ECOLOGIA BALKANICA
2018, Vol. 10, Issue 2 December 2018 pp. 165-172

Application of Experimental Metrics Based on Macrozoobenthos for Ecological Status Assessment of Bulgarian Standing Water Bodies

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Abstract. Surveys on benthic macroinvertebrate communities of ten standing water bodies (Bezbog, Kalin, Choklyovo marsh, Bistraka, Dospat, Stoykovtsi, Drenov dol, Pchelina, Dolna Dikanya, Dyakovo) were conducted in the period July-August 2018. They were chosen to represent natural (lakes) characterized with reference conditions as well as artificial and heavily modified water bodies (dams). They were associated with earlier data for three dams (Studena, Pyasachnik, Ovchi kladenets), studied over the period 2013-2017. The standing waters fall into the West and East Aegean Basin districts and belong to all types of water bodies (identified according to the Bulgarian typology) located in the Ecoregion 7 (L1-Glacial high-mountain lakes/Alpine lakes, L3-Mountain lakes, L4-Lowland and semi-mountain lakes and swamps, L6-Riverside wetlands, L11-Large deep reservoirs, L13-Medium-size and small semi-mountain reservoirs, L15 Large lowland reservoirs up to middle depth, L17-Small and medium size reservoirs). A current evaluation based on the values of the measured physicochemical parameters, regulated by the national water legislation was made. Four experimental biological metrics - Total number of taxa, Biotic index for slow-flowing river stretches, percentage of Oligocheata and PETI were applied to assess the ecological status of the studied water bodies. The Biotic index is leading in the evaluation, others metrics have a supportive role. The lack of type-specific scales of the indices used, insufficiently long ranges of data sets on which to test the methods as well as the anthropogenically induced fluctuations at the water level which affects the distribution of macrozoobenthos in the sampling littoral zone are the main difficulties for a more precise assessment of the ecological status/potential of standing water bodies in Bulgaria.

Key words: standing water bodies, macrozoobenthos, ecological status/potential.

Introduction

The importance of macroinvertebrates as bioassessment tools is widely recognized because of their limited mobility, comparatively long life cycles and differential sensitivity to pollution of various types and they reflect the impact of eutrophication on aquatic habitats quite satisfactorily (RASHID & PANDIT, 2014). Composition and distribution of macrozoobenthos in lakes and wetlands are governed by numerous environmental factors, that affect the structure of benthic community, and its distribution pattern should be considered while evaluating the ecological status of lakes (DAR & GANAI, 2017). Invertebrate communities have been widely used as biological indicators in the profundal of the standing waters where they are presented mainly by chironomid and oligochaete species. Macrozoobenthos is also indicative in the lake littoral zone, where can be used as indicators of anthropogenic disturbances (TIMM *et al.*, 2006).

Monitoring systems for potential application of standing waters in the UK were presented by MURPHY *et al.* (2002). POIKANE *et al.* (2016) summarize and analyze the main stages and difficulties in the process of the intercalibration of the macrozoobenthos methods for European standing waters evaluation. Number of benthic species and individuals are used to estimate habitat quality of lake ecosystem (MUSTAFA *et al.*, 2013). In the available limnological literature, different types of metrics for status/potential assessment of the lentic ecosystems have been applied (GERRITSEN *et al.*, 1998; BLOCKSOM *et al.*, 2002; KONIECZNY & DANISZEWSKI, 2013; OBOLEWSKI, 2014; RASHID & PANDIT, 2014; SHU *et al.*, 2018).

In Bulgaria, experimental metrics on different types of lakes and reservoirs were tested (CHESHMEDJIEV *et al.* 2010; VARADINOVA 2012; VARADINOVA 2013; TRICHKOVA *et al.* 2013; GECHEVA *et al.*, 2013; BORISOVA *et al.*, 2014; GECHEVA *et al.*, 2017; VARADINOVA *et al.*, 2019). Nevertheless, at this stage in the national water legislation there is no appropriate metric for evaluation of the status of freshwater standing water bodies based on macrozoobenthos.

The purpose of this work is to test and select appropriate experimental metrics for the ecological status/potential assessment on different types of surface standing water bodies identified in Ecoregion 7.

