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ALGAE IN THERMOMINERAL WATERS OF NIŠKA BANJA SPA (SERBIA)

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During September 1982, July 1983, April 1985 and November 1992 algological samples from thermomineral waters of spring Suva Banja and artificial, concrete canal with the water originated from Main spring were collected.

The qualitative and relatively quantitative composition of algal communities were analysed, as well as ecological characteristics of some presented taxons. On the basis of algological analyses, the algological types of thermomineral waters in Niška Banja spa are given.

Key words: algae, thermomineral waters, Niška Banja spa.

Ključne reči: alge, termomineralna voda, Niška Banja.

INTRODUCTION

Algological investigations of thermomineral waters in Serbia are of the great scientific interest in consideration of the great number of thermomineral springs in our country (Marković, 1980), which differ mutually by its origin as well as by its physical and chemical characteristics (Godić & Radić, 1963).

Because of their practical importance (medical treatments, tourism and recreation, heating etc.) some of those springs are more or less well investigated from different point of view (amount of water, chemical composition of water, its temperature and radioactivity etc.). Biological investigation has not been performed and reviewing literature we have found only two scientific papers dealing with algae from thermomineral waters of Niška Banja spa (Petrovska, 1969; Cvijan & Blaženčić, 1986).

MATERIAL AND METHODS

Samples of algae were collected from thermomineral water of Suva Banja spring and artificial, concrete canal with the water originated from Main spring.

Samples were collected in September 1982, July 1983, April 1985 and November 1992 from different places, mostly from concrete and stones which were under water flow, or from concrete or stones which were sprayed by thermomineral water, as well as from surfaces in the area of warm steam.

Collected material was preserved immediately in 3-4% formaldehyde.

Algological material was examined by DiastarTM photomicroscope. The most of algae were investigated directly from collected material except the diatoms which were prepared by standard method with sulphuric acid (Hustedt, 1930; Patrick & Reimer, 1966).

Financial support for the laboratory investigation was provided by the Contract No. 0321 Serbian Ministry of science.

RESULTS AND DISCUSSION

The general features of Niška Banja spa and general and particular features of thermomineral springs

Niška Banja spa is situated in central part of Serbia, 10 km south-east from the town Niš.

The surrounding of Niška Banja is built of limestone, sediments (clay and conglomerate) and river sands (Marković, 1980).

The climate of Niška Banja is moderate-continental with more features which are conditioned by great surfaces under the forests, orchards and vineyards. Good connections with Niš, as well as the presence of thermomineral springs, improved the development of tourism.

The existence of thermomineral water is caused by specific geological factors and by positions of limestone toward the sediments of clay and conglomerates (Đurović, 1963).

Exterior factors (the amount of fails, the time and intensity of snow melting), specially caused by presence of limestone, influence a lot at temperature and chemical composition of thermomineral water.

In Niška Banja spa there are two thermomineral springs: Main spring and Suva Banja spring.

Main spring givs 35-120 l/sec of water, tempepture of 38.2-38.5°C. This water is specially characterized by ions of Ca^{++} and HCO_3^- and belongs to group of homoeothermal water with moderate radioactivity (Marković, 1980).

Suva Banja givs 14-42 l/sec of water, temperature of 12-37°C. Great variability of temperature and amount of water is consequenced by considerable influence of external factors (Marković, 1980). The water is specially characterized by ions of Ca^{++} and HCO_3^- and belongs to group of homoeothermal water with low radioactivity (Marković, 1980).

The great amount of water of the springs (specially of the Main spring) is captured. This water is using for balneotherapy and only one part of water (surplus that are not utilized) is under the influence of natural factors. But, the influence of man is very expressive all over the year, specially during the summer when there are a great number of visitors.

The samples were collected from different places which we can put in two wholes;

A. Concrete canal. The artificial canal with water from Main spring. The temperature of thermomineral water along the concrete canal are given in Tab. 1.

Tab. 1. – Temperature of water (C⁰) in concrete canal in different periods of investigations

Year of collecting	"spring"	central part	end of canal
1982.	38.0	35.5	31.4
1983.	38.2	36.7	33.5
1985.	37.9	34.6	30.0
1992.	34.6	27.8	23.2

The pH reaction of thermomineral water at any time of sampling was between 7.0 and 7.2.

