ARTICLE HTTP://DX.DOI.ORG/10.5504/BBEQ.2013.0019 A&EB

WATER QUALITY AND ECOLOGICAL STATE ASSESSMENT OF THE BLAGOEVGRADSKA BISTRITSA RIVER (SOUTH-WEST BULGARIA) BASED ON MACROZOOBENTHOS COLLECTED BY TWO SAMPLING STANDARDS

Lidia Sakelarieva[1] and Emilia Varadinova[2]
[1]South-West University, Faculty of Mathematics and Natural Sciences, Blagoevgrad, Bulgaria
[2]Bulgarian Academy of Sciences, Institute of Biodiversity and Ecosystem Research, Sofia, Bulgaria
Correspondence to: Lidia Sakelarieva
E-mail: sakelarieva.lidia@swu.bg

ABSTRACT

Complex investigations of the Blagoevgradska Bistritsa River, left tributary of the trans-boundary Struma River, were carried out in the summer of 2008. Seven representative sites were sampled. Physico-chemical parameters such as water temperature, pH, oxygen concentration, oxygen saturation, conductivity, nitrates and phosphates were measured. The biological assessment was based on macroinvertebrate communities – one of the obligatory biological quality elements according to the Water Framework Directive requirements and the national legislation. Canonical Correlation Analysis (CCA) was used for the explanation of the site–physico-chemical factors relationship. Indices of species diversity (c, e, H), saprobiological index (S_R), biotic index (BI) and trophic index (RETI/PETI) were used to determine the water quality and the ecological state of the water bodies.

According to the values of the physico-chemical parameters, indices of species diversity and the saprobiological index, the water quality of the sites from the source to the city of Blagoevgrad was I – II category. The ecological state was assessed as high, according to BI and high and good, based on the trophic index RETI. The water quality at the Blagoevgradska Bistritsa mouth, influenced by the waste waters of the city of Blagoevgrad, was assessed as II – III category, and the ecological condition, as moderate and poor (BI) and bad (PETI). The distribution of the physico-chemical parameters at the ordination diagram divided the studied sites into two groups: upstream (clean, unaffected sites) and downstream (anthropogenically influenced sites) of the city of Blagoevgrad.

Two periods of investigation (2002–2003 and 2008) and two standard methods for macrozoobenthos sampling (handnet sampling of aquatic benthic macroinvertebrates and quantitative samplers for benthic macroinvertebrates on stony substrata in shallow freshwater) were compared. The results showed that for a five-year period of time changes in the water quality and the ecological state of the studied sites had not been observed. The two sampling methods gave similar results as regards the values of the indices used.

Biotechnol. & Biotechnol. Eq. 2013, **27**(3), 3787-3790

Keywords: Blagoevgradska Bistritsa River, macrozoobenthos, water quality, ecological state assessment

Introduction

The Blagoevgradska Bistritsa River and its basin were studied in the period 2002–2003 in order to make an up-to-date assessment of the river ecological state. Morphometric (5), hydrometric (15), and physico-chemical (13) research was done. Special attention was given to the hydro-biological studies and mainly to the macroinvertebrate benthic communities (11, 12, 14), which are one of the obligatory biological quality elements according to the Water Framework Directive requirements and the national legislation. The influence of the river flow on macrozoobenthos was also studied (15).

The aim of this study was to assess the current water quality and ecological state of the Blagoevgradska Bistritsa River based on macrozoobenthos, and to compare two periods of investigation (2002–2003 and 2008) and two standard sampling methods.

Materials and Methods

Complex investigations of representative sites of the Blagoevgradska Bistritsa River, tributary of the trans-boundary Struma River, were carried out in the summer of 2008. Seven river sites were sampled: Parangalitsa – 1, upstream of Bodrost – 2, Dobro Pole – 3, Slavovo – 4, Bistritsa – 5, upstream of the town of Blagoevgrad – 6, downstream of the town of Blagoevgrad (river mouth) – 7 (**Fig. 1**). Some physico-chemical parameters such as water temperature, pH (ISO 10523), oxygen concentration (EN 25814, mg/L), oxygen saturation (%), conductivity (EN 27888, µS), nitrates (ISO 7890-1) and phosphates (EN ISO 6878) were measured on site by means of a portable Windaus Labortechnik Package.

