Phytoplankton communities of the Danube-Tisza-Danube canal network Banatska Palanka - Novi Becej (Serbia)

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Introduction

The Hydrosystem Danube-Tisza-Danube is a dynamic system from hydrological, nutrient recycling, biotic diversity and resource perspectives point of view. In Banat region, the canal network Banatska Palanka – Novi Becej is disturbed by floods, droughts and the level of the wastewater purification, not only in Vojvodina, but also in the countries located upstream the small rivers (Figure 1). Water Framework Directive (WFD 2000/60/EC) proposed phytoplankton communities to be included in the assessment of the Ecological status/potential. Therefore, in the present framework of research, it was our intention to determine a selection of type-specific communities, which would be one of the hydrobiological elements in the estimation of changes in the quality of canal water. They should be characterized from the ecological point of view in order to estimate negative human impact and eutrophication.

The current practice of water resources management and the study of environmental dynamic problems such as the land use, land cover changes, the movement of sediments, nutrient content and chemicals over the watersheds require the development of spatially-distributed watershed hydrology models and conservation equations (KAVVAS, M. L. et al. 2005). Water modelling studies that use phytoplankton functional groups (ANDERSON, 2005) pointed out that the errors are likely caused as much by deficiencies in model physics as by problems in aquatic ecosystem model variables. Phytoplankton species composition and conservation processes have been suggested by zinc-containing enzymes phosphatases (COHEN, 2004; NEMES & MATAVULY, 2006), which enable phytoplankton communities to utilize dissolved organic phosphorus when inorganic phosphate is limited. Large variability in phosphatase production was found not only among different phytoplankton species, but also within the population of one species in an eutrophic reservoir (ŠTROJSOVA et al. 2003).

Material and methods

The investigation of the Canal Banatska Palanka – Novi Becej in Serbia was carried out in the course of 2003 and 2004 by collecting the surface water samples and sporadically probing sediments at selected sampling stations (Figure 1). This paper focuses on the summer season investigation, avoiding the flooding periods. The identification of algae was based on light microscopy and Scanning electron microscope (SEM). Phytoplankton counting was performed according to Németh & Vörös (1986). Algal biomass revealed chlorophyll- *a* content (APHA, 1995) that expresses trophic potential: *excellent* >3 mg m^{-3}, *good* 3-10 mg m^{-3}, *moderate* 10 - 30 mg m^{-3}, *poor* 30-100 mg m^{-3} and, finally, above 100 mg m^{-3}, *bad* ecological potential. Using the plate count method, the abundance of total coliform bacteria was determined according to PETROVIC et al. (1998). The statistical analyses were done by the S- PLUS springer student edition software package (1999). The agglomerative hierarchical cluster analysis revealed distances between phytoplankton communities according to phytoplankton composition and

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extracellular phosphatase enzyme activity of water. Phosphatase enzyme activity (PME-phosphomonoesterase) of an untreated water sample was measured spectrophotometrically using p-nitrophenylphosphate as a substrate for acid, neutral, and alkaline enzyme activity of water (OD_{420nm}). The phosphatase enzyme activity revealed the potential of the phosphor-monoester organic compounds of water being altered by the heterotrophic and autotrophic microbial communities. Therefore, the ecological status was proposed using the PAI index, described by MATAVULY, (1986): *excellent* 0.01-0.10 μmol pNP s^{-1} dm^{-3}, *good* 0.10-2.50 μmol pNP s^{-1} dm^{-3}, *moderate* 2.50-5.00 μmol pNP s^{-1} dm^{-3}, *poor* 5.00-10.00 μmol pNP s^{-1} dm^{-3}, and *bad* potential above 10.00 μmol pNP s^{-1} dm^{-3}.

