacillariophyceae (51), while 14 taxa belonged to Cyanophyceae, 11 to Chlorophyceae, four to Xanthophyceae and three to Zygnematophyceae. 11 taxa were new to Slovenia, most of them belonging to Bacillariophyceae.*

**Key words:** algae, periphyton, springs, thermal springs

# FLORA ALGALE PRESSO QUATTRO DIVERSE SORGENTI IN SLOVENIA

*SINTESI*

*La ricerca prende in esame le alghe appartenenti al perifiton di quattro diverse sorgenti in Slovenia – quella di Medvedje Brdo, quella sul Pohorje, la sorgente minerale "Rimski vrelec" e la sorgente termale delle Terme Čatež – con lo scopo di registrare l'abbondanza e la composizione specifica delle comunità algali negli anni 1999, 2000 e 2001. Questa è la prima ricerca sulle alghe presenti nelle quattro sorgenti. Sono stati misurati anche alcuni fattori fisici e chimici. Nelle quattro sorgenti sono stati individuati complessivamente 83 diversi taxon appartenenti a cinque classi di alghe: Bacillariophyceae (51), Cyanophyceae (14), Chlorophyceae (11), Xanthophyceae (4) e Zygnematophyceae (3). 11 specie sono state individuate in Slovenia per la prima volta, la maggior parte apparteneva alle diatomee.*

**Parole chiave:** alghe, perifiton, sorgenti, sorgenti termali

## INTRODUCTION

Algae are a highly diverse group of organisms with important functions in aquatic habitats. They inhabit different biotopes: aerial biotopes, freshwater, salty water and brackish water. Some of them occur in extreme biotopes like snow, thermal springs, mineral waters, caves, peat bogs... In Slovenia, the number of extreme biotopes is very high due to its geographic diversity and relatively low degree of pollution. Algae in such biotopes have been only partly investigated (Kosi & Vrhovšek, 1996).

Thermal waters are waters with temperatures above 30 °C (Cvijan & Blaženčić, 1996). Typical algal flora of such waters is Cyanophyceae. Beside them, Bacillariophyceae, Chlorophyceae, Chrysophyceae, etc. occur in thermal waters (Cvijan & Blaženčić, 1996). Cyanophyceae are common in most thermal springs through the world with pH above 5 and temperature below 74 °C (Doemel & Brock, 1971). In thermal springs with pH below 5 and water temperature between 40 and 56 °C, Cyanophyceae do not occur any more; in such waters, only the species *Cyanidium caldarium* is present (Doemel & Brock, 1971). Most common genera in thermal springs of Slovenia are *Phormidium*, *Pleurocapsa* and *Calothrix* (Vrhovšek, 1985).

The objective of the investigation was to establish the species composition and periphyton abundance in the Medvedje Brdo spring, the spring in Pohorje, the mineral Rimski vrelec spring and the Terme Čatež thermal spring in the years 1999, 2000 and 2001. Some physical and chemical parameters were also measured. The paper presents the first algological research carried out at these four springs.

## MATERIAL AND METHODS

### Study sites

For the purpose of our investigation, we chose four different springs in Slovenia: the spring at Medvedje Brdo, the spring in Pohorje, the mineral Rimski vrelec spring and the thermal Terme Čatež spring. The sampling sites are presented in figure 1. The Medvedje Brdo spring is a karst spring on limestone ground. The water appears on the surface only 2-3 meters, then it sinks. The spring is shaded (co-ordinates after Gaus-Krüger: X=5091875, Y=5432750). The spring in Pohorje is located on acid-silicate ground in Lovrenška jezera Forest Reserve. The spring is not shaded (co-ordinates after Gaus-Krüger: X=5147725, Y=5524775). The mineral Rimski vrelec spring is situated behind Rimski vrelec Hotel at Kotlje near the town of Ravne na Koroškem. The spring water belonged to "Ca-Mg-Na-hydrogencarbonate acid waters" with very high values of iron (Rogelj *et al.*, 1972). The spring is shaded and regulated (fountain). The thermal Terme Čatež spring is situated between Toplice Hotels and Zimska termalna riviera. The spring is regulated (fountain) and not shaded. The thermal water is pumped out of the well into the fountain. The temperature of the thermal water is 64 °C (Nosan, 1973).