Materials and Methods

Macrozoobenthos summer samples from ten standing water bodies (Bezbog lake, Choklyovo marsh, reservoirs - Kalin, Dospat, Stoykovtsi, Drenov dol, Pchelina, Dolna Dikanya, Dyakovo, Bistraka) were taken in the period July-August 2018. Data for other four dams studied in the period 2013-2017 were associated to the survey of the mentioned water bodies (Fig. 1). Older data were used to have representatives of all types of water bodies identified according to the Bulgarian typology (River Basin Management plans, 2016-2021), situated in the Ecoregion 7 (L1-Glacial high-mountain lakes/Alpine lakes, L3-Mountain lakes, L4-Lowland and semi-mountain lakes and swamps, L6-Riverside wetlands, L11-Large deep reservoirs, L13-Medium-size and small semi-mountain reservoirs, L15 Large lowland reservoirs up to middle depth, L17-Small amd medium size reservoirs). The studied lakes and dams are located in Ecoregion 7 Eastern Balkans, situated in the East and West Aegean Basin districts (Table 1).

The macrozoobenthos samplings were done with compliance to the multi-habitat sampling approach (CHESHMEDJIEV *et al.* 2011) in accordance with the standards BDS EN ISO 5667-1:2007 and BDS EN ISO 5667-3:2012. The basic physicochemical parameters (pH, electrical conductivity (μS/cm), dissolved oxygen concentration (mg/dm^3) were measured *in situ* at the studied water bodies with a portable Windaus Labortechnik Package.

The indices Total number of taxa (TNT) and Biotic index for slow-flow running waters (BI) with experimental scales (VARADINOVA, 2012; 2013; CHESHMEDJIEV & VARADINOVA, 2013) were used for the ecological status/potential assessment of the studied lakes and dams. In addition, the %Oligochaeta and the Trophic index RETI-PETI (specifically PETI which characterizes potamal river stretches) based on functional feeding groups according SCHWEDER (1990) and adapted by CHESHMEDJIEV & VARADINOVA (2013) were applied. The maps of the surveyed lentic water bodies were prepared with software product ArcGIS 9.1.

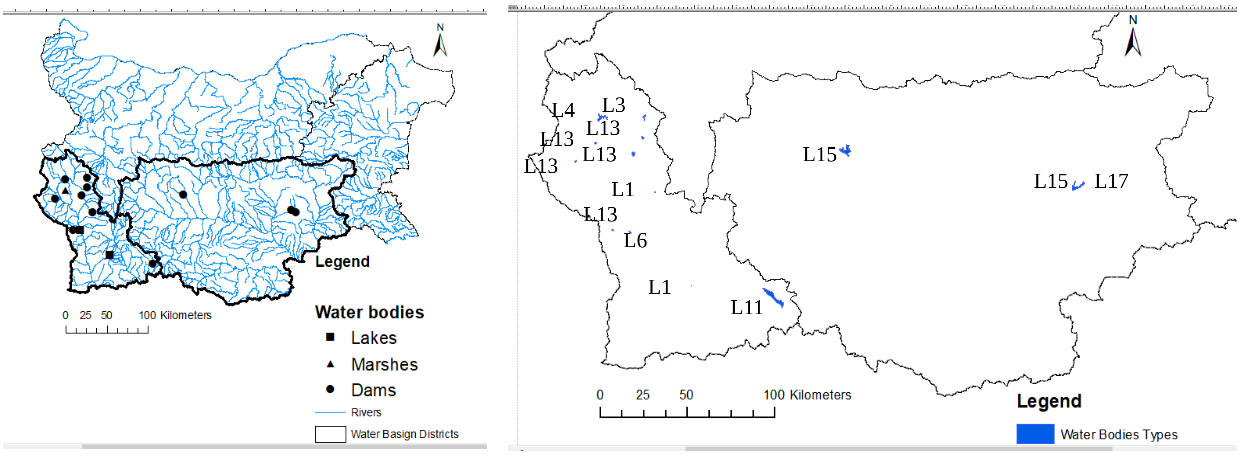

Fig. 1. Distribution of the studied water bodies in Bulgaria.

Table 1. Main features of the studied standing water bodies.

