

Seasonal Effects on Ecological Status/Potential Assessment in Lakes Based on Macrozoobenthos

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Abstract. Seasonal impact on the ecological status assessment through macrozoobenthos in representative lentic water bodies (lakes and dams) situated at Ecoregion 7 Eastern Balkans (South Bulgaria) was made. Data from twelve standing water bodies during three seasons (summer 2018, autumn 2018 and spring 2019) were analysed. The Total number of taxa index showed seasonal dependence. The Biotic index was not significantly changed across seasons in different types of stagnant waters. The seasonal effects on the ecological status/potential evaluation depended on the type of the standing water body (natural/heavily modified/artificial), environmental factors and different anthropogenic pressure which caused changes in the aquatic ecosystems.

Key words: macrozoobenthos, seasonality, ecological status/potential assessment.

Introduction

Water ecosystems conditions are shaped by environmental factors and anthropogenic impacts and directly affect the viability and distribution of the water communities. When characterizing the ecological situation in the aquatic ecosystems, it is essential to take into account the seasonal fluctuations of the environmental factors and their impact on the composition and structure of the bottom invertebrate fauna (Chen et al., 2018). Depending on their preferences to the aquatic environment, macrozoobenthos representatives are characterized by a different seasonal abundance and biomass in

the aquatic ecosystems (Kotwicki, 1997; Živic et al., 2005). Higher taxonomic richness of macrozoobenthos during the rainy season compare with the dry season has been reported by Moreno & Callisto (2006). According Atobatele & Ugwumba (2010) in reservoirs larger numbers of taxa were recorded during the dry season than in the wet season. Study of Borisova et al. (2016) in Srebarna Biosphere Reserve revealed that Sørensen's similarity coefficient showed clear differences between the taxonomic composition of macrozoobenthos but in the main distinguished types of habitats. Species richness, dominant species and standing

crops varied significantly in different seasons, and also in different areas (Yang et al., 2019). The development of an appropriate ecological status/potential assessment metrics based on a biological quality element macrozoobenthos has its importance in the context of the specific characteristics of the standing aquatic ecosystems as well as the human pressure on them. Some studies on standing waters demonstrated that diversity indices of the macrozoobenthos had no significant differences between seasons (Li & Ding, 2016; Gao et al., 2019) and, the abundance of dominant taxa indicated no clear seasonal changes (Cai et al., 2012).

Assessment based on Shannon index, Margalef index and Hilsenhoff biotic index showed that water quality in the Lake Nansi in spring and winter was slightly better than that in summer and autumn (Yang et al., 2019). Seasonal variations in quality indices were found to be site specific as some showed improvement in ecological status and macrozoobenthos quality while others revealed degradation from the dry season to the wet season (Kanhai & Juman, 2018). Both indices, %Oligochaeta and PETI, determined clear seasonal changes in ecological state assessment (Borisova et al., 2016).

The aim of the study is to make a comparative analysis of the ecological assessment in representative standing water bodies determined by macrozoobenthos during different seasons.

Material and Methods

The study was carried out in representative types (L1-Glacial high-mountain lakes/Alpine 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) of standing water bodies (lakes and dams) situated in Ecoregion 7 Eastern Balkans, South Bulgaria (Fig. 1).

Macrozoobenthos samples from twelve standing water bodies (Bezbog Lake, Choklyovo Marsh, Bistraka Marsh, Dospat Dam, Stoykovtsi Dam, Drenov Dol Dam, Pchelina Dam, Dolna Dikanya Dam, Dyakovo Dam, Pyasachnik Dam, Ovcharitsa Dam, Ovchi Kladenets Dam) during two sampling seasons - autumn 2018 and spring 2019 were taken. Data from these studies were associated with results received in the summer of 2018 (see Smilyanov et al., 2018) in order to analyze the impact of seasonality on the ecological status/potential of the studied lakes and dams.

Methodologies applied for the purposes of biological monitoring in Bulgaria and reporting of the state of standing water in Bulgaria to the European Environment Agency were used. Multi-habitat sampling approach (Cheshmedjiev et al., 2011) with the standards BDS EN ISO 5667-1:2007 and BDS EN ISO 5667-3:2018 was applied during the macrozoobenthos collecting. The indices Total number of taxa (TNT) and Biotic index for slow-flow running waters (BI) with experimental scale (Varadinova, 2012; 2013; Cheshmedjiev & Varadinova, 2013) were used for the ecological status/potential assessment of the standing water bodies.

