

# Trophic Structure of Macrozoobenthos and Assessment of Ecological Status of Lakes and Reservoirs in Bulgaria

*Emilia D. Varadinova<sup>1,2</sup>, Maria Y. Kerakova<sup>1</sup>, Mila K. Ihtimanska<sup>1</sup> & Rabia A. Soufi<sup>1</sup>*

<sup>1</sup> Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, 2 Gagarin Street, 1113 Sofia, Bulgaria

<sup>2</sup> South-West University "Neofit Rilski", 66 Ivan Mihailov Street, 2700 Blagoevgrad, Bulgaria; E-mail: emily.varadinova@gmail.com

**Abstract:** The trophic structure of macrozoobenthos in 50 of the largest standing water bodies (lakes and reservoirs) in Bulgaria was studied. Two-year benthic sampling from 11 lakes and 39 reservoirs, belonging to 15 national types of standing water bodies were taken. The analysis of the taxonomic composition and the abundance of functional feeding groups showed that the groups of scrapers and deposit feeders dominated in the trophic structure of the macrozoobenthos. The scrapers had a structuring role in lakes and the deposit feeders prevailed in modified/artificial standing waters (reservoirs). Ecological status assessment of the studied water bodies based on the metrics Total number of taxa, Biotic index for slow-flowing stretches and Trophic index, was made. The assessment based on the macrozoobenthos reveals that the prevailing part of the studied reservoirs was defined in the range from "High" to "Moderate" ecological status or potential.

**Key words:** macroinvertebrates, functional feeding groups, standing waters, ecological assessment

## Introduction

The concept of the trophic structure of the macrozoobenthos and functional feeding groups (FFGs) approach has been originally developed for river ecosystems (CUMMINS 1973, CUMMINS & KLUG 1979, MERRIT & CUMMINS 1996) and later applied for standing water bodies. Dynamics of composition, density, biomass and productivity (HARDING 1994, POEPPERL 1999, CASAGRANDA et al. 2006, SILINA & PROKIN 2008, CUI & WANG 2008, WÜRDIG et al. 2007, BURLAKOVA et al. 2012) as well as at climate-driven responses (ČIAMPOROVA–ZAŤOVIČOVÁ et al. 2010) of the FFGs of macrozoobenthos in different wetlands and lakes have been studied. In Bulgaria, PAVLOVA (2013) assessed the macrozoobenthic trophic structure of lakes and reservoirs by linking the FFGs of bottom invertebrates to other biotic components in vertical trophic webs. Taxon list of benthic species found in 50 lakes and reservoirs was published by VIDINOVA et al. (2016).

Relatively few studies have been devoted to

the bioindicative capabilities of the FFGs of macrozoobenthos in standing water bodies. A review and report on ecologically-based classification and monitoring systems, using macrophytes, phytoplankton and benthic invertebrates, individually or in combination, for potential application to standing waters in the UK is presented by MURPHY et al. (2002). POIKANE et al. (2016) summarised the obstacles for using functional metrics in standing waters in Europe. In Bulgaria, in connection with the development of a classification system for ecological status or potential assessment of the defined surface water types, experimental metrics for lakes and reservoirs are applied (CHESHMEDJIEV et al. 2010, VARADINOVA 2012, 2013, TRICHKOVA et al. 2013).

The purpose of this article was to study the trophic structure of bottom invertebrates in large lakes and reservoirs in Bulgaria and to assess their current ecological status based on macrozoobenthos metrics.

## Materials and Methods

Macrozoobenthic samples were collected from 50 standing water bodies (11 natural lakes and 39 reservoirs) in Bulgaria (Fig. 1) in 2011-2012. The studied water bodies belong to 15 types (L1, L2, L3, L4, L5, L7, L8, L9, L10, L11, L12, L13, L14, L15, L16), which have been described in the RIVER BASIN MANAGEMENT PLAN (2010-2015). Currently, with the introduction of the newly-developed RIVER BASIN MANAGEMENT PLANS (2016-2021), some of the types were updated and corrected. The typology changes were reflected in the explanatory notes under Fig. 1. Macrozoobenthos was sampled using the multi-habitat approach (CHESHMEDJIEV et al. 2011). Sample processing was according BDS EN ISO 5667-1:2007 and BDS EN ISO 5667-3:2012.

After primary processing and identification of macrozoobenthos, feeding groups affiliation (shredders – SH, scrapers – SC, collectors – CL, filterers – FL, predators – PR and deposit feeders – DF) was assigned according to CHESHMEDJIEV & VARADINOVA (2013). The Total Number of Taxa (TNT) and Biotic Index (BI) for slow-running river stretches (VARADINOVA 2012, 2013) were used for the ecological status (or potential) assessment of the studied lakes and reservoirs. In addition, the index PETI, which characterises potamal river zone based on FFGs (SCHWEDER 1990) and adapted by CHESHMEDJIEV & VARADINOVA (2013), was applied. The assessment was carried out in five status classes: high, good, moderate, poor and bad according to the requirements of the WATER FRAMEWORK DIRECTIVE (2000/60/EC) and national legislation (REGULATION №1/2011).