### Sampling

The samples were collected seasonally during the years 1999, 2000 and 2001. Four periphyton samples were taken in the Medvedje Brdo spring (2.4.1999, 6.8.1999, 17.10.1999, 19.2.2000), the thermal Terme Čatež spring (28.3.2000, 16.9.2000, 20.11.2000, 15.1.2001) and the mineral Rimski vrelec spring (12.8.1999, 20.10.1999, 25.2.2000, 14.5.2000), and three in the Pohorje spring (7.8.1999, 16.10.1999, 3.6.2000). Periphyton samples were taken in the springs of Medvedje Brdo and Pohorje by scratching the surface of gravel and rocks in the water and overgrowth with mosses and in the mineral Rimski vrelec and Terme Čatež springs by scratching the bottom and the walls of the fountain. The fixation of the samples was done *in situ* with 4 % formalin concentration. For diatom determination, samples were pre-treated with saturated $HNO_3$ (APHA, 1985).

Taxa of the algae using light microscope (magnification 1000×) and following identification monographs were determined: Lazar (1960), Starmach (1966, 1968, 1972), Bourrelly (1968), Kramer & Lange-Bertalot (1986, 1988, 1991a, 1991b), Hindak *et al.* (1978), Hindak (1996), Cvijan & Blaženčić (1996). The abundance of

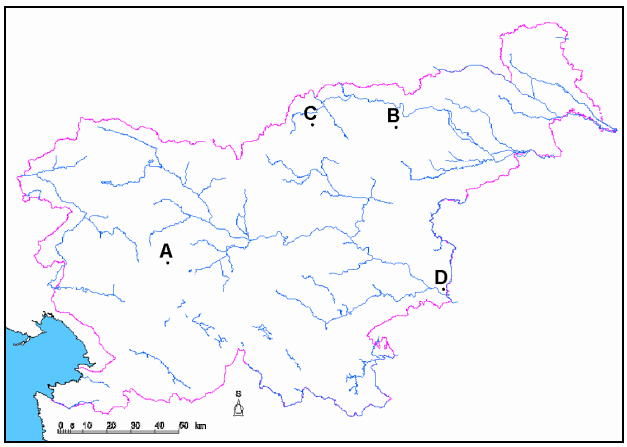


***Fig. 1: Map of Slovenia with marked sampling sites. Legend: A – Medvedje Brdo spring, B – Pohorje spring, C – Rimski vrelec mineral spring, D – Terme Čatež thermal spring.***
***Sl. 1: Zemljevid Slovenije z označenimi vzorčnimi mesti. Legenda: A – izvir na Medvedjem Brdu, B – izvir na Pohorju, C – mineralni izvir Rimski vrelec, D – termalni izvir v Termah Čatež.***

most common species was evaluated using the following scale (Pantle & Buck, 1995):

| Abundance | species present in % of visible fields |
|---|---|
| 1 – single | 1-15 |
| 3 – customary | >15-60 |
| 5 – dominate | >60-100 |

In 1999 and 2000, various physical and chemical parameters were measured; these included temperature, conductivity, pH, dissolved oxygen and percentage saturation (APHA, 1985).

## RESULTS AND DISCUSSION

### Physical and chemical parameters

Range of some physical and chemical parameters at all four springs in the years 1999, 2000 and 2001 are presented in Table 1.

Water temperature of springs, which receive water from deeper layers, was more or less constant and oscillated around the average annual air temperature (Rejic, 1988). Such springs are also the Medvedje Brdo spring, the mineral Rimski vrelec spring, and the spring in Pohorje with minor temperature changes of water through the year. Temperatures of thermal waters exceed 30 °C (Cvijan & Blaženčić, 1996); such is also the thermal Terme Čatež spring, with its temperatures ranging, at the time of our measurements, from 46.4 °C to 55.5 °C.