The map of the surveyed lentic water bodies was prepared with software product ArcGIS 9.1. The lake types, geographical coordinates and main features of the standing water bodies were presented in Smilyanov et al. (2018). Cluster analysis techniques from Statistica 7 was used to visualize the similarity in the taxonomic composition of the macrozoobenthos in the studied standing water bodies.

Results

Benthic communities showed greater similarity in taxonomic composition between analysed dams within a one season than the lakes. In contrast, seasonality does not play a determining role in the formation of the macrozoobenthos in the natural lentic water bodies. Macrozoobenthos found in reference lakes (Bezbog, Bistraka) demonstrated close resemblance in community composition through the three studied periods (Fig. 2).

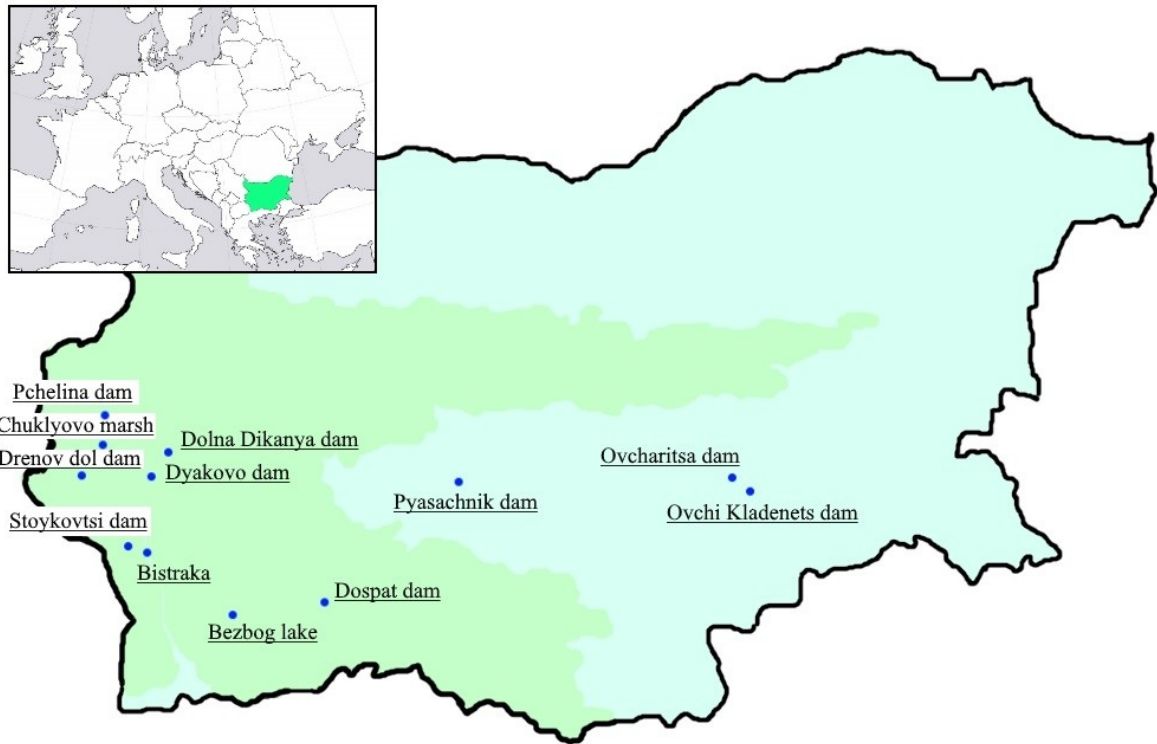


Fig 1. Distribution of the studied water bodies on the territory of Bulgaria.