The maps of the surveyed lentic water bodies were prepared with Quantum GIS Version 2.18 Las Palmas. Multidimensional scaling (MDS) plot analysis was performed with Primer 6.1.6 (CLARKE & WARWICK 2001) and was used to assess the similarity of macrozoobenthos FFGs between the different types of standing water bodies.

## Results

### Composition of the FFGs of the macrozoobenthos

Analysis of registered FFGs in lakes revealed dominance of SC, DF and PR (Fig. 2 A). Unlike the trophic structure registered in the lakes, in reservoirs with the highest number of taxa was the group of DF, which corresponded to the presence of sufficient quantities of deposited organic matter (SHIEH et al. 1999) in this type of standing water bodies (Fig. 2 B).

### Abundance of the FFGs of the macrozoobenthos

The mean density of functional groups (average number of individuals per 1 m<sup>2</sup>), demonstrated that most of the studied standing water bodies were characterised by an incomplete trophic structure, i.e. did not contain all FFGs (Fig. 3). In addition, the studied lakes and reservoirs had a different type-specific ratio among the analysed groups. Thus, 90% of the trophic structure of macrozoobenthos in the Atanasovsko Lake was composed by SC (Fig. 3 A). In the trophic structure of the high-mountain lake Bezbog were registered two FFGs (DF, PR), with full dominance of DF, which was represented only by *Chironomus* sp. PR were present in most of the natural lakes and FL were registered mainly in the Black Sea lakes (Fig. 3 A). In heavily modified water bodies, the trophic structure was mainly represented by three or four FFGs, among which a key role had DF, FL, SC and FL (Fig. 3 B).

The analysis of the density of FFGs showed that in natural lentic ecosystems the largest group of SC exceeded almost twice the group of DF (Fig. 4 A). The groups of PR and FL were represented with relatively similar percentage shares, both in lakes and reservoirs. The prevalence of DF in reservoirs could be explained with favourable conditions for a development of rich organic matter (SHIEH et al. 1999) (Fig. 4 B). The amount of that trophic resource corresponded with the increasing share of DF (PEROVA 2010). A reduction of almost half of the group of SC in reservoirs as compared to the lakes was registered. Representatives (mainly *Corophium* sp. and *Gammarus* sp.) of SC dominated in Black Sea lakes (L7, L9, L10) and DF in Alpine (L1) and Riparian lakes (L5) (Fig. 5 A). In highly modified standing water bodies the groups of SH and CL were characterised with a negligible share or complete absence, respectively (Fig. 5 B).

The analysis of the similarity based on abundance of FFG did not demonstrate a clear distinction between different types (Fig. 6). Among the studied lakes, type L9 - designated as Black Sea middle salty lakes and swamps, separated from the others due to the specific benthic fauna, typical for brackish (transitional) waters. Specific trophic structure was observed in L7 (Durankulak and Shablensko Lakes). Typical of the aquatic ecosystems in these lakes were well-developed macrophyte vegetation and periphyton, which created optimal nutritional conditions for the mass development of benthic taxa from the group of SC (Fig. 6 A). The macroinvertebrate fauna of the reservoirs was characterised by a taxonomic composition more similar between them and a unified trophic structure (Fig. 6 B).