B. Suva Banja. Typical representative of cave-therms (Martinović & Kostić, 1977). Thermomineral water is flowing out of the cave but the entrance of the cave was closed for visitors with metal bars and in 1992 by metal plates. Because of that, the samples were collected only from narrow zone around the entrance of the cave and they were characterised by the temperature of thermomineral water between 32.3 and 37.0°C and pH reaction between 7.1 and 7.2. However, in algological analyzed we distinguished two different groups of samples:

a. The samples from the surfaces inside the cave with constant tempepture and pH, constant flow of thermomineral water and, specially in 1992, with strong shaded surface of concrete.

b. The samples from the surface out of the cave with some changeable temperature, pH and water flow, and not strong shaded surface of concrete.

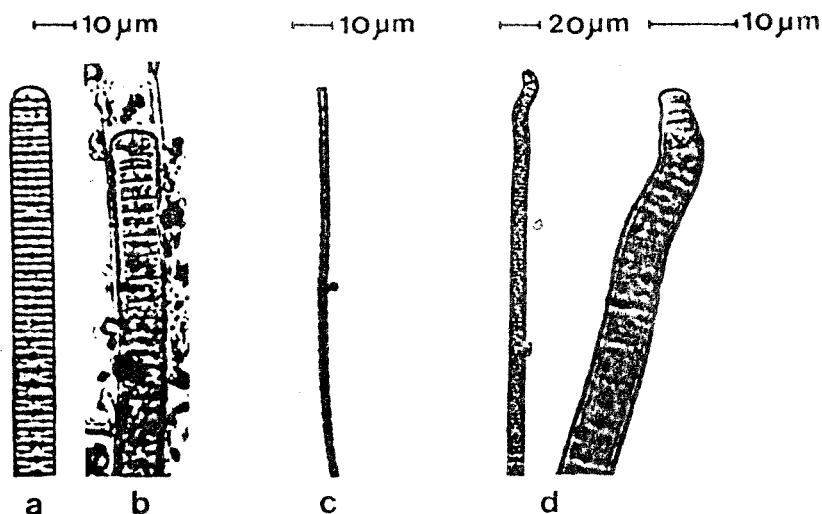


Fig. 1. – Some dominant representatives of algae in thermomineral water of Niška Banja spa

- a – *Oscillatoria limosa*
 b – *Oscillatoria limosa* f. *phormidioides*
 c – *Phormidium foveolarum*
 d – *Oscillatoria cortiana*

Algae in thermomineral waters of Niška Banja spa

Concrete canal. By the examination of the samples from concrete canal in Niška Banja spa, the presence of algae from 3 divisions was established: *Cyanophyta*, *Bacillariophyta* and *Chlorophyta* (Tab. 2 and Tab. 3).

In the first three years of our investigation some differences in qualitative and quantitative compositions of algae exist, but they were insignificant. In November 1992 we established qualitative and quantitative poverty of algae. On the other hand, *Oscillatoria cortiana* and *Phormidium foveolarum* were dominant. Beside that, *O. cortiana* was not found in any samples collected before November 1992.

All differences are the consequence of specific, unusual conditions for development of algae in November 1992. Namely, in the period of low temperature (near 0°C), the flowing of thermomineral water through the canal does not exist. Because of that, in November 1992 thermomineral water was not flowing through the canal over the night and the conditions for development of some stable algal communities were not present. Some taxons (*Phormidium foveolarum*, partly *Oscillatoria limosa*, *O. limosa* f. *phormidioides* etc.) are more or less well accommodated to changeable conditions. But, some taxons were eliminated. On the contrary, some new taxons were developed for the first time (*Gloeocapsa montana*, *Oscillatoria anguina*, *O. cortiana*, *O. formosa* and *O. limosa* f. *disperso-granulata*). In that period *O. limosa* as a dominant species in the earlier periods, was substituted by *O. cortiana*.

