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HEALTH STATUS OF ŠUMARICE RESERVOIR: A STUDY BASED ON INDEX OF BIOTIC INTEGRITY (IBI)

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Abstract: Aquatic ecosystems are impacted by human activities. This disruption affects ecosystem integrity, causing declines in water quality and changes in the structure of hydrobionts. We assessed the health status of the Šumarice reservoir in 2011 and 2020 using the Index of Biotic Integrity (IBI), a index based on 12 metrics. The IBI value was 40 for 2011 and 30 for 2020, out of a maximum possible value of 60. Six of 12 metrics had the same values in both years, while the values of the other metrics differ, contributing to the change in the index value. Effective strategies based on biological data could be essential for evaluating the impact of human activities on aquatic ecosystems.

Keywords: fish assemblage structure, metric characteristics, Central Serbia

Introduction

Aquatic ecosystems are the most heavily influenced by anthropogenic activities. As a result, surface waters are significantly degraded in terms of both water quality and habitat, which in turn leads to disruptions in biodiversity and ecosystem integrity. With these changes, the proper functioning of aquatic ecosystems is compromised, leading to deteriorating water quality and alterations in the distribution and structure of hydrobionts (Stojković Piperac, 2015).

According to the Water Framework Directive (WFD, EU Directive 2000/60/EC), ichthyofauna is considered an essential group of hydrobionts in assessing the ecological status of inland waters. Fish are important biological indicators of surface waters (Karr, 1981). Their mobility, longevity, diversity in functional groups, and sensitivity to a wide range of anthropogenic stressors make them effective bioindicators (Wootton, 1990). As apex predators in aquatic

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ecosystems, fish communities can reflect the ecological health of entire ecosystems (Hawkes, 1975).

The Index of Biotic Integrity (IBI) was first developed by James Karr (Karr, 1981) to assess and describe the ecological conditions of small river ecosystems in central Illinois and Indiana (USA). It is a multimetric index based on 12 metric characteristics that can be used to assess changes in fish communities. Each metric characteristic is assigned a value of 5, 3, or 1, and by summing the points, index values ranging from 12 to 60 are obtained. At the reference point, the total score is 60, and if the score is close to 60, it indicates that the quality of the aquatic ecosystem is well-preserved. If the score is closer to the minimum, it indicates a high degree of degradation of the aquatic ecosystem.

The aim of this paper is to present the state i.e. health status of the Šumarice reservoir in 2011 and 2020 based on the value of the Index of Biotic Integrity.

Materials and methods

The Šumarice Reservoir (Central Serbia) is located about 5 km from the center of Kragujevac. The surface area of the reservoir is 22 ha, and its maximum depth is 14 m. The reservoir is 1,5 km long and its width is 175 m, situated at an altitude of approximately 220 m. The trophic status of reservoir indicates that it is eutrophic ecosystem (Ranković et al., 2006), and it is occasionally hypereutrophic (Simić et al., 2017).

Fieldwork was conducted in years 2011 and 2020. Fish were collected using gillnets with mesh sizes ranging from 10 to 120 mm in offshore areas, as well as electrofishing in the littoral zone. The DC electrofishing device „Aquatech" IG 1300 (2.6 kW, 80-470 V) was used for the electrofishing. Each fish was measured for total length (TL) to the nearest mm and weighed to the nearest g (W). The fish were identified using Kottelat and Freyhof (2007).

The Index of Biotic Integrity consists of 12 metric characteristics divided into three groups relating to i) the structure of the community, ii) the trophic composition of the community and iii) the fish abundance and condition. The twelve metric characteristics are, in order: 1) Number of species 2) Number of fish i.e. individuals 3) Number of species from the family Percidae 4) Number of species from the families Salmonidae and Centrarchidae 5) Number of species from the family Cyprinidae 6) Number of intolerant species 7) Prevalence of tolerant individuals 8) Prevalence of omnivorous and herbivorous individuals 9) Prevalence of insectivorous individuals 10) Prevalence of piscivorous individuals

11) Prevalence of diseased fish and 12) Prevalence of species with several age groups (Karr, 1981).

Results and discussion

Many characteristics can be attributed to fish that make them reliable indicators for the biological assessment of water quality. Historically, the use of macroinvertebrates in water quality assessment has been of exceptional importance. However, in recent years, data obtained from studying fish community structure have increasingly been used for this purpose (Fame Consortium, 2004). Our earlier studies have shown that the fish community in the reservoir studied consists mainly of the following fish species: rudd *Scardinius erythrophthalmus* (Linnaeus, 1758), roach *Rutilus rutilus* (Linnaeus, 1758), pumpkinseed *Lepomis gibbosus* (Linnaeus, 1758) and bullhead *Ameiurus* sp. (Pavlović et al., 2015; Radenković, 2019).

Table 1 contains the values assigned to each of the 12 metrics individually, as well as their sum, which represents an IBI value of 40 for 2011 and 30 for 2020. Six of the 12 metrics have the same values in 2011 and 2020. The values of the other six metrics differ, which contributes to the difference in the index value between the two years.

Table 1. Values assigned to the individual metric characteristics and the overall IBI for the study period

metric characteristic	2011	2020
1	3	3
2	3	1
3	5	5
4	1	1
5	3	1
6	5	1
7	3	1
8	1	1
9	3	3
10	5	3
11	5	5
12	3	5
Σ	**40**	**30**

Barbour et al. (2002) state that as the degree of habitat degradation increases, the number of species in that habitat decreases. This statement refers to the first and second metrics. Table 1 shows that for the first metric, the value is 3 for both years of the study, which is the midpoint of the values assigned, while for the second metric, the value decreases from 3 in 2011 to 1 in 2020, which also contributes to the reduction of the IBI value. In Šumarice reservoir, the fish population of the family Percidae is sustainable, as indicated by the third metric. The fifth, sixth, and seventh metrics, along with the decrease in their values, significantly influence the lower IBI value in 2020. The family Cyprinidae is associated with the fifth metric, and fish from this family have a long lifespan, providing a long-term picture of the environmental condition (Overton, 2001). The percentage of omnivores in the community increases as the physical and chemical conditions of the habitat deteriorate. The ability to utilize different types of food allows omnivores to switch to another food source when one becomes scarce (Barbour et al., 2002). This is related to the eighth metric (Table 1), as a high proportion of omnivores is also present in Šumarice reservoir. At the same time, the number of insectivorous individuals is constant for both studied years, with a value of 3 for the ninth metric. The presence of piscivorous individuals was satisfactory in 2011 (value of 5 for the tenth metric), while in 2020 it declined (value of 3). This metric is what distinguishes high from medium water quality, as the presence of sustainable piscivorous populations indicates a healthy, trophically diverse fish community (Niemela and Feist, 2000). The last two metrics have been assigned high values, indicating the health and condition of each individual.

Based on the presented results, we can conclude that the status of Šumarice reservoir, as determined by the IBI, was worse in 2020 compared to 2011. Furthermore, the IBI value of 30 is closer to the lowest possible value of the index rather than reference value. This result is influenced by the composition of the fish community and the abundance of individuals within that community. However, it is essential to consider that this composition of the fish community is characteristic of an ecosystem type such as the Šumarice reservoir. In order to monitor the status of this reservoir for purpose of sustainable management, continuous monitoring of fish communities is necessary.

Conclusion

Knowledge of species distribution and the development of effective ecological approaches based on biological data are crucial for managing aquatic biodiversity and assessing the impact of human activities on aquatic ecosystems.

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