**Fig. 1.** Location of studied standing water bodies in Bulgaria. (type of standing water bodies, name and date of sampling: L1: Beli Iskar Reservoir (21.09.2011), Bezbog Lake (14.10.2012), Dolno Kremensko Lake (20.08.2011); L2: Yovkovtsi Reservoir (28.10.2011, 10.10.2012), Ognyanovo Reservoir (08.11.2012), Srechenska bara Reservoir (23.10.2012); L3: Batak Reservoir (28.09.2011), Barzina Reservoir (L16 / 02.10.2011), Studena Reservoir (07.09.2011, 28.09.2012); L4: Rabisha Reservoir (30.09.2011, 15.10.2012); L5: Srebarna Lake (21.09.2011, 18.10.2012); L7: Durankulashko Lake (29.10.2011, 10.10.2012), Mandra Reservoir (05.11.2012), Shablensko Lake (29.10.2011, 10.10.2012); L8: Alepu Lake (06.11.2011, 23.10.2012), Burgasko Lake (30.10.2012); L9: Varnensko Lake (18.10.2012), Mandrensko Lake (05.11.2012); L10: Atanasovsko Lake (06.11.2011), Pomoriysko Lake (06.11.2011), Tri cladentsi Reservoir (L16 / 02.10.2011); L11: Aleksandar Stamboliyski Reservoir (28.10.2011), Eleshnitsa Reservoir (L12 / 11.10.2012), Zhrebchevo Reservoir (01.10.2011), Iskar Reservoir (05.09.2011, 22.11.2012), Ivaylovgrad Reservoir (11.10.2011), Kamchiya Reservoir (29.10.2011), Koprinka Reservoir (30.09.2011), Kardzhali Reservoir (12.10.2011), Studen kladenets Reservoir (12.10.2011, 19.11.2012), Ticha Reservoir (29.10.2011), Tsonevo Reservoir (11.10.2012); L12: Kavatsite Reservoir (26.10.2011, 17.10.2012), Sopot Reservoir (12.10.2012), Saedinenie Reservoir (L11 / 09.10.2012), Yasna polyana Reservoir (27.11.2011), Yastrebino Reservoir (29.10.2011, 17.10.2012); L13: Borovitsa Reservoir (18.11.2012), Dyakovo Reservoir (07.09.2011, 12.10.2012), Pchelina Reservoir (17.09.2011); L14: Bebresh Reservoir (L2/ 10.09.2011), Gorni Dabnik Reservoir (11.09.2011, 11.10.2012), Ogosta Reservoir (24.10.2012), Hristo Smirnenski Reservoir (L16 / 30.09.2011); L15: Pyasachnik Reservoir (11.11.2012), Trakiets Reservoir (17.11.2012); L16: Asparuhov val Reservoir (01.10.2011, 15.10.2012), Aheloy Reservoir (25.10.2012), Poroy Reservoir (25.10.2012), Telish Reservoir (11.09.2011, 11.10.2012).

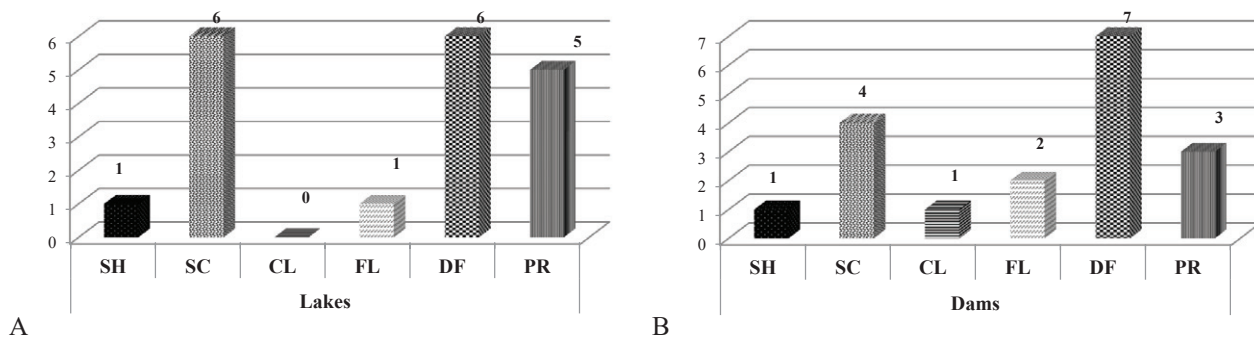


Fig. 2. Number of macrozoobenthic taxa per FFG (average data)