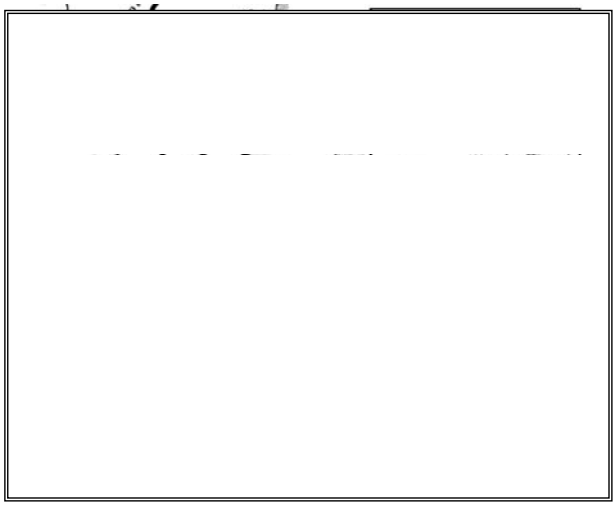

Figure 1. Distribution of studied sampling sites of the canal Banatska Palanka – Novi Becej with the river tributaries entering from Romania.

Results and discussion

Phytoplankton communities were characterized by the presence of 140 of algal taxa of which 19 Cyanobacteria, 18 Euglenophyta, 62 Bacillariophyceae, 2 Chrysophyceae, 39 Chlorophyta, 2 Dinophyta in summer of 2003 and 2004. In the middle of the canal, the alpha-mesosaprobic bioindicators (GULYÁS, 1998) such as *Cyclotella meneghiniana, Melosira varians, Nitzshia palea*, *Rhoicosphenia abbreviata* and *Surirella ovalis* were dominant species. We also detected the presence of brackish-water diatoms such as *Bacillaria paradoxa, Nitzschia constricta, N. filiformis, N. levidensis, Entomoneis paludosa* in the middle of the Canal, as one of the subdominant species in a colder period. In June, the dominance of centric diatom *Stephanodiscus minutulus* was recorded by comparing it to the group of Euglenophyta and green algae. However, the phytoplankton development in July 2003. was characterized by the dominance of the centric diatom *Cyclotella meneghiniana* and eutrophication of the canal water (Figure 4). Downstream of the river Tamis, the species such as *Cymatopleura solea, Fragilaria ulna, Fragilaria capucina, Gyrosigma scalproides* and *Nitzschia* were present together with desmid species (*Closterium moniliferum*, *Closterium ehrenbergii*, *Closterium aciculare*, *Cosmarium botrytis*, *Cosmarium laeve*). However, when the river Moravica almost lost its feature when the water discharge decrease to almost 0 m^3 s^{-1} in August of 2004, the blooming of toxic cyanobacteria *Anabaena*

flos-aquae with max. chlorophyll- *a* content exceeded 1001.2 mg m^{-3}, and thus caused the decrease in the number of phytoplankton species and the highest phosphatase activity of water 66.65 µmol pNP $s^{-1}dm^{-3}$ (*bad* ecological status). In general, results relating to the comparative data on phytoplankton communities of the canal Banatska Palanka – Novi Becej and its tributaries are similar according to the sampling sites, and thus denote the influence of tributaries on the algal composition in the canal (Figure 2). The chlorophyll-*a* concentration and phosphatase enzyme activity of the Banatska Palanka – Novi Becej canal waters exceeded *moderate* ecological potential in the middle Banat region in the summer season (Figure 4).

Superior acid, neutral and alkaline phosphatase enzyme activity of water in sediments pointed out the most prominent values in the canal near Botos: 2740, 2597, and 1996 (av. 2445)

µmol pNP $s^{-1}dm^{-3}$. Most probably, it was due to the bacterial extracellular phosphatase enzymes, and the affinity for transformation of phoshomonoester bonds of accumulated organic material and orthophosphorus release. However, the differences in the values deserve further research of the sediments in biodiversity point of view.