Conductivity in freshwaters increases with increase of salinity, which is influenced by the ground and its geology, climate, temperature, dust, precipitation, evaporation, winds, distance from the sea, flora and fauna (Rejic, 1988). In the Pohorje spring, the conductivity at the time of our measurements was low (16.5–51.3 µS/cm), which can be explained by the acid-silicate ground. In the Rimski vrelec mineral spring, on the other hand, the conductivity at the time of measurements was very high (1667-1755 µS/cm), which can be explained by the high values of iron in spring water (Rogelj *et al.*, 1972). Physical and chemical results revealed that the temperature and conductivity are closely connected: the higher the water temperature, the higher the conductivity. Wetzel & Likens (1991) ascertained that the conductivity increases by about 2 to 3% per 1 °C. At the Medvedje Brdo spring and Terme Čatež thermal spring, pH was about 7 to 8, while at the mineral Rimski vrelec spring and the spring in Pohorje it ranged between 5.5 and 6.5.

The amount of dissolved oxygen in water and the percentage saturation in the mineral Rimski vrelec spring and the thermal spring was extremely low at the time of measurements, which can be explained by the absence of biogen input of oxygen into spring water and high water temperature in the thermal spring. In the Pohorje spring, the amount of dissolved oxygen in water and the percentage saturation was much higher, although the percentage saturation was at the time of measurements below 100%. Only in the Medvedje Brdo spring the amount of dissolved oxygen in water was above 10 mg/l at the time of measurements, while the percentage saturation was above 100%.

### Species composition and abundance

Altogether, 83 algal taxa were determined (Tab. 2). Most of them (51) belonged to Bacillariophyceae, 14 to Cyanophyceae, 11 to Chlorophyceae, four to Xanthophyceae, and three to Zygnematophyceae.

38 algal taxa were determined in the Medvedje Brdo spring, 37 in the mineral Rimski vrelec spring, 19 in the Pohorje spring, and 8 in the thermal Terme Čatež spring (Tab. 2). The algal structure by classes in all three waterfalls is shown in figure 2. The most frequent classes of algae in the Medvedje Brdo spring and in the mineral Rimski vrelec spring were Bacillariophyceae, followed by Cyanophyceae and Chlorophyceae. Most common in the Pohorje spring was the class Chlorophyceae, and Cyanophyceae in the thermal Terme Čatež spring.

***Tab. 1: Ranges of some physical and chemical parameters in the Medvedje Brdo spring, the Pohorje spring, the mineral Rimski vrelec spring, and the thermal Terme Čatež spring in the 1999, 2000 and 2001. Legend: A – Medvedje Brdo spring, B – Pohorje spring, C – Rimski vrelec mineral spring, D – Terme Čatež thermal spring.***
***Tab. 1: Obseg nekaterih fizikalnih in kemijskih parametrov v izviru na Medvedjem brdu, izviru na Pohorju, mineralnem izviru Rimski vrelec in termalnem izviru v Termah Čatež v letih 1999, 2000 in 2001. Legenda: A – izvir na Medvedjem Brdu, B – izvir na Pohorju, C – mineralni izvir Rimski vrelec, D – termalni izvir v Termah Čatež.***

| sampling point | temperature (°C) | conductivity (µS/cm) | pH | oxygen (mg/l) | saturation (%) |
|---|---|---|---|---|---|
| A | 7.4-10.4 | 300-450 | 7.65-8.13 | 12.0-13.6 | 107-111 |
| B | 7.7-8.7 | 17-51 | 5.56-5.70 | 9.9-12.5 | 93-97 |
| C | 8.5-10.3 | 1667-1755 | 6.00-6.44 | 3.0-5.2 | 27-45 |
| D | 46.4-55.5 | 457-662 | 7.10-7.17 | 1.3-2.3 | 17-34 |