№	**Name**	**Type**	**Geographic coordinates**	**Specific features**
1	Bezbog Lake	L1	N 41.733536 E 23.523569	High-mountain lake, situated in Pirin National Park. It is characterized by pure waters and unpolluted aquatic ecosystems, which determines the reference character of this type of water body.
2	Kalin dam	L1	N 42.173451 E 23.251726	The highest located dam in Bulgaria, situated in National Park Rila. It is used for drinking water supply, hydropower purposes and angling. Characterized by reference conditions that determine the maximum ecological potential of the dam.
3	Studena dam	L3	N 42.536074 E 23.149008	Mountain type, used for drinking water supply, industrial and hydropower purposes.
4	Chuklyovo marsh	L4	N 42.400299 E 22.829804	Semi-mountain type swamp, characterized by reference conditions. Protected area under the Habitats Directive and the Biodiversity Act.
5	Bistraka	L6	N 41.978368 E 23.073456	Quarry lake, former ballast. Used for amateur fishing.
6	Dospat dam	L11	N 41.657335 E 24.157648	Large deep reservoir. Established pressure from aquaculture and domestic waste water. Used for hydropower purposes.
7	Stoykovtsi dam	L13	N 41.978934 E 22.973570	Semi-mountain dam with close to maximum ecological potential conditions. Used for irrigation and angling.
8	Drenov dol dam	L13	N 42.303901 E 22.691295	Semi-mountain dam used for irrigation and angling.
9	Pchelina dam	L13	N 42.508177 E 22.829246	Semi-mountain dam used for industrial purposes, irrigation and angling.

10	Dolna Dikanya dam	L13	N 42.436583 E 23.151154	Semi-mountain dam influenced by land used. Designed for irrigation, angling and aquacultural purposes.
11	Dyakovo dam	L13	N 42.351540 E 23.079700	Semi-mountain dam used for drinking water supply and industrial purposes.
12	Pyasachnik dam	L15	N 42.398549 E 24.573257	Large lowland reservoir with middle depth. Close to maximum ecological potential conditions. Ornithological important place, used for angling.
13	Ovcharitsa dam	L15	N 42.256730 E 26.167981	Large lowland reservoir with middle depth. Protected area under Directive on the conservation of wild birds and Biodiversity act. Probable impact of discharging industrial wastewater and active angling.
14	Ovchi kladenets dam	L17	N 42.233570 E 26.245958	Medium size reservoir. There are no natural lakes equivalent to this type. Used for amateur fishing. Probable impact of agricultural activities.

Results and Discussion

Bottom invertebrates formed specific communities in the studied standing water bodies. The deep-water zone and the littoral of the lakes were sufficiently different in the type of bottom sediments, in species composition, and in the abundance of the macrozoobenthos. The greatest species richness and diversity of the benthic fauna was observed in the littoral, where a high content of oxygen and organic matter, along with biotopic diversity create favorable conditions for many benthic organisms (PEROVA, 2010). In the studied lakes and dams the taxonomic composition was determined both by the type of standing water body and type of anthropogenic impact. The macrozoobenthos was dominated by chironomid larvae and oligochaete worms. The mollusks, true bugs, larvae of insects such as mayflies, dragonflies, caddis flies, beetles and true flies (manly ceratopogonids) were common for lakes and reservoirs. Human pressure was predominantly expressed in local load of tourism and angling, influence of adjacent agricultural areas, changes in morphology and in hydrological regime in the dams, using for drinking-household, industrial purposes and irrigation (River Basin Management plans, 2016-2021). Mentioned effects have led to a reduction in taxonomic richness and domination of more tolerant to pollution species of oligochaetes and chironomids, registering a permanent presence in the community of species as isopod *Asselus aquaticus* and water leech *Erpobdella octoculata*.

The presence of macrozoobenthos in lentic ecosystems is strongly influenced by various abiotic factors such as temperature, salinity, dissolved oxygen, pH, and substrate of the bottom water (BEUCHEL *et al*. 2006). These factors have determining role in non-polluted or slightly affected superficial water.

The evaluation by the physicochemical parameters, defined in the national legislation (Regulation H-4/2012) characterized the state of the environment that supports the biological assessment in determining the ecological status/potential of the standing water bodies (Table 2).