Two standard methods for collection of macrozoobentos were used: ISO 7828:1985/EN 27828:1994, and ISO 8265:1988/EN 28265:1994. The ecological assessment was made according to the Water Framework Directive (3) requirements and the national legislation (7, 8, 9).

Canonical Correlation Analysis (CCA, PAST data analysis package) was used for the explanation of the site–physico-chemical parameters (water temperature, oxygen

concentration, nitrates and phosphates) relationship (4). Data of species composition at three sites in 2002 (sites 1, 6, and 7) and at all seven studied sites in 2008 were included in the ordination diagram.

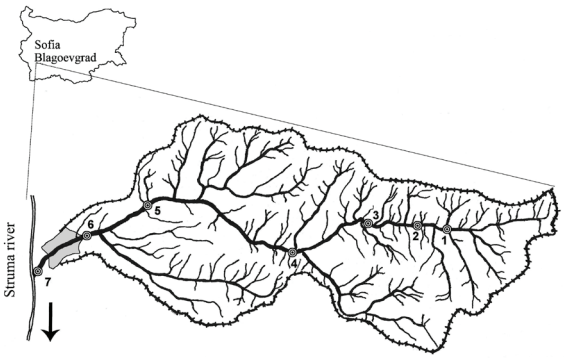

Fig. 1. The Blagoevgradska Bistritsa River basin and location of the studied sites.

Indices of species diversity: index of dominance (c) of Simpson (18), evenness index (e) of Pielou (6) and index of general diversity (H) of Shannon and Weaver (17), saprobiological index (S_R) of Zelinka and Marvan (19) and Rothschein (10), number of taxa, biotic index (BI) – adapted version of the Irish Biotic Index (1, 2), and trophic index (RETI/PETI) (16), were used for the water quality and ecological state assessment. EQR (ecological quality ratio) scales, developed on the basis of the values of the number of taxa, BI and RETI/PETI for the project "Development of classification system for the ecological state/potential of the identified types of surface waters (rivers and lakes) on the territory of the Republic of Bulgaria (Contract No. 6/27.03.2009 with the MOEW under the EC Operation Programme "Environment") were used.

The water quality and the ecological state of the river in 2008 were compared with those in the period 2002–2003 (11), when the bioassessment was made on the basis of macrozoobenthos collected according to ISO 7828:1985/EN 27828:1994.

Results and Discussion

Water temperature varied from 11.4 °C to 19.2 °C and increased naturally from the source down to the river mouth (**Fig. 2**). The values of pH (**Fig. 2**) fluctuated in relatively narrow limits (6.8 at site 1 to 7.54 at site 4). Close to the neutral values of pH were measured in the summer of 2002–2003. The lowest value (site 6 – 5.93) of this parameter was measured in the spring and autumn of the same period (13). The oxygen concentration remained almost the same until the sixth site, which corresponds to I category according to Regulation 7/1986 (**Fig. 2**). The oxygen concentration decreased to 5.74 mg/L at the river mouth (II category). An alternative tendency was observed for the oxygen saturation (**Fig. 2**). The conductivity (**Fig. 2**) increased downstream from 17.7 μS to 479 μS (I category).

According to the values of nitrates and phosphates (**Fig. 3**), the water quality of the sudied sites was I category with only one exception: the concentration of phosphates at the river mouth (2.8 mg/L) corresponded to III category, which could be explained with the heavy organic pollution caused by the sewage waters of the city of Blagoevgrad.

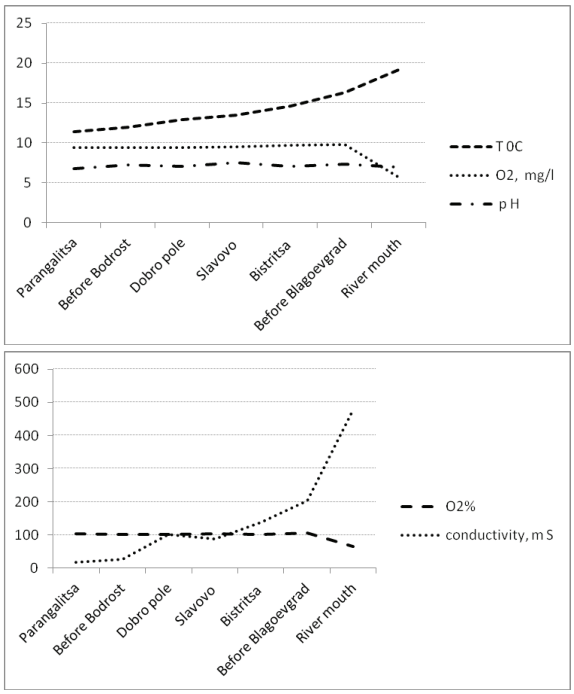

Fig. 2. Warer temperature, oxygen concentration, pH, oxygen saturation and conductivity along the Blagoevgradska Bistritsa River in July 2008.