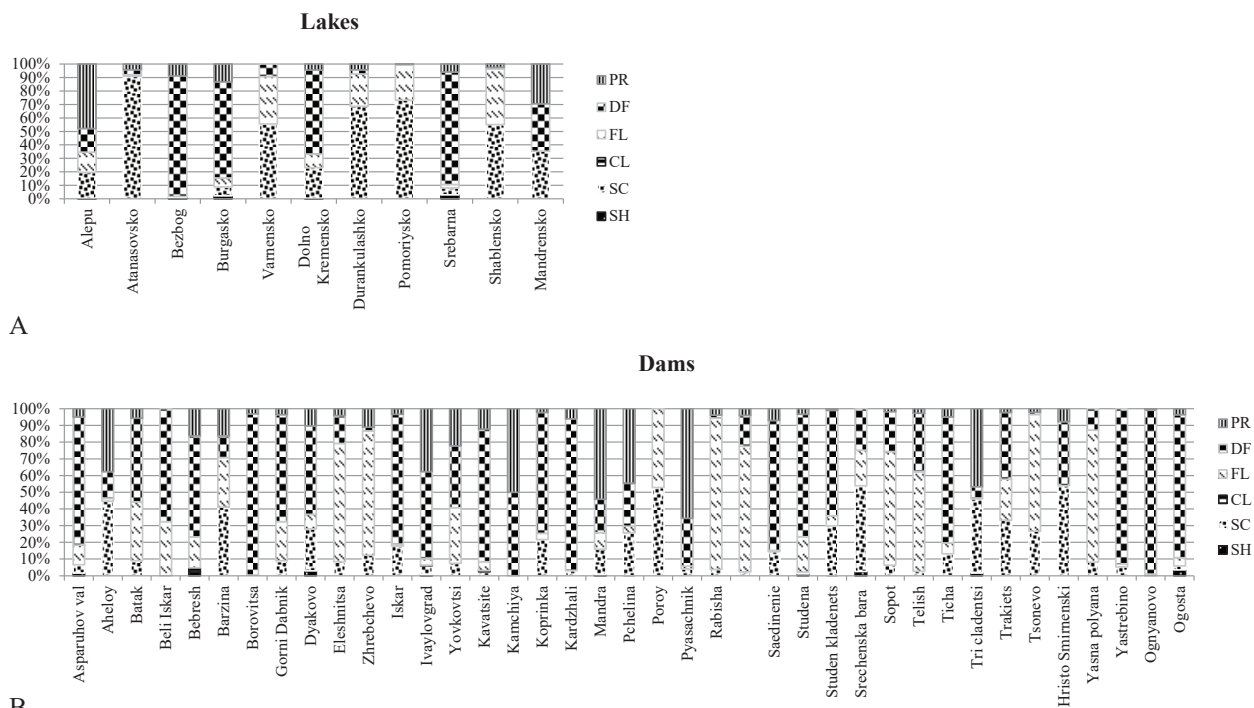


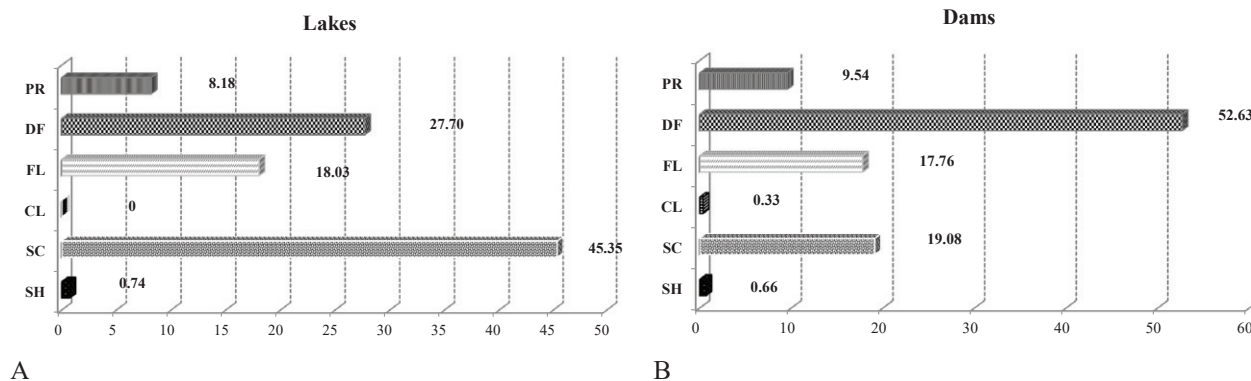
Fig. 3. Abundance of macrozoobenthos per FFG (average data in percentage share)

### Assessment of ecological status

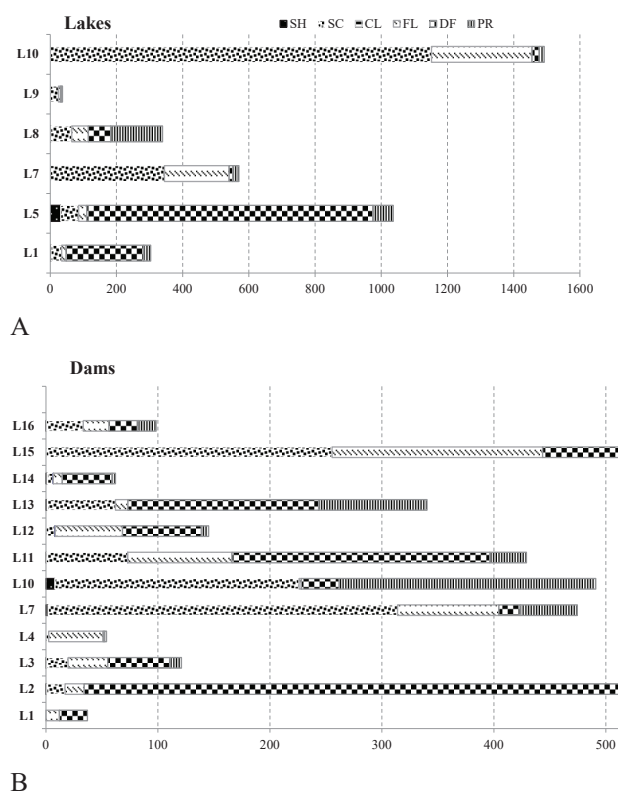
Currently, there is no established methodology in the national legislation for the assessment of the ecological status of freshwater lentic ecosystems based on macrozoobenthos. In research analyses, BI is mostly used for assessment of slow-flowing stretches of rivers, with a supporting application of the indices TNT and PETI. The mentioned metrics were used for the purposes of the national monitoring of standing water in Bulgaria and the reporting of the status/potential of lakes and reservoirs at European level. The application of these indices in the present study (Table 1 and Table 2) was justified based on the correspondence of the results with those of preliminary for both BI and TNT (VARADINOVA 2012, 2013) or for the trophic index PETI (VARADINOVA et al. 2008, BORISOVA et al. 2014).