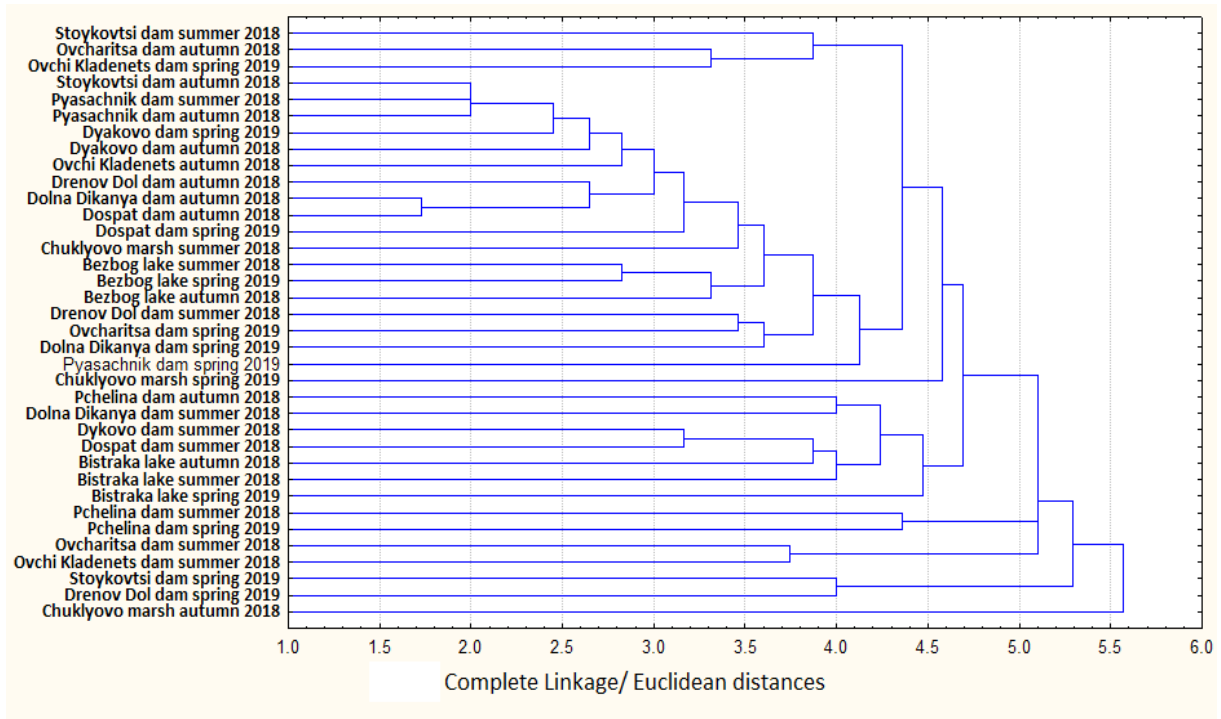


Fig. 2. Analysis of the similarity in the taxonomic composition of the macrozoobenthos between studied water bodies in three different seasons (summer 2018, autumn 2018, spring 2019).

The greatest taxonomic richness was recorded in the summer of 2018 in all standing water bodies (Fig. 3). The bigger diversity corresponded to the registered higher ecological assessment of the water bodies status based on TNT index. In the autumn 2018 and spring 2019, the number of taxa decreased (except for the Chuklyovo Marsh in the autumn) and accordingly, the ecological evaluation was worsened.

The ecological status/potential evaluated by BI didn't change over the seasons in the nearly half of the studied water bodies (Fig. 4). Thus, in Chuklyovo Marsh and Bistraka Lake, the values of the BI moved within the limits of good ecological status in all three seasons. Among the dams, Dospat, Pchelina, Ovcharitsa and Ovchi Klagenets were characterized by unchanged conditions (moderate potential for first two dams, poor for the third and fourth) in all three seasons. Unlike the evaluation defined by TNT, in the above water bodies there was no registered seasonal dependence in the ecological status/potential assessment determined by BI.

The values of BI changed within two (Drenov Dol, Dolna Dikanya and Dyakovo) or three (Pyasachnik, Stoykovtsi) adjacent ecological quality classes (good, moderate, bad) in the rest studied dams. The ecological status assessment of Bezbog Lake also shifted during the three different seasons, showing a deterioration in the spring 2019.

Discussion

Similar taxonomic composition of the bottom invertebrate fauna registered in natural water bodies (Bezbog, Bistraka) during the whole vegetation period could be explained by the reference nature of the two lakes and lack of significant human pressure. The change of seasons affected more considerable on the macrozoobenthos composition in the dams than in the natural water bodies (Fig.2). However, the reasons for these differences were not only the seasonal alteration but external unfavourable influences. Formation of the benthic communities composition in the standing waters are the result of a number of factors.