***Tab. 2: Algal species list with estimation of abundance (1 – single, 3 – customary, 5 – dominate) from the Medvedje Brdo spring, Pohorje spring, Rimski vrelec mineral spring, and Terme Čatež thermal spring in the years 1999, 2000 and 2001 with marked taxa new to Slovenia.***
***Tab. 2: Vrstna sestava alg z oceno abundance (1 – posamična, 3 – običajna, 5 – prevladujoča) v izviru na Medvedjem brdu, izviru na Pohorju, mineralnem izviru Rimski vrelec in termalnem izviru v Termah Čatež v letih 1999, 2000 in 2001 z označenimi taksoni, ki so novi za Slovenijo.***

| taxon | Medvedje Brdo spring | | | | Pohorje spring | | | Rimski vrelec mineral spring | | | | Terme Čatež thermal spring | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2.4. 99 | 6.8. 99 | 17.10. 99 | 19.2. 00 | 7.8. 99 | 16.10. 99 | 3.6. 00 | 12.8. 99 | 20.10. 99 | 25.2. 00 | 14.5. 00 | 28.3. 00 | 16.9. 00 | 20.11. 00 | 15.1. 01 |
| **PROKARYOTA** | | | | | | | | | | | | | | | |
| **CYANOPHYTA** | | | | | | | | | | | | | | | |
| CYANOPHYCEAE | | | | | | | | | | | | | | | |
| ¤*Calothrix thermalis* (Schwabe) Hansg. | | | | | | | | | | | | 1 | 1 | 3 | 1 |
| *Gloeocapsa alpina* Naegeli | | | | | | | | | | | | 3 | 3 | 3 | 3 |
| ¤*Gloeocapsa bituminosa* (Bory) Kuetz. | | | | | | | | | 1 | | | | | | |
| *Gloeocapsa compacta* Kuetz. | | 1 | | | | | | | | | | | | | |
| *Gloeocapsa montana* Kuetz. | | 1 | | | | | | | | | | | | | |
| *Gloeocapsa turgida* (Kuetz.) Holler. | 1 | 1 | | | | | | | | | | | 1 | | |
| *Microcystis* sp. | | | | | 1 | | 1 | | | | | | | | |
| *Oscillatoria* sp. | | 1 | | 1 | | | | | | | | | | | |
| *Oscillatoria splendida* Greville | | | | | | | | 1 | 1 | | | | | | |
| ¤*Phormidium angustissimum* W. & G. S. West | | | | | | | | 1 | 1 | | | 1 | 1 | 1 | 1 |
| *Phormidium retzii* (Agardh) Gomont | 1 | 1 | | | | | | | | | | | | | |
| *Phormidium* sp. | 1 | 1 | 1 | | 1 | | 1 | | | 1 | | | | | |
| ¤*Phormidium valderiae* (Delp.) Geitler | | | | | | | | 1 | | | | 3 | 3 | 3 | 1 |
| *Pseudanabaena constricta* (Szafer) Lauterb. | | | | | | | | 1 | 1 | | | | | | |
| **EUKARYOTA** | | | | | | | | | | | | | | | |
| **HETEROKONTOPHYTA** | | | | | | | | | | | | | | | |