### Discussion

Leading factors influencing the composition and abundance of macrozoobenthos in lakes are development of macrophytes or phytobenthos, food availability and oxygen conditions (ZBIKOWSKI & KOBAK 2007). Hydrological connectivity and the frequency and intensity of floods are also important for determining the structure of macroinvertebrates, especially in the frequently flooded lakes (OBOLEWSKI 2011). According WÜRDIG et al. (2007), predominance of SC and DF or the prevailing of a certain group have been determined either by substrate or by the presence of organic matter, or by both. SILI & PROKIN (2008) demonstrated the structuring role of the functional group of SC and its prevalence in lakes and marshes. The dominance of DF in L5 was the result of the thick layer of sapropel, the low oxygen con-



**Fig. 4.** Abundance of macrozoobenthos per FFG in natural (lakes) and artificial (reservoirs) lentic water bodies (percentage share)



**Fig. 5.** Distribution of macrozoobenthic FFGs by different type of standing water bodies

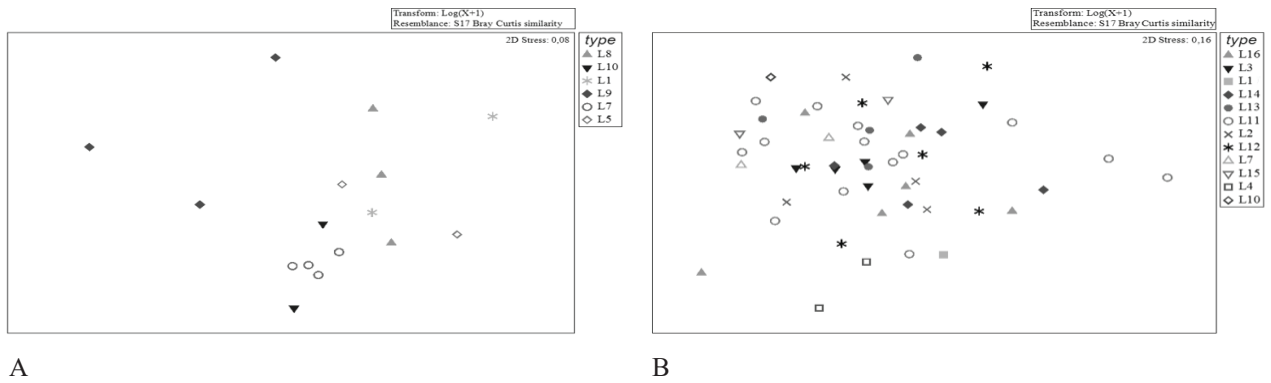
ditions and the accumulated organic matter (UZUNOV et al. 2012). The extreme environment (ice and freezing, low temperatures and lack or insufficient trophic resources) in high-mountain lakes (L1) were probably the cause of survival of the more tolerant benthic organisms belonging to the DF. The absence of suitable food resources and appropriate environmental conditions (ANDERSON & SEDELL 1979, HALL & MEYER 1998) were the reason SH, FL and especially CL had a less significant share in the trophic structure of bottom invertebrates in the studied lakes.

A FFGs distribution similar to that in our study was observed by ČIAMPOROVA-ZAŤOVIČOVÁ et al.

(2010) for alpine lakes at different elevations in the Tatra Mts. (Slovakia) and also by YONG-DE CUI et al. (2008) for standing waters in an area outside temperate latitudes.

The groups of DF, FL and SC, among which predominantly were representatives of oligochaete worms and chironomid larvae, were more or less dominant in the composition of the trophic structure of the macrozoobenthos in different types of reservoirs. A reduction of the group of SC in the reservoirs compared to the lakes was due to the periodic fluctuations of water levels – a result of water abstraction, which affected mostly the dynamically changing environment of the littoral zone, where the sampling took place. In addition, the oxygen deficiencies and the deposits in the lower layers, as well as the specific nutritional base did not favour the development of primary consumers. As long as they actively pursue their prey, the PR also occupied a significant share in the overall structure. Because of the specific purpose of the reservoirs for water supply and irrigation, the macrozoobenthos trophic structure of the majority of them was simplified and in some even destroyed (L4, L1). Into account should also be taken the unfavourable effects of diffuse pollution, as well as the discharge of organic waste water into heavily modified/artificial standing water bodies (KERAKOVA 2015, RIVER BASIN MANAGEMENT PLANS, 2016-2021). The heavily reduced number of representatives of SH and CL could be explained by the lack of appropriate trophic resource and conditions of the aquatic environment as far as the main feeding base for SH is coarse particulate organic matter (CUMMINS & KLUG 1979, BIS et al. 2000) and CL needs water flow to actively capture food particles (ANDERSON & SEDELL 1979, HALL & MEYER 1998).