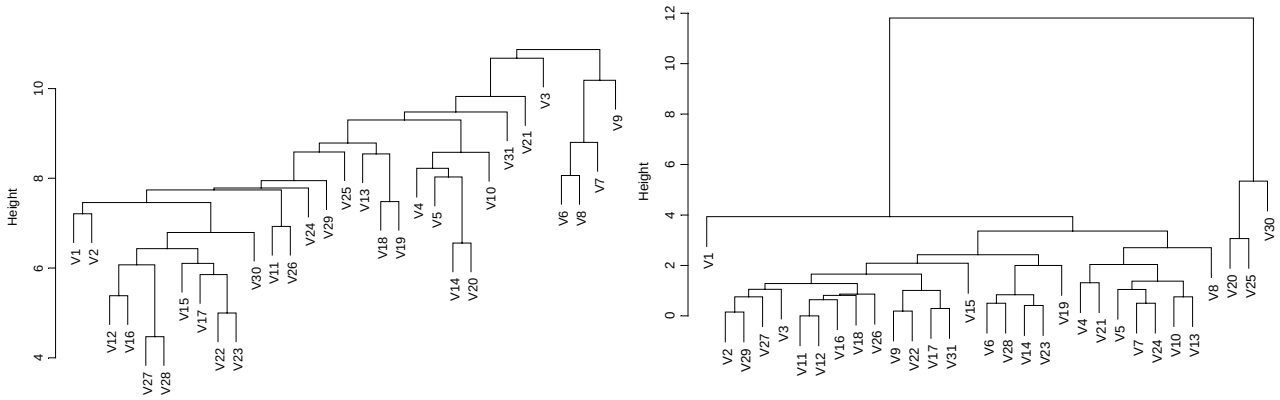

Figure 2-3. Cluster analysis of the phytoplankton communities according to the abundance of dominant species (cell cm^{-3}) (right) and cluster analysis of acid, neutral and alkaline phosphatase (µmol pNP s^{-1} dm^{-3}) (left) at the sampling sites in HS DTD canal network in the middle and southern Banat region in the summer season of 2003 and 2004: 1. The river Tisza- Novi Becey (July ’03) and in canal 2. Novi Becey (July ’03), 3. Melenci (July ’03), 4. The river Begej- Hetin (July ’03) and canal 5. DTD Jankov most (July ’03), 6., 7. Srpski Itebej (July ’03, July ’04), 8. Klek (July ’03), 9. Lazarevo (July ’03), 10., 11. The river Tamis at Botos (July ’03, June ’04) and in canal 12., 13. Botos; 14.,15. The river Brzava and downsteam in the canal near 16., 17. Banatska dubica, 18., 19. Jermenovci, (June and August ’04); 20., 21. The river Moravica (July ’03, June ’04); 22., 23. DTD canal downstream Vlajkovac and small Vrsacki canals (June and August ’04); 24., 25., 26. The river Karas and 27., 28., 29. The river Nera (July ’03, June and August ’04); 30., 31. Sampling stations of the entrance of DTD canal in the river Danube- Banatska Palanka (June and August ’04).

The dynamic nature of the use of coliforms as microbial indicators of the surface water quality assessment in the Banatska Palanka – Novi Becej (MATAVULY et al. 2004; RADNOVICY et al. 2004) suggested the further usage in the estimation of ecological potential and the assessment of human impact. The total coliform bacteria number in the canal revealed the pollution in the middle Banat region from the Canal Navigable Begej and the Old Begej River, and was in correspodence with the ammonia concentration in the rivers coming from Romania (NEMES et al.

2005). During the late summer season, phytoplankton communities were characterized by the increase in green algal inedible species such as *Scenedesmus opoliensis, Scenedesmus quadricauda* and *Pediastrum spp.* in the canal, and *Pandorina morum* in the rivers. Increase of the number of total coliform bacteria was in correspondence to orthophosphate availability in water and hence indicated Ecological potential (figure 4; 5).