| XANTHOPHYCEAE | | | | | | | | | | | | | | | |
| *Botryochloris minima* Pasch. | | | | | 1 | | | | | | | | | | |
| *Gloeobotrys monochloron* Ettl. | | | | | 5 | 5 | 3 | | | | | | | | |
| *Tribonema minus* Hazen | | | | | | | | | 1 | | 5 | | | | |
| *Tribonema vulgare* Pascher | | | | | | | | 3 | 1 | 3 | | | | | |
| BACILLARIOPHYCEAE | | | | | | | | | | | | | | | |
| *Achnanthes delicatula* ssp. *hauckiana* (Grun.) Lan.-Bert. | 3 | 3 | 1 | 1 | | | | | | | | | | | |
| *Achnanthes lanceolata* (Breb.) Grun. | | | | | 1 | | | | | | | | | | |
| *Achnanthes lanceolata* ssp. *lanceolata* var. *lanceolata* (Breb.) Grun. | 1 | 1 | 1 | | | | | 5 | 5 | 5 | 5 | | | | |
| *Achnanthes minutissima* Kuetz. | 3 | 3 | 1 | 1 | | | | 3 | 1 | 1 | 1 | 1 | | | |
| *Achnanthes* sp. | | | 1 | | 1 | | | | 1 | | | | | | |
| *Amphora ovalis* (Kuetz.) Kuetz. | 1 | 1 | 1 | | | | | 1 | | | | | | | |
| *Amphora pediculus* (Kuetz.) Grun. | 1 | | 1 | 1 | | | | | | | | | | | |
| *Aulacoseira granulata* (Ehren.) Simon. | | | 1 | | | | | | | | | | | | |
| *Caloneis bacillum* (Grun.) Cleve | 1 | 1 | 1 | | | | | | | | | | | | |
| ¤*Caloneis molaris* (Grun.) Kramm. | | | | | | | | 1 | 1 | 1 | 1 | | | | |
| *Cocconeis placentula* Ehren. | 3 | 3 | 1 | 3 | | | | | | | | | | | |
| *Cymbella affinis* Kuetz. | | | | | | | | 1 | 1 | 1 | 1 | | | | |
| *Cymbella aspera* (Ehren.) Peragallo | 1 | | | | | | | | | | | | | | |
| *Cymbella cymbiformis* Agardh | | | | | | | | 1 | | | | | | | |
| *Cymbella helvetica* Kuetz. | 1 | 1 | | | | | | | | | | | | | |
| *Cymbella silesiaca* Bleisch | | 1 | | | | | | | | | | | | | |
| *Cymbella* sp. | 1 | | | | | | | | | | | | | | |
| *Denticula tenuis* Kuetz. | 1 | 3 | 1 | | | | | 1 | 1 | 1 | 1 | | | | |
| *Diatoma vulgaris* Bory | | | | | | | 1 | | | | | | | | |
| *Diploneis oblongella* (Naegeli) Cleve-Euler | | | | | | | | 1 | 1 | 1 | 1 | | | | |
| *Ellerbeckia arenaria* (Moore) Craw. | 1 | | 1 | 1 | | | | | | | | | | | |
| *Epithemia adnata* (Kuetz.) Breb. | | | 1 | | | | | | | | | | | | |
| *Eunotia bilunaris* Ehren. | | | | | | | 5 | | | | | | | | |
| *Eunotia exigua* (Breb.) Raben. | | | | | 1 | | 1 | | | | | | | | |