Tab. 2. - Qualitative and relatively quantitative composition of algae in thermomineral water of concrete canal of Niška Banja spa

Taxons	23-30	30-35	35-38
	In C ⁰		
<i>Aphanocapsa thermalis</i> (Kütz.) Brügg.	-	1	r
<i>Calothrix elenkinii</i> Kossinsk.	-	-	r
<i>Galothrix thermalis</i> (Schwabe) Hansg.	-	1	r
<i>Gloeocapsa minuta</i> (Kütz.) Hollerb.	1	2	-
<i>Gloeocapsa crepidium</i> (Rabh.) Thur.	-	-	r
<i>Gloeocapsa montana</i> Kütz.	1	-	-
<i>Gloeocapsa punctata</i> Näg.	1	r	-
<i>Gloeotehece rupestris</i> (Lyngeb.) Born.	-	-	r
<i>Merismopedia punctata</i> Meyen	-	2	-
<i>Oscillatoria anguina</i> (Bory) Gom.	1	-	-
<i>Oscillatoria amphibia</i> Kütz.	-	r	r
<i>Oscillatoria brevis</i> Kütz.	r	1	-
<i>Oscillatoria chalybea</i> (Mert.) Gom.	-	-	1
<i>Oscillatoria cortiana</i> (Menegh.) Gom.	3	-	-
<i>Oscillatoria formosa</i> Bory	1	-	-
<i>Oscillatoria limosa</i> Ag.	1	3	3
<i>Oscillatoria limosa</i> f. <i>phormidioides</i> (Rabh.) Elenk.	1	2	2
<i>Oscillatoria limosa</i> f. <i>disperso-granulata</i> (Schkorb.) Elenk.	1	-	-
<i>Oscillatoria okenii</i> Ag.	-	r	1
<i>Oscillatoria princeps</i> Vauch.	-	-	1
<i>Oscillatoria tenuis</i> Ag.	1	-	1
<i>Oscillatoria tenuis</i> var. <i>symplociformis</i> (Hansg.) Elenk.	-	-	1
<i>Oscillatoria terebriformis</i> (Ag.) Gom.	-	r	1
<i>Phormidium ambiguum</i> Gom.	-	-	r
<i>Phormidium ambiguum</i> f. <i>maius</i> (Lemm.) Elenk.	-	-	2
<i>Phormidium favosum</i> (Bory) Gom.	-	1	r
<i>Phormidium fovoelatum</i> (Mont.) Gom.	5	2	3
<i>Phormidium mole</i> (Kütz.) Gom. f. <i>tenuis</i> (Woronich.) Elenk.	-	-	r
<i>Phormidium tenue</i> (Menegh.) Gom.	r	1	2
<i>Phormidium valderiae</i> (Delip.) Geitl. f. <i>maius</i> (Ag.) Gom. (Lemm.) Elenk.	1	-	2
<i>Phormidium valderiae</i> (Delip.) Geitl. f. <i>tenuis</i> (Woronich.) Elenk.	-	1	1
<i>Achnanthes coarctata</i> Bréb.	-	r	-
<i>Achnanthes lanceolata</i> (Bréb.) Grun.	1	1	1

Continue

<i>Amphora ovalis</i> (Kütz.) Kütz.	r	r	r
<i>Caloneis silicula</i> (Ehr.) Cleve	-	r	r
<i>Cyclotella radiosa</i> (Grun.) Lemm.	-	r	-
<i>Cymbella affinis</i> Kütz.	1	1	1
<i>Diatoma vulgare</i> Bory	1	1	-
<i>Fragilaria brevistriata</i> Grun.	1	2	2
<i>Fragilaria dilatata</i> (Bréb.) Lange-Bertalot	-	r	r
<i>Fragilaria ulna</i> (Nitzsch.) Lange-Bertalot	r	r	r
<i>Gomphonema acuminatum</i> Ehr.	r	r	r
<i>Gomphonema clavatum</i> Ehr.	r	r	r
<i>Gomphonema angustum</i> Kütz.	-	r	r
<i>Hantzschia amphioxys</i> (Ehr.) Grun.	-	r	r
<i>Navicula cuspidata</i> (Kütz.) Kütz.	1	1	1
<i>Navicula nivalis</i> Ehr.	-	-	r
<i>Navicula pupula</i> Kütz.	r	r	1
<i>Navicula radiosa</i> Kütz.	1	1	1
<i>Navicula rhynchocephala</i> Kütz.	1	r	r
<i>Nitzschia palea</i> (Kütz.) W. Smith	-	-	1
<i>Pinnularia borealis</i> Ehr.	-	1	r
<i>Pinnularia braunii</i> (Grun.) Cleve	1	2	2
<i>Pinnularia viridis</i> (Nitzsch.) Ehr.	1	1	1
<i>Rhoicosphaenia abbreviata</i> (A. Ag.) Lange-Bertalot	r	1	1
<i>Surirella ovalis</i> Bréb.	-	r	r
<i>Cosmarium laeve</i> Rabh	r	r	-
<i>Protococcus viridis</i> Ag.	1	-	r
<i>Scenedesmus quadricauda</i> (Turp.) Bréb.	r	-	-