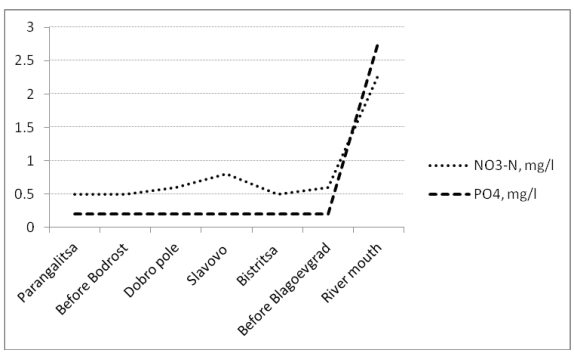

Fig. 3. Dynamics of nitrates and phosphates along the Blagoevgradska Bistritsa River in July 2008.

The water quality assessed on the basis of physico-chemical parameters in 2008 did not show any difference in comparison with that in the period 2002–2003 (13). The CCA ordination diagram confirmed these results (**Fig. 4**). The first two axes explain 77 % of the total variance of data ($p < 0.01$). The combination of the four physico-chemical water parameters determines the location of the studied sites. The ordination diagram presents the formation of gradient of the water temperature ($R = 0.844$), nitrates ($R = 0.881$) and phosphates ($R = 0.892$) which positively and significantly correlate with the first axes. The oxygen concentration demonstrates very high negative correlation with axes X ($R = -0.965$). Significant differences in the conditions and the benthic macroinvertebrate communities found at the studied sites upstream (sites 1–6) and downstream (site 7) of the city of Blagoevgrad were registered.

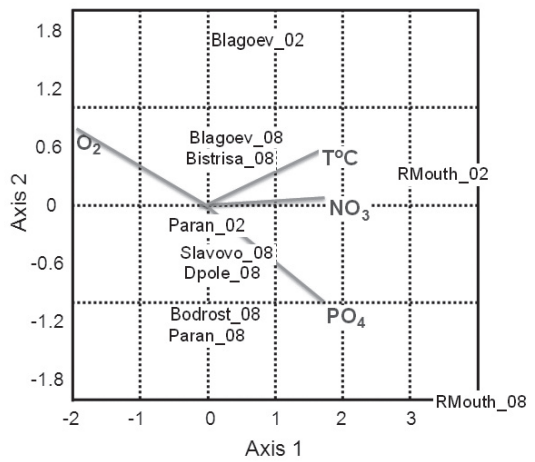

Fig. 4.CCA ordination diagram presenting selected phisico-chemical variables and the studied sites of the Blagoevgradska Bistritsa River.

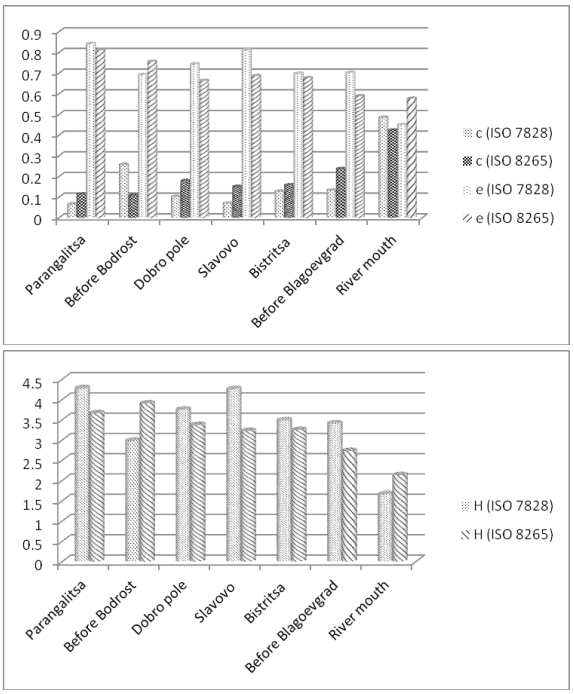

Fig. 5. Indices of dominance (c) and evenness (e), and Shannon's index of diversity (H) at different sites of the Blagoevgradska Bistritsa River in July 2008.