| taxon | Medvedje Brdo spring | | | | Pohorje spring | | | Rimski vrelec mineral spring | | | | Terme Čatež thermal spring | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2.4. 99 | 6.8. 99 | 17.10. 99 | 19.2. 00 | 7.8. 99 | 16.10. 99 | 3.6. 00 | 12.8. 99 | 20.10. 99 | 25.2. 00 | 14.5. 00 | 28.3. 00 | 16.9. 00 | 20.11. 00 | 15.1. 01 |
| *Fragilaria capucina* Desm. | | | | | | | | 3 | 3 | 3 | 3 | | | | |
| *Fragilaria fasciculata* (Agardh) Lan.-Bert. | 1 | | | | | | | | | | | | | | |
| *Frustulia rhomboides* (Ehren.) De Toni | | | | | | | | | | | | | 1 | | |
| *Frustulia vulgaris* (Thwait.) De Toni | | | | | | | | 1 | 1 | 1 | 1 | | | | |
| *Gomphonema angustatum* (Kuetz.) Raben. | 1 | 1 | | | | | | 1 | | | 1 | | | | |
| *Gomphonema angustum* Agardh | 3 | 1 | 1 | 1 | | | | | | | | | | | |
| *Gomphonema clavatum* Ehren. | | 1 | | | | | | 3 | 3 | 3 | 3 | | | | |
| *Gomphonema gracile* Ehren. | | | | | | | | | | 1 | 1 | | | | |
| *Gomphonema parvulum* Kuetz. | | | | | | | | 1 | 1 | | | | | | |
| *Navicula angusta* Grun. | | 1 | | | | | | | | | | | | | |
| ¤*Navicula cincta* (Ehren.) Ralfs in Pritchard | | | | | | | | 1 | 1 | | | | | | |
| *Navicula contenta* Grun. | | | | | | 1 | | | | | | | | | |
| ¤*Navicula gregaria* Donkin | | | | | | | | 1 | 1 | 1 | 1 | | | | |
| *Navicula mutica* var. *mutica* Kuetz. | | 1 | | | | | | | | | | | | | |
| *Navicula* sp. | 1 | | | | | | | | | | | | | | |
| *Navicula tripunctata* (Muell.) Bory | 1 | 1 | 1 | 1 | | | | | | | | | | | |
| *Navicula veneta* Kuetz. | | 1 | | | | | | 1 | 1 | | | | | | |
| *Nitzschia dissipata* (Kuetz.) Grun. | | 1 | | | | | | | | | | | | | |
| *Nitzschia fonticola* Grun. | | | | | | | | | 1 | | 1 | | | | |
| *Nitzschia linearis* (Agardh) W.Smith | | | | | | | | | 1 | | 1 | | | | |
| *Nitzschia linearis* var. *linearis* (Agardh) W. Smith | | 1 | 1 | 1 | | | | | | | | | | | |
| *Nitzschia palea* (Kuetz.) W.Smith | | | | | | | | 1 | 1 | 1 | 1 | | | | |
| ¤*Nitzschia sinuata* var. *delognei* (Grun.) Lan.-Bert. | | | | | | | | | 1 | 1 | 1 | | | | |
| ¤*Pinnularia sudetica* (Hilse) Peragallo | | | | | | | | 1 | 1 | 1 | 1 | | | | |
| *Surirella linearis* W. Smith | | 1 | | 1 | | | | | | | | | | | |
| *Surirella* sp. | 1 | | | | | | | | | | | | | | |
| *Surirella spiralis* Kuetz. | | 1 | | | | | | | | | | | | | |
| **CHLOROPHYTA** | | | | | | | | | | | | | | | |
| CHLOROPHYCEAE | | | | | | | | | | | | | | | |
| *Cladophora* sp. | | | | | | | | 1 | 1 | 1 | | | | | |
| *Gloeocystis vesiculosa* Naeg. | | | | | 1 | | | | | | | | | | |
| *Klebsormidium flaccidum* (Kuetz) Silva, Mattox & Black. | | | | | 1 | 1 | 1 | 1 | | 1 | | | | | |
| ¤*Koliella crassa* Hindak | | | | | 1 | | | | | | | | | | |
| ¤*Koliella variabilis* (Nyg.) Hindak | | | | | 1 | | 1 | | | | | | | | |
| *Microspora amoena* (Kuetz.) Raben. | | | | | 1 | 1 | | | | | | | | | |
| *Microthamnion kuetzingianum* Naegeli | | | | | | | | 1 | 3 | 1 | 3 | | | | |
| *Oedogonium* sp. | | 1 | | | | | | | | | | | | | |
| *Stigeoclonium farctum* Berthold | | | | | | 3 | | | | | | | | | |
| *Stigeoclonium tenue* (Agardh) Kuetz. | | | | | | | | 1 | 1 | 1 | 1 | | | | |
| *Trentepohlia aurea* (L.) Martius | 1 | 3 | 1 | 1 | 1 | | 1 | | 1 | | 1 | | | 1 | 1 |
| ZYGNEMATOPHYCEAE | | | | | | | | | | | | | | | |
| *Bambusina brebissonii* Kuetz. | | | | | 1 | | | | | | | | | | |
| *Mougeotia* sp. | | | | | | | | 1 | 1 | 1 | 1 | | | | |
| *Netrium digitus* (Ehren.) Itzigs. & Rothe | | | | | | 1 | | | | | | | | | |