Tab. 3. – Number of taxons on different temperature in thermomineral water of concrete canal of Niška Banja spa

Divisions	23.2-30.0	30.0-35.0	35.0-38.2
	°C	°C	°C
<i>Cyanophyta</i>	14	15	22
<i>Bacillariophyta</i>	15	24	23
<i>Chlorophyta</i>	3	1	1
TOTAL	36	40	46

In consideration to its temperature in November 1992, water in concrete canal was not thermal from biological point of view (Vouk, 1936).

On the basis of qualitative and relatively quantitative composition of algae, the vegetation of this thermomineral water may be specified as **cyano-diatomaceous** and as *Oscillatoria-Phormidium* - type.

Spring Suva Banja. By the examination of the sampels from the Suva Banja spring, the presence of algae from 3 divisions was established: *Cyanophyta*, *Rhodophyta* and *Bacillariophyta* (Tab. 4 and Tab. 5).

Tab. 4. - Qualitative and relatively quantitative composition of algae in the-rrnomineral water of Suva Banja spring of Niša Banja spa

Taxons	surfaces in the cave	surfaces out of the cave
<i>Aphanocapsa thermalis</i> Brü g.	1	1
<i>Gloeocapsa minor</i> (K ü t z.) H o l l e r b.	1	r
<i>Gloeocapsa punctata</i> N ä g.	1	r
<i>Lyngbya martensiana</i> R a b h.	-	r
<i>Oscillatoria numidica</i> G o m.	-	r
<i>Oscillatoria tenuis</i> A g.	1	r
<i>Oscillatoria tenuis</i> var. <i>symplociformis</i> (H a n s g.) E l e n k.	2	1
<i>Phormidium foveolarum</i> (M o n t.) G o m.	1	1
<i>Phormidium ambiguum</i> G o m.	1	1
<i>Pleurocapsa minor</i> H a n s g. e m e n d G e i t l.	-	1
* <i>Chantransia chalybea</i> (L y n g b.) F r i e s	7	1
<i>Achnathes lanceolata</i> (B r é b.) G r u n.	-	r
<i>Amphora ovalis</i> (K ü t z.) K ü t z.	-	1
<i>Caloneis silicula</i> (E h r.) C l e v e	-	r
<i>Cymbella affinis</i> K ü t z.	1	1
<i>Fragilaria brevistriata</i> G r u n.	1	2
<i>Fragilaria ulna</i> (N i t z s c h.) L a n g e - B e r t a l o t	-	1
<i>Gomphonema clavatum</i> E h r.	-	1
<i>Navicula pupula</i> K ü t z.	-	1
<i>Navicula nivalis</i> E h r.	-	r
<i>Navicula radiosa</i> K ü t z.	r	r
<i>Navicula rhynchocephala</i> K ü t z.	-	r
<i>Pinnularia braunii</i> (G r u n.) C l e v e	1	2
<i>Rhoicosphaenia abbreviatum</i> (C. A g.) L a n g e - B e r t a l o t	-	1
<i>Surirella ovalis</i> B r é b.	-	1

**Chantransia chalybea* (L y n g b.) F r i e s is not found in any samples collected in November 1992.

Tab. 5. – Number of taxons on different surfaces in thermomineral water of spring Suva Banja of Niška Banja spa

Divisions	surfaces in the cave	surfaces out of the cave
<i>Cyanophyta</i>	7	10
<i>Bacillariophyta</i>	4	14
<i>Rhodophyta</i>	1	1
TOTAL	12	25

The qualitative diversity of algae was not great. The dominant species was *Chantransia chalybea*, specially at the beginning of the cave. Beside *Ch. chalybea* some greater abundance have *Oscillatoria tenuis* var. *symplociformis*, *Fragilaria brevistriata* and *Pinnularia braunii*.