The poorer benthic community in the reservoirs is the result of the survival of a relatively small number of more-tolerant species in conditions of the periodically changing hydrological parameters of the en-



**Fig. 6.** MDS plot of similarity of macrozoobenthos trophic structure between different types of standing water bodies (the analysis is based on the abundance of FFGs).

**Table 1.** Ecological status assessment of the studied lakes

Names of lakes	BI	PETI	TNT
Alepu_11.11	high	moderate	high
Alepu_10.12	good	good	high
Atanasovsko_11.11	moderate	poor	good
Bezbog_10.12	high	high	good
Burgasko_10.12	moderate	high	high
Varnensko_10.12	good	poor	moderate
Dolno Kremensko_08.11	moderate	good	good
Durankulashko_10.11	moderate	bad	high
Durankulashko_10.12	moderate	moderate	good
Pomoriysko_11.11	good	good	high
Srebarna_09.11	high	high	high
Srebarna_10.12	good	good	high
Shablensko_10.11	good	bad	high
Shablensko_10.12	good	good	high
Mandrensko_11.12	moderate	moderate	moderate

vironment. Furthermore, the draining of significant volumes of water leads to large areas being dried out and washed away of nutrients from the littoral sampling zone. (UZUNOV & KOVACHEV 2009). These changes for a short time could cause a displacement of the actual littoral zone (flooding or withdrawal), which despite the high adaptive capabilities of the macroinvertebrates, had a strong negative effect on them. The above was related to destruction and loss of habitats for aquatic invertebrates, which was the probable reason for the lack of type-specific communities and registered greater similarity in the composition of the macrozoobenthos and its trophic structure in the studied reservoirs.

The parallel application of three different indices BI, TNT and RETI-PETI allowed to evaluate the structure and functioning of aquatic invertebrate communities and to give an adequate status/potential assessment of the studied water bodies. The applied metrics demonstrated variances in the eco-

**Table 2.** Ecological potential assessment of the studied reservoirs

Name of reservoirs	BI	PETI	TNT
Asparuhov val_10.11	good	high	high
Asparuhov val_10.12	moderate	good	high
Aheloy_10.12	moderate	poor	high
Batak_09.11	good	high	high
Batak_11.12	moderate	high	high
Beli Iskar_09.11	moderate	cannot be calculated	poor
Bebresh_09.11	good	high	high
Barzina_10.11	moderate	good	high
Borovitsa_11.12	good	high	good
Golyam Dabnik_09.11	good	high	high
Golyam Dabnik_10.12	moderate	high	high
Dyakovo_09.11	high	good	high
Dyakovo_10.12	good	high	high
Eleshnitsa_10.12	moderate	high	moderate
Zhrebchevo_10.11	moderate	high	good
Iskar_09.11	good	high	high
Iskar_11.12	moderate	cannot be calculated	moderate
Ivaylovgrad_10.11	good	high	high
Yovkovtsi_10.11	good	high	good
Yovkovtsi_10.12	moderate	high	good
Kavatsite_10.11	good	high	high
Kavatsite_10.12	moderate	high	good
Kamchiya_10.11	moderate	cannot be calculated	poor
Kardzhali_10.11	moderate	high	good
Mandra_11.12	good	good	high
Pchelina_09.11	high	good	high

logical status or potential evaluation of the standing water bodies. Coincidence of the status assessment based on three indices was reported only for the Srebarna\_09.11 and Mandrensko Lake as well as for Hristo Smirnenki and Tsonevo Reservoirs. Our re-

sults show that it is necessary to conduct systematic long-term studies and based on them to implement a multi-metric evaluation approach, in which the presented indices should be included with different weight. For developing assessment tools of the ecological status/potential of standing water bodies, it is essential to take into account invasive alien species registered in inland water ecosystems. In parallel, other metrics that have been successfully applied in other countries could be tested and adapted.

## Conclusion

The aquatic environment conditions in the standing water bodies formed a specific incomplete trophic structure, which was characterised with a reduced number of FFGs. The dropping out of certain groups depended on the sensitivity of benthic taxa to the combination of environmental factors and the anthropogenic pressure. It is determined as well by the purpose of the use of the standing water bodies (water supply, irrigation) and the frequency of water abstraction.

The ecological status or potential evaluation of some of the biggest standing water bodies in Bulgaria based on macrozoobenthos has shown that further long-term studies are needed to allow the collection data, which will help to develop an appropriate multi-metric assessment system for standing water bodies. An important condition for the ecological status/potential evaluation is to take into account the type-specific characteristics of the studied lakes and reservoirs.