¤ Algae first recorded in Slovenia

Ecological conditions in thermal springs are more or less constant with very high water temperature; most common in springs of this type is the class Cyanophyceae (Vrhovšek, 1985). Cyanophyceae are most common in various thermal springs worldwide (Doemel & Brock, 1971; Carr & Whitton, 1973; Round, 1973; Noguerol, 1991). As far as other classes of algae are concerned, only Bacillariophyceae are also common in thermal springs (they appeared only when water temperature was below 40 °C) (Cvijan & Blaženčić, 1996). Species from the classes Xanthophyceae and Zygnematophyceae occurred only in the mineral Rimski vrelec spring.

In the mineral Rimski vrelec spring and in the thermal Terme Čatež spring, no seasonal changes were found in the algal communities. In the springs of Med-

vedje Brdo and Pohorje, high species richness was established in summer samples and low in autumn and winter samples.

In all samples of the Medvedje Brdo spring, the following taxa were recorded: *Achnanthes delicatula* ssp. *hauckiana*, *A. minutissima*, *Cocconeis placentula*, *Gomphonema angustum*, *Navicula tripunctata* and *Trentepohlia aurea*, most common amongst which were *A. delicatula* ssp. *hauckiana* and *C. placentula*. In all Rimski vrelec samples, the following taxa were determined: *Achnanthes lanceolata* ssp. *lanceolata* var. *lanceolata*, *A. minutissima*, *Caloneis molaris*, *Cymbella affinis*, *Denticula tenuis*, *Diploneis oblongella*, *Fragilaria capucina*, *Frustulia vulgaris*, *Gomphonema clavatum*, *Navicula gregaria*, *Nitzschia palea*, *Pinnularia sudetica*, *Microthamnion kuetzingianum*, *Mougeotia* sp. and *Stigeoclonium tenue*. The predominant species were *Tribonema minus* and *A. lanceolata* ssp. *lanceolata* var. *lanceolata*. In the mineral Rimski vrelec spring, many species were typical of waters with high level of electrolytes; some of them were typical even of brackish waters *(Gomphonema gracile*, *Navicula cincta*, *N. veneta*, *Nitzschia linearis*, *N. sinuata* var. *delognei),* which can be explained by the high conductivity values (1667-1755 µS/cm) in spring water. Many species were typical of eutrophic waters: *Oscillatoria splendida*, *N. cincta*, *N. veneta*, *G. angustatum*, *G. parvulum*, *N. palea* etc.

Algal community in the Pohorje spring greatly differed from algal communities in the springs of Medvedje Brdo and Rimski vrelec. In all samples from the Pohorje spring, the species *Gloeobotrys monochloron* and *Klebsormidium flaccidum* were recorded. The most frequently found species were *G. monochloron* and *Eunotia bilunaris*. Many species were typical of acid waters: *Netrium digitus*, *Bambusina brebissonii* and *Botryochloris minima*.

The most common species in Terme Čatež spring was *Gloeocapsa alpina*. Species *A. minutissima*, *Frustulia rhomboides* and *Trentepohlia aurea* were also fairly common. Stockner (1967) found out that some diatoms can live at very high water temperatures, although their optimum is below 30 °C. Cvijan (1986), who studied algae in various Serbian thermal springs, established that algae occur in water with temperatures up to 73 °C. At 73 °C, he found only one species of algae in the water – *Phormidium angustissimum*. In all four Terme Čatež periphyton samples, *P. angustissimum* was recorded. In waters with temperature up to 46 °C, *Synechococcus* was often the prevailing genus, while in waters with temperatures up to 57 °C, species of the genus *Phormidium* prevailed. At water temperatures below 46 °C, species of the genus *Calothrix* were prevalent (Stewart, 1970). Noguerol (1991) studied algal flora in hot springs of northwest Spain. He found 15 algal species, with prevailing Cyanophyceae. Cyanophyceae are extremely resistant to high temperatures. Some of them were found even in waters with temperatures up to 85 °C (Round, 1973).

In the four springs, 11 taxa were recorded for the very first time in Slovenia (Tab. 2), eight of these in the mineral Rimski vrelec spring, four in the Pohorje spring, three in the thermal Terme Čatež spring, and two in the Medvedje Brdo spring. Five of the first recorded taxa belonged to Bacillariophyceae, four to Cyanophyceae and two to Chlorophyceae.