On the basis of qualitative and relative quantitative composition of algae, the vegetation of thermomineral water of Suva Banja spring may be specified as **rhodo-cyano-diatomaceous** and as *Chantransia* – type.

In November 1992 *Chantransia chalybea* was not found in any of collected samples. As the entrance into the cave was closed by metal plates, this alga was absent inside the cave. That fact means that in 1980, 1983 and 1985, *Ch. chalybea* out of the cave, was originated from the population of *Ch. chalybea* from the cave.

Some characteristics of determined taxons of algae from thermomineral water of Niška Banja spa

As we know from literature data, *Oscillatoria cortiana* (M e n e g h.) G o m. is noticed for the first time for territory of Serbia.

With exception of thermomineral waters of Niša Banja spa (C v i j a n, 1986), the next taxons are noticed for the first time in Serbia too: *Calothrix thermalis*, *Gloeocapsa crepidium*, *Gl. punctata*, *Oscillatoria tenuis* var. *symplociformis*, *O. numidica*, *Phormidium mole* f. *tenuis*, *Achnanthes coarctata*.

The next taxons are common inhabitants of therms: *Aphanocapsa thermalis*, *Calothrix thermalis*, *Gloeocapsa minor*, *Gl. punctata*, *Merismopedia punctata*, *Oscillatoria amphibia*, *O. numidica*, *O. okenii*, *O. terebriformis*, *Phormidium ambiguum*, *Ph. ambiguum* f. *maius*, *Ph. mole* f. *tenuis*, *Ph. tenue*, *Ph. valederiae*. But the most of them are represented by small number of individuals. The dominant algae are common inhabitants of water of different types or are living out of water too.

CONCLUSION

In the scope of algal studies of thermomineral water of Serbia the respective material from thermomineral water of Niška Banja spa was collected in September 1982, July 1983, April 1985 and November 1992.

Niška Banja spa is situated in central part of Serbia, 10 km south-east of the town Niš.

In Niška Banja there are two thermomineral springs: Main spring (with 35-120 l/sec. of water, temperature of 38.2-38.5°C) and spring Suva Banja (with 14-42 l/sec of water, temperature of 12-37°C). The both of them belong to the group of homeotherm water with moderate high (Main spring) or low (Suva Banja spring) radioactivity. The water of both springs is characterized by ions of Ca⁺⁺ and HCO₃ and pH near 7.

We investigated the thermomineral water of Suva Banja spring and thermomineral water flowing through the artificial, concrete canal originated from Main spring.

By the examination of collected material from concrete canal, the presence of algae from three divisions was established: *Cyanophyta* (31 taxons), *Bacillariophyta* (26) and *Chlorophyta* (3 taxons).

The dominant taxons are *Oscillatoria limosa* A g. and *O. limosa* f. *phormidioides* (R a b h .) E l e n k ., as well as *Phormidium foveolarum* (M o n t .) G o m ., *Fragilaria brevistriata* G r u n . and *Pinnularia braunii* (G r u n .) C l e v e .

The vegetation of thermomineral water of concrete canal in Niška Banja spa may be specified as **cyano-diatomaceous** and as *Oscillatoria-Phormidium* - type.

Only in November 1992 *O. limosa*, as a dominant species in the earlier periods, was substituted by *O. limosa*, (M e n e g h .) G o m . But samples from November 1992 was not typical for this thermomineral water from many reasons.

By the examination of collected material from thermomineral water of cave-spring Suva Banja, the presence of algae from three divisions was established: *Cyanophyta* (10 taxons), *Rhodophyta* (1) and *Bacillariophyta* (14 taxons).

The dominant species is *Chantransia chalybea* (L y n g b .) F r i e s ., specially at the beginning of the cave. Beside *Ch. chalybea* great abundance show *Oscillatoria tenuis* A g. var. *symplociformis* (H a n s g .) E l e n k ., *Fragilaria brevistriata* G r u n . and *Pinnularia braunii* (G r u n .) C l e v e . too.