## References

- ANDERSON N. H. & SEDELL J. R. 1979. Detritus processing by macroinvertebrates in stream ecosystems. *Annual Review of Entomology* 24: 351-377.
- BIS B., ZDANOWICZ A. & ZALEVSKI M. 2000. Effects of catchment properties on hydrochemistry habitat complexity and invertebrate community structure in a lowland river. *Hydrobiologia* 422-423: 369-387.
- BORISOVA P., VARADINOVA E., KERAKOVA M., KAZAKOV S., STOICHEV S., UZUNOV Y. & PEHLIVANOV L. 2014. Seasonal changes in benthic communities of the Srebarna Lake (Northeast Bulgaria): Habitat Perspective. *Acta Zoologica Bulgaria* 66 (2): 239-245.
- BURLAKOVA L. E., KARATAYEV A. Y. & KARATAYEV V. A. 2012. Invasive mussels induce community changes by increasing habitat complexity. *Hydrobiologia* 685:121-134.
- CASAGRANDA C., DRIDI M. S. & BOUDOURESQUE C. F. 2006. Abundance, population structure and production of macroinvertebrate shredders in Mediterranean brackish lagoon, Lake Ichkeul, Tunisia. *Estuarine, Coastal and Shelf Science* 66: 437-466.
- CHESHMEDJIEV S., MLADENOV R., BELKINOVA D., GEHEVA G., DIMITROVA-DYULGEROVA I., IVANOV P. & MIHOV S. 2010. Development of classification system and biological reference conditions for Bulgarian rivers and lakes according to the water frame work directive. *Biotechnology & Biotechnological Equipment* 24/2010/SE.
- CHESHMEDJIEV S., SOUFI R., VIDINOVA Y., TYUFEKCHIEVA V., YANEVA I., UZUNOV Y. & VARADINOVA E. 2011. Multi-habitat sampling method for benthic macroinvertebrate communities in different river types in Bulgaria. *Water Research and Management* 1 (3): 55-58.
- CHESHMEDJIEV S. & VARADINOVA E. 2013. Bottom Invertebrates. In: *Biological Analysis and Ecological Status Assessment of Bulgarian Surface Water Ecosystems*. Plovdiv: University of Plovdiv Publishing House, pp. 147-164 (In Bulgarian).
- ČIAMPOROVA –ZAŤOVIČOVÁ Z., HAMERLÍK L., ŠPORKA F. & BITUŠÍK P. 2010. Littoral benthic macroinvertebrates of alpine lakes (Tatra Mts) along an altitudinal gradient: a basis for climate change assessment. *Hydrobiologia* 648:19-34.
- CLARKE K. R. & WARWICK R. M. 2001. *Change in Marine Communities: An Approach to Statistical Analysis and Interpretation*. Primer-E Ltd: Plymouth, UK.
- CUI Y. & WANG H. 2008. Ecology of macrozoobenthic communities in two plateau lakes of Southwest China. *Chinese Journal of Oceanology and Limnology* 26 (4): 345-352.
- CUMMINS K. W. 1973. Trophic relation of aquatic insects. *Annual Review of Entomology* 18: 183-206.
- CUMMINS K. W. & KLUG M. J. 1979. Feeding ecology of stream invertebrates. *Annual Review of Ecology and Systematics* 10: 147-172.
- DIRECTIVE 2000/60/EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy
- HALL R. O. & MEYER J. L. 1998. The trophic significance of bacteria in a detritus-based stream food web. *Ecology* 79: 1995-2012.
- HARDING J. S. 2010. Variations in benthic fauna between differing lake outlet types in New Zealand. *New Zealand Journal of Marine and Freshwater Research* 28: 417-427.
- KERAKOVA M. 2015. Trophic structure of the macrozoobenthos in native and influenced freshwater ecosystems. PhD thesis. Sofia: IBER-BAS, 266 p. (In Bulgarian, with English summary).
- MERRIT R. W. & CUMMINS K. W. 1996. Trophic relations of macroinvertebrates. In: HAUER F. R. & G. LAMBERTI A. (Eds). *Methods in Stream Ecology*. San Diego: Academic Press, pp. 453-474.
- MURPHY K. J., KENNEDY M. P., MCCARTHY V., Ó'HARE M. T., IRVINE K. & ADAMS C. 2002. A review of ecology-based classification systems for standing freshwaters. SNIFFER Project Number: W(99)65, Environment Agency R&D Technical Report: E1-091/TR.
- OBOLEWSKI K. 2011. Macrozoobenthos patterns along environmental gradients and hydrological connectivity of oxbow lakes. *Ecological Engineering* 37 (5):796-805.
- PAVLOVA M. 2013. Trophic structure of zoocenoses in freshwater ecosystems under anthropogenic pressure and impact. PhD thesis. Sofia: IBER-BAS, 254 p. (In Bulgarian, with English summary).
- PEROVA S. N. 2010. Structure of macrozoobenthos in the Gorky Dam at the beginning of XXI century. *Inland Water Biol-*