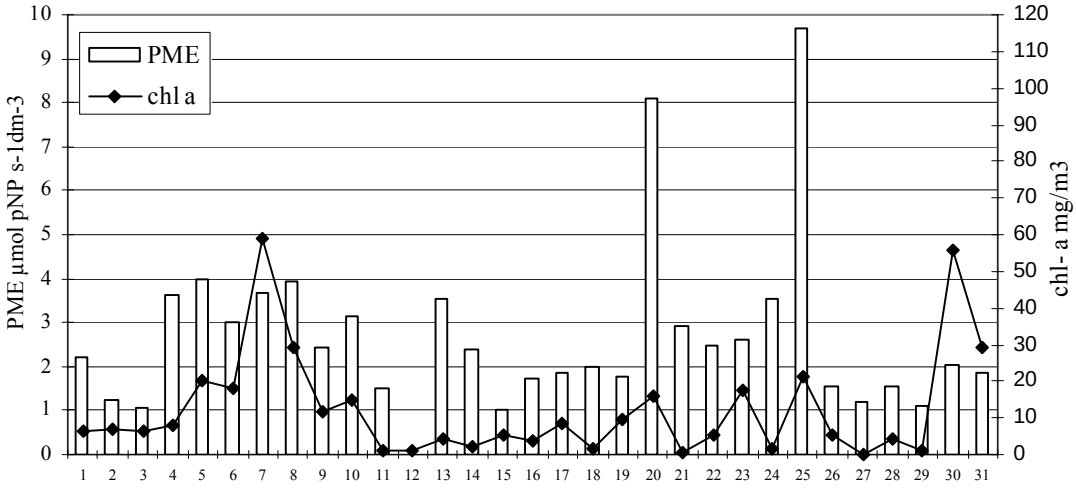

Figure 4. Phosphatase enzyme activity in water (µmol pNP s^{-1} dm^{-3}) in the canal Banatska Palanka–Novi Becej and its tributaries and the concentrations of chlorophyll- *a* (mg m^{-3}) in the water at selected sampling sites corresponded to the figure 2-3.

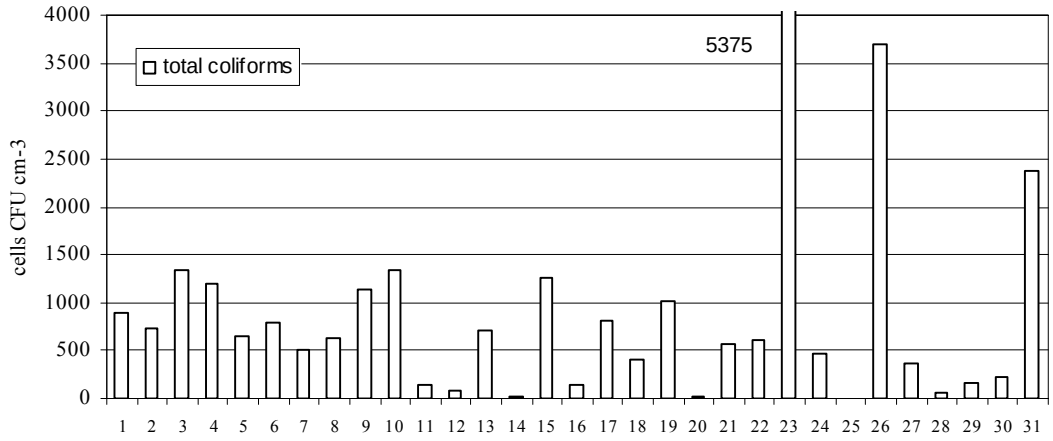

Figure 5. The number of total coliform bacteria cells (CFU cm^{-3}) in the canal Banatska Palanka – Novi Becej and its tributaries from selected sampling stations corresponded to the figure 2-3.