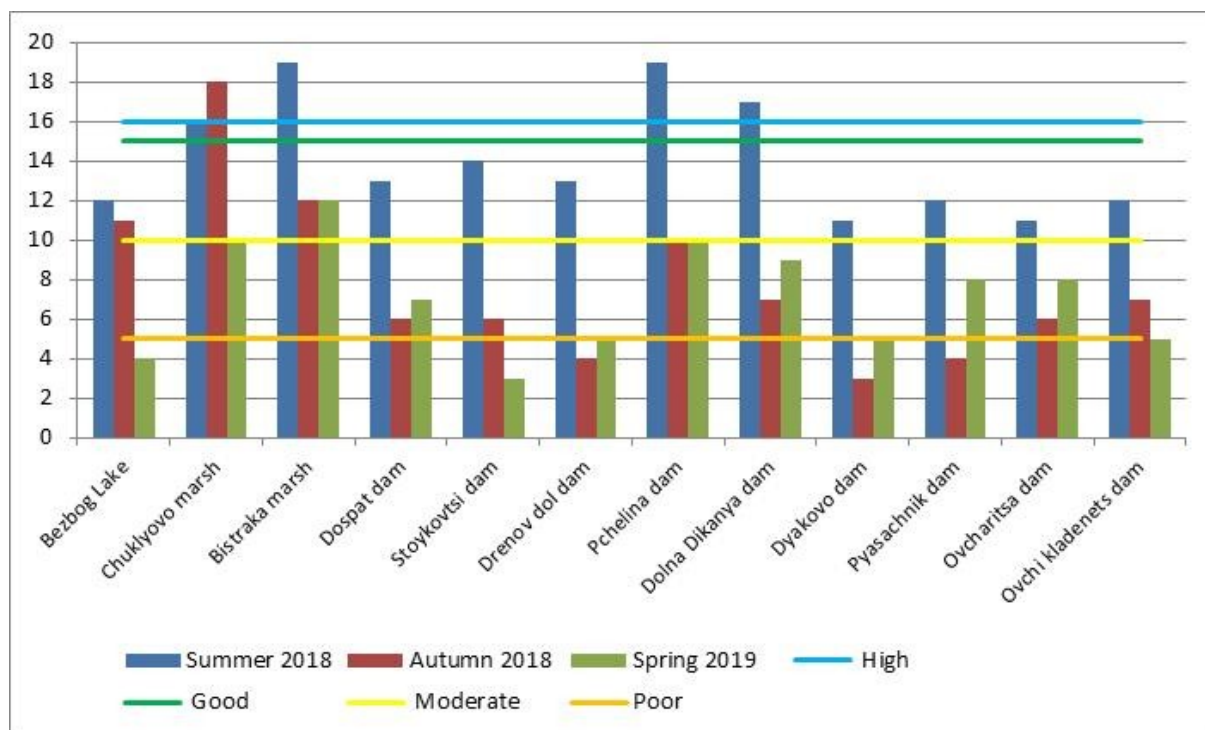


Fig. 3. Dynamics of the TNT index at the studied standing water bodies during the three seasons.

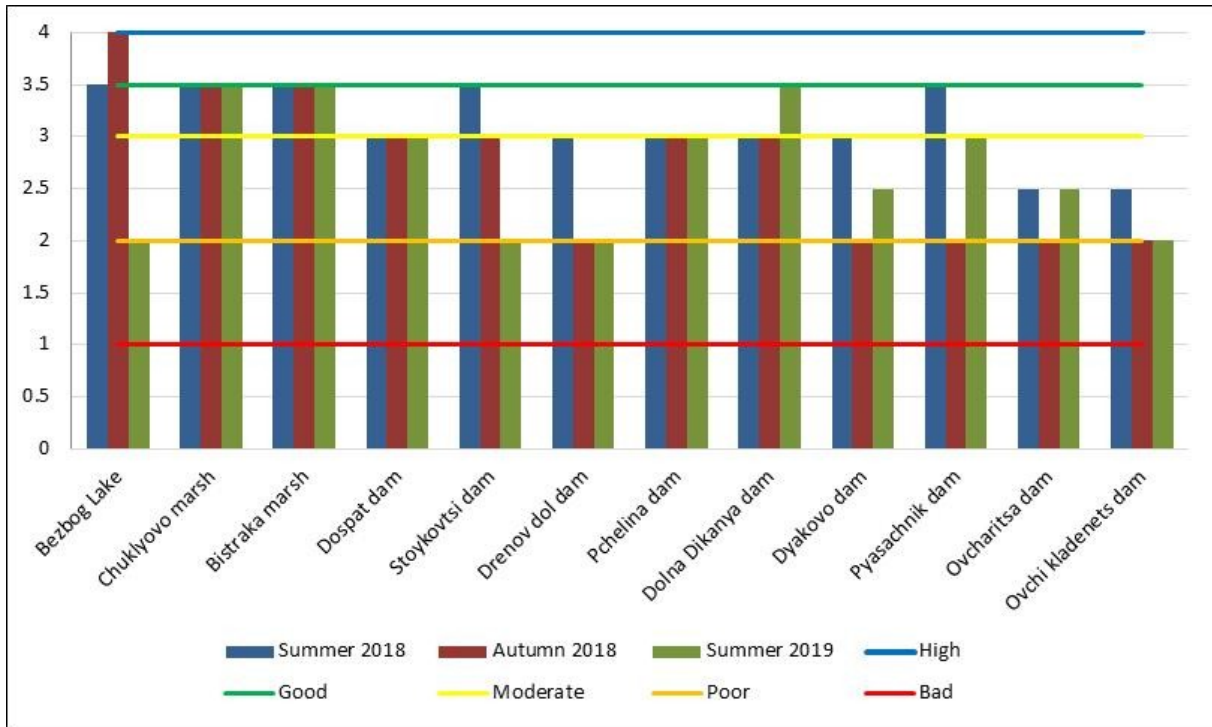


Fig. 4. Dynamics of the BI index at the studied standing water bodies during the three seasons.