- ogy 3 (2): 142-148.
- POEPPERL R. 1999. Functional feeding groups of a macroinvertebrate community in a Northern German lake outlet (Lake Belau, Schleswig-Holstein). *Limnologica* 29: 137-145.
- POIKANE S., JOHNSON R. K., SANDIN L., SCHARTAU A. K., SOLIMINI A. G., URBANIČ G., ARBAČIAUSKAS K., AROVIITA J., GABRIELS W., MILER O., PUSCH M. T., TIMM H. & BÖHMER J. 2016. Benthic macroinvertebrates in lake ecological assessment: A review of methods, intercalibration and practical recommendations. *Science of the Total Environment* 543: 123-134.
- REGULATION №1/2011 on water monitoring ([www.moew.government.bg/static/media/ups/tiny/filebase/Water/Legislation/Naredbi/Naredba\\_1\\_za\\_monitoring.pdf](http://www.moew.government.bg/static/media/ups/tiny/filebase/Water/Legislation/Naredbi/Naredba_1_za_monitoring.pdf))
- RIVER BASIN MANAGEMENT PLANS (2010-2015; 2016-2021) ([www.moew.government.bg/bg/vodi/planove-za-upravlenie](http://www.moew.government.bg/bg/vodi/planove-za-upravlenie))
- SCHWEDER H. 1990. Neue Indizes für die Bewertung des oecologischen Zustandes von Fließgewässern, abgeleitet aus der Macroinvertebraten-Ernährungstypologie. In: FRIEDRICH G. & LACOMBE J. (Eds.), *Ökologische Bewertung von Fließgewässern*. *Limnologie aktuell* 3. Stuttgart: G. Fischer Verlag. pp. 353-377.
- SHIEH S., KONDRATIEFF B. C. & WARD J. V. 1999. Longitudinal changes in benthic organic matter and macroinvertebrates in a polluted Colorado plains stream. *Hydrobiologia* 411: 191-209.
- SILINA A. E. & PROKIN A. A. 2008. The Trophic Structure of Macrozoobenthos in Marsh Water Bodies of the Forest-Steppe Zone in the Middle Russian Hills. *Inland Water Biology* 1 (3): 231-240.
- TRICHKOVA T., TYUFEKCHIEVA V., KENDEROV L., VIDINOVA Y., BOTEV I., KOZUHAROV D., HUBENOV Z., UZUNOV Y., STOICHEV S. & CHESHMEDJIEV S. 2013. Benthic macroinvertebrate diversity in relation to environmental parameters, and ecological potential of dams, Danube River Basin, North-West Bulgaria. *Acta Zoologica Bulgarica* 65 (3): 337-348.
- UZUNOV Y. & KOVACHEV S. 2009. *Hydrobiology*. University textbook. Sofia: Pensoft Publishing House, 343 p. (In Bulgarian).
- UZUNOV Y., GEORGIEV B. B., VARADINOVA E., IVANOVA N., PEHLIVANOV L. & VASILEV V. (Eds.). 2012. *Ecosystems of the Biosphere Reserve Srebarna Lake*. Sofia: Prof. Marin Drinov Academic Publishing House. 218 p.
- VARADINOVA E., VIDINOVA Y., TYUFEKCHIEVA V. & YANEVA I. 2008. Trophic structure of macrozoobenthos as measure of water bodies ecological state assessment. *Journal of Balkan Ecology* 11 (3): 297-308.
- VARADINOVA E. 2012. Monitoring of macrozoobenthos in lakes / dams as part of the National Surface Water Monitoring Program for 2011. Final report, project № 2072/01.08.2011 IBER/EEA (In Bulgarian).
- VARADINOVA E. 2013. Monitoring of macrozoobenthos in lakes / dams as part of the National Surface Water Monitoring Program for 2012. Final report, project № 2364/20.09.2012 IBER/EEA (In Bulgarian).
- VIDINOVA Y., TYUFEKCHIEVA V., VARADINOVA E., STOICHEV S., KENDEROV L., DEDOV I. & UZUNOV Y. 2016. Taxonomic list of benthic macroinvertebrate communities of inland standing water bodies in Bulgaria. *Acta Zoologica Bulgarica* 68 (2): 147-158.
- WÜRDIG N. L., CENZANO C. S. S. & MOTTA MARQUES D. 2007. Macroinvertebrate communities structure in different environments of the Taim Hydrological System in the state of Rio Grande do Sul, Brazil. *Acta Limnologica Brasiliensia* 19 (4): 427-438.
- YONG-DE CUI, XUE-QIN LIU & HONG-ZHU WANG. 2008. Macrozoobenthic community of Fuxian Lake, the deepest lake of southwest China. *Limnologica - Ecology and Management of Inland Waters* 38 (2): 116-125.
- ZBIKOWSKI J. & KOBAK J. 2007. Factors influencing taxonomic composition and abundance of macrozoobenthos in extralittoral zone of shallow eutrophic lakes. *Hydrobiologia* 584 (1): 145-155.

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