The indices of dominance and evenness, calculated on the basis of macrozoobenthos collected by the two sampling methods, had similar values (**Fig. 5**). According to Simpson's index of dominance, the water quality at the first six sites was I category in all cases, except site 2 (ISO 7828) and site 6 (ISO 8265), while the values of the evenness index indicated I or II category. The water quality at the river mouth was determined as II category according to the index of dominance and III category according to the evenness index.

The values of Shannon's index were high, varied slightly at the first six sites (**Fig. 5**) and determined the water quality as I category, except for site 2 (ISO 7828) and site 6 (ISO 8265) – II category. At the river mouth the index had lower values and accordingly the water quality was assessed as II – III category. These results correspond to the ones obtained in the period 2002–2003 (11, 12).

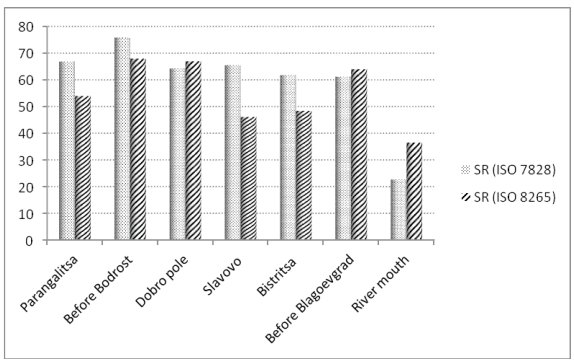

Fig. 6. Values of the saprobiological index (S_R) at different sites of the Blagoevgradska Bistritsa River in July 2008.

The comparison of the two sampling methods demonstrated some differences in the water quality characterized by the values of the SR index (**Fig. 6**). According to all measured values of SR – ISO 7828 the river at the first six sites was I category. The assessment based on SR – ISO 8265 indicated I (sites 2, 3 and 6) or II category (sites 1, 4, 5). The water quality at the river mouth was determined as III (SR ISO 8265) or exceeded the requirements for III category (SR ISO 7828). The water quality had not changed for the period 2002–2008 (14).

At the first six sites the ecological state assessed by the EQR scales for the number of taxa and BI was high, and according

TABLE 1

Parameters characterizing the ecological quality state of the Blagoevgradska Bistritsa River

Sites	Number of taxa (ISO 7828)	Number of taxa (ISO 8265)	BI (ISO 7828)	BI (ISO 8265)	RETI/PETI (ISO 7828)
Parangalitsa	36	23	5	4.5	60
Before Bodrost	33	36	4.5	4.5	94
Dobro pole	31	34	4	4.5	66
Slavovo	37	26	4.5	4.5	70
Bistritsa	32	28	4.5	4.5	78
Before Blagoevgrad	28	25	4.5	4.5	93
River mouth	13	13	2	2.5	4

to the values of the trophic index, high and good (**Table 1**). The complex assessment characterized the state of the water bodies in the river section down to the city of Blagoevgrad as close to the referent. The ecological state at the river mouth was quite different and varied from good to bad, depending on the three parameters used. The low values of BI, the small number of taxa and the destroyed trophic structure could be explained with the unfavourable conditions at this site, caused by the waste waters of the city of Blagoevgrad. Probably the ecological state of the river in this section has improved since 2009, when the Waste Water Treatment Plant of Blagoevgrad started working. Additional studies are required to find whether the ecological situation has been improved and the macrozoobenthic community has been recovered.

Conclusions

According to the values of the physico-chemical parameters, indices of species diversity and the saprobiological index, the water quality of the sites from the source to the city of Blagoevgrad was I – II category. The water quality at the river mouth, influenced by the waste waters of Blagoevgrad, was assessed as II – III category. The water quality of the Blagoevgradska Bistritsa River in 2008 had not changed in comparison with 2002–2003. This indicates that the anthropogenic impact on the river and its basin had not changed in the period 2002–2008. The CCA confirmed these results and also the significant differences in the conditions and the benthic macroinvertebrate communities found at the studied river sites situated upstream and downstream of the city of Blagoevgrad.

The ecological state of the water bodies in the river section downstream of Blagoevgrad (sites 1 to 6) was assessed as high (referent conditions) according to BI and high and good, based on the trophic index RETI. The ecological condition at the river mouth was determined as moderate and poor (BI) and bad (PETI).