Summary

Phytoplankton community analyses were carried out in the canal network Banatska Palanka – Novi Becej in the summer of 2003 and 2004. Dominant species which belong to these communities are diatoms of the following genera: *Cyclotella, Surirella, Diatoma*, *Anomoeoneis, Nitzschia, Rhoicosphenia*, *Navicula*, *Cymatopleura*, *Bacillaria, Fragilaria* and *Gyrosigma*. The

phosphatase enzyme activities suggested the changing level of phosphorus availability in phytoplankton communities. The chlorophyll-*a* concentration and phosphatase enzyme activity of the Banatska Palanka – Novi Becej canal waters indicated *moderate* ecological potential in the middle Banat region in the summer season.

Acknowledgements

These studies were supported by the Ministry of Science and Environmental Protection of the Republic of Serbia.

References

(APHA, 1995): Standard methods for the examination of water and wastewater. 19th edition. Washington.

COHEN, P. T.W. (2004): Overview of protein serine/threonine phosphatases. Topics in Current genetics, Vol. 5. J. Arino, D. R. Alexander (Eds.). Protein phosphatases. Springer-Verlag Berlin.

DIRECTIVE 2000/60/EC of the European Parliament and of the Council of 23 October 2000. Official Journal of the European Communities.

GULYÁS, P. (1998): Szaprobiológiai indikátorfajok jegyzéke. Vízi természet és környezetvédelem, 6. kötet, Budapest.

ANDERSON, T. R. (2005): Plankton functional type modelling: running before we can walk? Journal of Plankton research. Volume 27. Number 11. Pages 1073 – 1081.

KAVVAS, M.L., CHEN, Z.K., DOGRUL, C., YOON, J.Y., OHARA, N., LIANG, L., AKSOY, H., ANEDERSON, M.L., YOSHITANI, J., FUKAMI, K., MATSURA, T. (2005): Watershed Environmental Hydrology (WEHY) Model based on upscaled Conservation equations: Hydrologic Module, J. of Hydrologic Engineering.

MATAVULY, M. GAYIN, S., PETROVICY, O., RADNOVICY, D., SIMEUNOVICY, Y., BOKOROV, TEODOROVICY, I., KARAMAN, M. (2004): Water quality of the Zrenyanin-Banatska Palanka stretch of the major canal of the Danube-Tisza-Danube canal system according to microbiological parameters. Intern. Assoc. Danube Res. 35. -315-323. Novi Sad, April 2004.

MATAVULY, M. (1986): The nonspecific phosphomonoester-hydrolases of microorganisms and their significance in phosphorus cycle in aquatic environments. (In Serbian) Ph.D. Thesis, University of Zagreb, 1986.

NEMES, K., SIMEUNOVICY, Y., BUGARSKI, R., RADNOVICY, D., MATAVULY, M. (2005): Plankton investigation of the Canal Navigable Begey (Voyvodina, Serbia). 8th International Symposium Interdisciplinary Regional Research, CD Proc., EEP17.

NEMES, K. MATAVULY, M. (2006): Phosphatase enzyme activity of water in Hydrosystem Danube-Tisza-Danube (Serbia). Congress of FEMS 2006. abstract. pp.172.

NÉMETH, J., VÖRÖS, L. (1986): Koncepció és módszertan felszsíni vizek algológiai monitoringjárhoz. Orsz. Környezet – és Term. véd. Hiv. Budapest, 136 pp.

RADNOVICY, D., MATAVULY, M., GAYIN, S., SIMEUNOVICY, Y., MILJANOVICY, B., NEMESH, K., BOKOROV, M. (2004): Water quality of the transboundary flowing waters of the Serbian part of Banat region according to biological indicators. Intern. Assoc. Danube Res. 35. pp. 331-339.

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ŠTROJSOVA, A., VRBA, J., NEDOMA, J., KOMÁRKOVA, J., ZNACHOR, P. (2003): Seasonal study of extracellular phosphatase expression in the phytoplankton of eutrophic reservoir. Eur. J. Phycol. 38: 295-306.