The vegetation of thermomineral water of Suva Banja spring in Niša Banja spa is specified as **rhodo-cyano-diatomaceous** and as *Chantransia*-type.

Exception is November of 1992 when the entrance of the cave was closed by metal plates and algae disappeared from the cave because of low level of the light intensity.

As we know from literature data (C v i j a n and B l a ž e n č i ć, 1988), *Oscillatoria cortiana* (M e n e g h .) G o m . is noticed for the first time for territory of Serbia.

Some of presented taxons are common inhabitants of the thermns. But the most of them are represented by small number of individuals. Practically, algological base of thermomineral water of Niška Banja spa are presented by algae which are not characteristic for thermomineral water. The most of them are common inhabitants of the waters of different types or are living out of the water too.

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Rezi me

MIRKO CVIJAN

ALGE U TERMOMINERALNIM VODAMA NIŠKE BANJE (SRBLJA)

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U okviru istraživanja termomineralnih izvora Srbije u septembru 1982, julu 1983, aprilu 1985. i novembru 1992. sakupljen je algološki materijal iz termomineralne vode izvora Glavni izvor i izvora Suva Banja u Niškoj Banji.

Izvor Suva Banja karakteriše 14-42 l/sec. vode čija je temperatura 12-37°C, a Glavni izvor 35-120 l/sec. vode čija je temperatura 38.2-38.5°C. Oba izvora pripadaju grupi homeotermnih voda sa umereno visokom (Glavni izvor), odnosno niskom (Suva Banja) radioaktivnošću. Takođe ih odlikuje prisustvo jona Ca⁺⁺ i HCO₃⁻, kao i pH oko 7.

U termomineralnoj vodi Glavnog izvora utvrđeno je prisustvo algi iz tri razdela: *Cyanophyta* (31 taksona), *Bacillariophyta* (26) i *Chlorophyta* (3 taksona).

Utvrđena je kvantitativna dominacija *Oscillatoria limosa* A g. i *O. limnosa* f. *phormidioides* (R a b h.) E l e n k., kao i uvećana brojnost *Phormidium foveolarum* (M o n t.) G o m., *Fragilaria brevistriata* G r u n. i *Pinnularia braunii* (G r u n.) C l e v e. Na osnovu toga termomineralna voda Glavnog izvora označena je kao **cyano-dijatomejska**, a bliže kao *Oscillatoria-Phormidium*-tip.

Izuzetak je novembar 1992. kada je *Oscillatoria limosa* (dominantna u ranijim periodima istraživanja), zamenjena vrstom *O. cortiana* (M e n e g h.) G o m. Ali uzorci iz ovog perioda nisu reprezentativni iz više razloga.

U termomineralnoj vodi izvora Suva Banja utvrđeno je prisustvo algi iz tri razdela: *Cyanophyta* (10 taksona), *Rhodophyta* (1) i *Bacillariophyta* (14 taksona).

Utvrđena je kvantitativna dominacija *Chantransia chalybea* (L y n g b.) F r i e s, posebno na ulazu u pećinu. Osim toga visokom brojnošću odlikovale su se i *Oscillatoria tenuis* A g. var. *symplociformis* (H a n s g.) E l e n k., *Fragilaria brevistriata* G r u n. i *Pinnularia braunii* (G r u n.) C l e v e. Na osnovu toga termomineralna voda izvora Suva Banja označena je kao **rodo-cijano-dijatomejska**, a bliže kao *Chantransia*-tip.

Izuzetak predstavlja novembar 1992. kada je ulaz u pećinu bio zatvoren metalnim pločama te su alge u unutrašnjosti pećine, usled prevelike zaseve, bile odsutne.

Na osnovu dostupnih literaturnih podataka, *Oscillatoria cortiana* (M e n e g h.) G o m. po prvi put je zabeležena za teritoriju Srbije.

Neke od determinisanih algi široko su rasprostranjene u termomineralnim vodama. Međutim većina takvih predstavnika u termomineralnoj vodi istažnih izvora u Niškoj Banji zastupljena je malim ili veoma malim brojem jedinki. Praktično, algološku osnovu termomineralne vode oba istražena izvora čine alge koje za takve vode nisu karakteristične, koje su uobičajeni stanovnici voda različitog tipa ili, pak, žive i van vode.