The two sampling methods gave similar results as regards the values of the indices used.

An improvement in the ecological state of the river mouth could be expected since the Waste Water Treatment Plant of the city of Blagoevgrad started working in 2009. Additional studies are required to find out whether the species and trophic structure of macrozoobenthos in this river section have been recovered.

Acknowledgements

The authors would like to thank Prof. Dr. Jordan Uzunov, Assoc. Prof. Dr. Ivanka Yaneva, Dr. Stefan Stoichev, Dr. Lyubomir Kenderov, Yanka Vidinova, Violeta Tyufekchieva, Rabia Soufi and Aleksandar Pulev for their valuable contribution to the sampling and determining some of the benthic groups, as well as for their technical assistance.

The study was supported by the Human Resources Development Operational Programme 2007–2013, co-financed by the European Social Fund (Project BG051PO001/07/3.3-01/100/17.06.2008).

REFERENCES

1. **Clabby K.** (1981) The National Survey of Irish Rivers. A Review of Biological Monitoring 1971–1979, An Foras Forbartha, Dublin.
2. **Clabby K.J., Bowman J.J.** (1979) In: 3rd Technical Seminar on Biological Water Assessment Methods (P.F. Ghetti, Ed.), Parma, 1978, **Vol. 1**, Commission of the European Communities.
3. **EU Water Framework Directive** (2000) Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32000L0060:EN:NOT>
4. **Hammer Ø., Harpet, D. A. T., Ryan P. D.** (2001) Palaeontologia Electronica, **4**(1), 9.
5. **Michailov M., Sakelarieva L.** (2005) In: Mathematics and Natural Sciences Proceedings of the International Scientific Conference, 8–11 June 2005, SWU "Neofit Rilski", Blagoevgrad, **Vol. 2**, 251-255.
6. **Pielou E.** (1966) J. Theor. Biol., **10**, 370-383.
7. **Regulation** (1986) Regulation 7/1986 on Criteria and Standards for Water quality assessment of superficial running waters, State Gazette, **96**/12.12.1986. (In Bulgarian)
8. **Regulation** (2007) Regulation 13/2007 for Superficial Waters Assessment <http://www3.moew.government.bg/files/file/Legislation/Naredbi/vodi/N13_harakt_PV.pdf> (In Bulgarian)
9. **Regulation** (2011) Regulation 1/2011 for Water Monitoring <http://www3.moew.government.bg/files/file/Legislation/Naredbi/vodi/N1_monitvodi.pdf> (In Bulgarian)
10. **Rothschein J.** (1962) Veda a vyskum praxi VUVH, Bratislava, **9**, 1-64.
11. **Sakelarieva L.** (2006) Ecological Condition and Problems of the Blagoevgradska Bistritsa River – the Main Water Source of the City of Blagoevgrad. PhD Dissertation, Sofia. (In Bulgarian).
12. **Sakelarieva L., Janeva I.** (2005) In: Biodiversity Ecosystems Global Changes, I National Scientific Conference in Ecology (N. Chipev, V. Bogoev, Eds.), Petekston, Sofia, 323-330. (In Bulgarian, English summary).
13. **Sakelarieva L., Janeva I.** (2006) Ecology and Industry, **8**(1-2), 249-251. (In Bulgarian, English summary).
14. **Sakelarieva L., Janeva I.** (2007) In: Mathematics and Natural Sciences Proceedings of the International Scientific Conference, 6–10.06.2007, SWU "Neofit Rilski", Blagoevgrad, **Vol. 2**, 249-255.
15. **Sakelarieva L., Janeva I., Michailov M., Hristov H.** (2010) In: 12th International Conference on Wetland Systems for Water Pollution Control October 4–8, 2010, Venice, Italy, **Vol. II,** 1473-1480.
16. **Schweder H.** (1990) In: Okologische Bewertung von Fliebgewassern (G. Friedrich, J. Lacombe, Eds.), Limnologie Aktuell, **3**, G. Fischer Verlag, Stuttgart, 353-377.
17. **Shannon S., Weaver W.** (1963) The Mathematical Theory of Communication, University of Illinois Press, Urbana, p. 117.
18. **Simpson E.** (1949) Nature, **163**, 688.
19. **Zelinka M., Marvan P.** (1961) Arch. Hydrobiol., **57**, 389-407.