The studied waters were representative for different types of standing water bodies and were suitable for testing experimental methods for ecological status/potential assessment. Official data presented in the current River Basin Management Plan (2016-2021) showed that the standing water bodies with identified reference conditions (Bezbog Lake and Kalin Dam) or close to maximum ecological potential (Stoikovtzi and Pyasachnik Dam) were characterized in this study in high and good status by all physicochemical parameters and experimental biological (assessed according Cheshmedjiev &

Varadinova, 2013) indices. Choklyovo marsh, which is protected under the Habitats Directive (1992) and Biodiversity act (2002) and riverside wetland (Bistraka Dam) were also defined in high and good status based on physicochemical and biological indices. The most unfavorable assessments pursuant to biological parameters were recorded in the Ovcharitsa and Ovchi Kladenets Dams. In these water bodies destroyed trophic structure evaluated by PETI was also registered. According to the information of the River Basin Management Plan (2016-2021), the reasons could be the influence of discharging industrial wastewaters (Ovcharitsa Dam) and the local anthropogenic impact caused by active angling (Ovchi Kladenec Dam). It should be noted that estimates of Ovcharitsa and Ovchi Kladenets Dams were based on earlier studies conducted in the period 2013-2017. The upcoming autumn and next seasonal sampling will present an up-to-date picture of the potential of the pointed out water bodies.

Table 2. Evaluation of the ecological status/potential of the studied water bodies.

Name of the water body	O_2 mg/dm^3	pH	Conduc-tivity µS/cm	TNT	BI	% Oligo-chaeta	PETI
Bezbog Lake	High	Good	High	Good	Good	High	Good
Kalin dam	Good	Good	High	Good	Good	High	Good
Studena dam	High	Good	High	Moderate	Moderate	Good	Good
Chuklyovo marsh	High	Good	High	High	Good	High	Good
Bistraka dam	High	Good	High	High	Good	High	Good
Dospat dam	Good	Good	High	Good	Moderate	Good	Good
Stoykovtsi dam	Good	Good	High	Good	Good	Lack of oligochetes	Good
Drenov dol dam	High	Good	High	Good	Moderate	High	Good
Pchelina dam	High	Good	High	High	Moderate	Good	Good
Dolna Dikanya dam	High	Good	High	High	Moderate	High	Moderate
Dyakovo dam	High	Good	High	Good	Moderate	High	Moderate
Pyasachnik dam	High	Good	High	Good	Good	Good	High
Ovcharitsa dam	High	Outside the categories	Moderate	Good	Moderate	Moderate	Bad
Ovchi kladenets dam	High	Good	High		Moderate	Poor	Bad

The highest evaluations were obtained on the physicochemical parameters and TNT index. It should be noted that the scales used to estimate the tested biological indices are common and non type-specific.At this stage, according to expert judgment, BI has the leading role in determining the ecological status of standing water bodies

(Cheshmedjiev & Varadinova, 2013). Our results showed that none standing water was evaluated in high ecological status or maximum ecological potential based on BI. Further on-going studies will reveal whether this was due to insufficient refinement of ecological quality ratio scale, especially boundaries between good and high ecological status. The lowest/unfavorable assessments of the tested standing waters were recorded through BI and PETI. Higher values of PETI characterized high water quality and stable, unaffected aquatic ecosystems (Schweder, 1990). Status worse than good was indicative of an imbalanced benthic communities as a result of pressures such as influx of heavy organic pollution and water level fluctuation which most strongly affect the macrozoobenthos, especially in the littoral zone where the sampling was taken. In addition, the other local anthropogenic impact (camping, fishing) could also have an adverse impact on the ecological situation in the aquatic ecosystems. Bad ecological status according PETI revealed that the trophic structure of the benthic communities was considered to be destroyed. Both the previous (Varadinova, 2012; 2013) and the current study showed that the %Oligochaeta works well for a sludgy substrate and given the multi-habitat sampling approach, it is not appropriate to use this metric as an independent evaluation but possibly as a part of a multimetric system.

Conclusions

The obtained results are preliminary, based on a single sampling and analysis of the taxonomic composition of the macrozoobenthos fauna. The scales of the tested indices need optimization and refinement of the boundaries between the quality classes. The challenge is also to develop type-specific scales of relevant evaluation indices. This requires longer-term studies to provide a more objective assessment of the relevance of each index, particularly when it is applied separately. Three-year seasonal (spring, summer, autumn) surveys are going to be conducted to help gather the data needed to develop a relevant type specific multimetric/metrics for assessment the ecological status/potential of the standing water bodies by biological quality element macrozoobenthos. The seasonal sampling will give opportunity to take into account the life cycles of macrozoobenthos, as well as the specifics of the sampling of the littoral zone, where the environmental factors are highly variable. Another aspect related to the need of conducting periodic studies is to assess the impact of the natural dynamics of water levels on benthic communities without underestimating the water abstraction for different purposes in the heavily modified and artificial water bodies.

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Received: 17.11.2018
Accepted: 21.12.2018