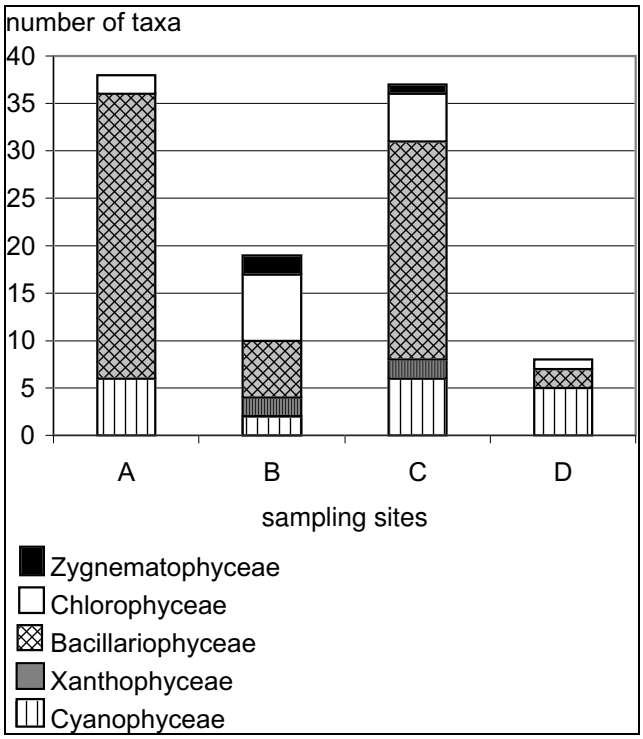


***Fig. 2: Algal structure by classes in the Medvedje Brdo spring, Pohorje spring, Rimski vrelec mineral spring, and Terme Čatež thermal spring in the years 1999, 2000 and 2001 Legend: A – Medvedje Brdo spring, B – Pohorje spring, C – Rimski vrelec mineral spring, D – Terme Čatež thermal spring.***

***Sl. 2: Sestava alg po razredih v izviru na Medvedjem brdu, izviru na Pohorju, mineralnem izviru Rimski vrelec in termalnem izviru v Termah Čatež v letih 1999, 2000 in 2001. Legenda: A – izvir na Medvedjem Brdu, B – izvir na Pohorju, C – mineralni izvir Rimski vrelec, D – termalni izvir v Termah Čatež.***

# FLORA ALG V ŠTIRIH RAZLIČNIH IZVIRIH V SLOVENIJI

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*POVZETEK*

*V nalogi so bile raziskane perifitonske alge v štirih različnih izvirih v Sloveniji: izviru na Medvedjem Brdu, izviru na Pohorju, mineralnem izviru Rimski vrelec in termalnem izviru v Termah Čatež z namenom ugotoviti abundanco in vrstno sestavo algnih združb v letih 1999, 2000 in 2001. To je prva raziskava alg v naštetih izvirih. V izviru na Medvedjem Brdu, termalnem izviru v Termah Čatež in mineralnem izviru Rimski vrelec so bila opravljena po štiri vzorčenja, v izviru na Pohorju pa tri. V laboratoriju so bili vzorci perifitona pregledani pod svetlobnim mikroskopom. Pri pregledovanju vzorcev so bile ocenjene pogostosti posameznih vrst in podvrst s števili od 1 do 5 (1 – posamična, 3 – običajna, 5 – prevladujoča). Izmerjeni so bili tudi nekateri fizikalni in kemijski dejavniki, ki vplivajo na sestavo in številčnost algnih združb.*

*Skupno je bilo v vseh štirih izvirih določenih 83 različnih taksonov iz petih razredov alg. Od tega je bilo v izviru na Medvedjem Brdu določenih 38, v izviru na Pohorju 19, v mineralnem izviru Rimski vrelec 37 in v termalnem izviru v Termah Čatež 8 različnih taksonov alg. Po številu taksonov so v izviru na Medvedjem Brdu in v izviru Rimski vrelec prevladovale kremenaste alge, v izviru na Pohorju Chlorophyceae in v termalnem izviru Cyanophyceae.*

*V vseh štirih izvirih je bilo skupno določenih 11 taksonov, ki so v Sloveniji zabeleženi prvič. Pet taksonov pripada razredu Bacillariophyceae, štiri razredu Cyanophyceae in dva razredu Chlorophyceae. V izviru Rimski vrelec je bilo določenih 8 vrst, v izviru na Pohorju 4, v termalnem izviru v Termah Čatež 3 in v izviru na Medvedjem Brdu 2 novi vrsti.*

**Ključne besede:** alge, perifiton, izviri, termalni izviri

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