Human activities have seriously destroyed the macrozoobenthos habitats and led to the decline in macrozoobenthos diversity (Li et al., 2019). Anthropogenic eutrophication was considered to have a negative influence on macrozoobenthos intolerant groups in lakes (Timm et al., 2006). Hydromorphological pressure (mainly water abstraction) also played adverse effect in dams and caused habitat degradation which led to deterioration of benthic communities biodiversity (Smilyanov et al., 2018). These impacts induced worsening of the environmental conditions and reflected negatively on the ecological status/potential of the standing water.

An important requirement for the ecological status/potential assessment is to take into account the type-specific characteristics of the studied lakes and dams (Varadinova et al., 2019). Studies on the application of the various indices based on macrozoobenthos did not give a definite answer as to whether seasonality affects the environmental assessment of standing water (Shou et al., 2009; Cai et al., 2012; Borisova et

al., 2016; LI & Ding, 2016; Kanhai & Juman, 2018; Gao et al., 2019; Yang et al., 2019). It is essential to determine to what extent applied benthic indices could reflect different aspects of natural and anthropogenic impacts and characterised a real ecological situation in the aquatic ecosystem.

In this study the TNT index demonstrated seasonal dependence. For all standing water bodies, its values varied within the boundaries of good and high ecological status in the summer of 2018 (Fig. 3). A tendency of deterioration of the ecological evaluation in autumn 2018 and spring 2019 compared to summer 2018 was registered. This trend was observed not only in natural water bodies (including the reference ones) but also in dams in which the aquatic ecosystem was under permanent anthropogenic pressure of different nature such as disturbance in hydrological regime, allochthonous inputs, etc. (Smilyanov et al., 2018). Other studies revealed that macrozoobenthos diversity is higher in dry than in wet seasons (Atobatele et al., 2010), more species were found in the summer than in the winter season, (Mustafa et al., 2013) or species richness was more or less similar in both season

(Gao et al., 2019). Registered in our study higher number of taxa in summer, in all studied lakes and dams was the result of favourable environmental conditions with the defining role of the water temperature as the main environmental factor affecting the most contributing macrobenthos species (Chen et al., 2018).

To assess the influence of the seasonality on the on-going evaluation of the ecological status/potential in lakes and dams has to be recorded under relatively unaltered external conditions. However, for some dams, the impact of various anthropogenic factors (eg withdrawal for irrigation, water supply, active angling and aquaculture cultivation) could alter the conditions in the aquatic ecosystem during two consecutive seasons. This could provoke a response of biotic stress, which is particularly noticeable for the littoral macrozoobenthos where the samples were taken. The disturbance of the ecological health in aquatic habitat caused a negative effect on the ecological status of the water body, which was assessed by analysed biological quality element (Fig. 4). Changes in the status of the natural water body Bezbog are more likely due to other specific factors. Bezbog lake is located at more than 2000 m above sea level. This is a prerequisite for the shift of the biological seasons, later snowmelt and the effects of the subsequent activation of the mineralization processes of the accumulated organic matter on the benthic habitat conditions, which was a probable cause of the unfavourable assessment registered in the spring of 2019. Consideration should be given here to the fact that these are one-off studies conducted only over three seasons (excluding winter). A series of consecutive studies may provide a more accurate picture of the impact of seasonal changes on the correctness of the macrozoobenthos-based ecological assessment.

Conclusions

The analysis of the seasonality impact on the ecological status/potential assessment should be made in the relatively similar stagnant waters with similar type specific characteristics and environmental conditions. It is important to choose a representative evaluation approach and appropriate indices that, in different seasons,

could adequately assess the effect of the natural and anthropogenic factors. The influence of seasonality depends on the type of standing water body (natural/heavily modified/artificial) and anthropogenic pressure (water abstraction, organic pollution, etc.). The diverse in nature and degree human impacts have different reflection on the aquatic ecosystems and make difficult to distinguish only the seasonal effect on the ecological assessment of the studied water bodies.

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