Potpeć Reservoir ecosystem health: An analysis based on the Index of Biotic Integrity (IBI)

Aleksandra M. Milošković[1], Milena D. Radenković[2*], Nataša M. Kojadinović[2], Tijana Z. Veličković[2], Simona R. Đuretanović[2], Marijana D. Nikolić[2], Vladica M. Simić[2]

[1]University of Kragujevac, Institute for Information Technologies Kragujevac, Jovana Cvijića bb, Kragujevac, Serbia
[2]University of Kragujevac, Faculty of Science, Radoja Domanovića 12, Kragujevac, Serbia

* *Corresponding author*

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Abstract: Freshwater ecosystems are increasingly subjected to anthropogenic pressures that compromise their ecological integrity, resulting in degraded water quality and altered biological communities. To assess the ecological status of the Potpeć Reservoir, we employed the Index of Biotic Integrity (IBI)—a multi-metric tool comprising 12 fish-based metrics—across three sampling campaigns conducted in 2008, 2011, and 2017. The obtained IBI scores were 30, 36, and 32, respectively (maximum possible score: 60). While nine metrics remained stable throughout the study period, interannual variability in three metrics accounted for the observed fluctuations in the overall index values. In particular, changes in total individuals, trophic composition, and the presence of sensitive taxa were the main drivers of index variability. These results highlight the utility of biologically-based assessment frameworks in tracking ecological changes and evaluating the impact of human activities on reservoir ecosystems. The application of such indices provides a scientifically grounded basis for the development of management strategies aimed at preserving or improving the ecological condition of aquatic environments under increasing environmental stress.

Keywords: fish assemblage structure, metric characteristics, southwestern Serbia

1. Introduction

Aquatic ecosystems are among those the most impacted by anthropogenic activities. Consequently, surface waters experience significant degradation in both water quality and habitat conditions, which leads to disruptions in biodiversity and overall ecosystem integrity. These changes compromise the proper functioning of aquatic systems, resulting in further deterioration of water quality and alterations in the distribution and composition of hydrobionts [1].

In accordance with the Water Framework Directive [2], ichthyofauna represents a key biological element for evaluating the ecological status of inland waters. Fish are widely recognized as reliable indicators of surface water quality [3] due to their mobility, relatively long life span, ecological diversity, and sensitivity to various anthropogenic pressures that make them particularly suitable as bioindicators [4]. Moreover, as top predators within aquatic food webs, fish communities can serve as integrative indicators of overall ecosystem health and integrity [5].

The Index of Biotic Integrity (IBI) was originally developed by James Karr [3] to detect and quantify changes within fish communities. Each metric is assigned a score of 5, 3, or 1, and the sum of these values yields an overall index score ranging from 12 to 60. At pristine or reference sites, the total score reaches 60, whereas scores approaching the minimum reflect a high level of degradation.

The primary objective of this study is to provide a comprehensive assessment of the ecological condition—essentially the "health status"—of the Potpeć Reservoir during three monitoring periods (2008, 2011, and 2017) through the application of the IBI.

2. Methodology

The Potpeć Reservoir, in southwestern Serbia near Priboj, was surveyed in 2008, 2011, and 2017. Offshore fish were caught with gillnets (10–120 mm mesh), and littoral specimens by electrofishing using a DC-powered "Aquatech" IG 1300. For each fish, total length (mm) and weight (g) were recorded, and species identified following Kottelat and Freyhof [6].

The Index of Biotic Integrity comprises 12 metrics: 1) total species, 2) total individuals, 3) Percidae species, 4) Salmonidae and Centrarchidae species, 5) Cyprinidae species, 6) intolerant species, 7) tolerant individuals, 8) omnivores/herbivores, 9) insectivores, 10) piscivores, 11) diseased fish, and 12) species with multiple age classes [3].

3. Results and Discussion

Fish exhibit a combination of ecological, physiological, and behavioral traits that make them highly suitable as indicators in biological assessments of water quality. Although macroinvertebrates have historically represented a cornerstone in aquatic bioassessment, contemporary monitoring programs increasingly incorporate fish community data as a complementary and, in some cases, primary assessment tool [7]. Within the Potpeć Reservoir, the ichthyofauna is predominantly represented by *Alburnus alburnus* (Linnaeus, 1758), *Squalius cephalus* (Linnaeus, 1758), *Chondrostoma nasus* (Linnaeus, 1758), and *Carassius gibelio* (Bloch, 1782).

Table 1 presents the scores assigned to each of the 12 individual metrics, along with their total sum, corresponding to an IBI value of 30 in 2008, 36 in 2011, and 32 in 2017.

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

Metric characteristics	2008	2011	2017
1	1	1	1
2	1	5	1
3	1	1	1
4	1	1	1
5	3	3	3
6	5	5	5
7	3	3	5
8	1	1	1
9	3	5	3
10	1	1	1
11	5	5	5
12	5	5	5
Σ	30	36	32

According to Barbour et al. [8], an increase in habitat degradation is typically accompanied by a decline in species richness. This relationship is directly relevant to the first and second metrics of the IBI. As shown in Table 1, the first metric scored 1 in all three study years, representing the lowest possible value. For the second metric the score was also 1 in 2008, peaked at 5 in 2011, and then declined again to 1 in 2017, contributing to the observed reduction in overall IBI values.

In the Potpeć Reservoir, the fish population of the family Percidae is sparse to nearly absent, as reflected in the low score of the third metric. The fourth, fifth, and sixth metrics showed no variation between sampling years. The fifth metric is associated with the family Cyprinidae, whose representatives typically exhibit long lifespans, thus providing an integrated, long-term reflection of environmental conditions [9].

The proportion of omnivores (eighth metric) increases as habitat quality declines [8]. Insectivores (ninth metric) scored 3 in 2008 and 2017, and 5 in 2011. Piscivores (tenth metric) were scarce in all years, scoring 1, a key indicator for distinguishing high from moderate water quality, as stable piscivore populations characterize healthy, trophically complex fish communities [10].

Finally, the last two metrics received high scores across all years, indicating generally good individual condition among the fish present in the reservoir.

The IBI results show that the Potpeć Reservoir had its poorest ecological status in 2008, with a score of 30 indicating significant impairment. This was mainly driven by fish community structure and abundance, though the composition is partly typical for such a reservoir. Sustainable management requires regular, long-term monitoring to track changes and enable timely conservation or restoration actions.

4. Conclusions

The Index of Biotic Integrity (IBI) provided key insights into the ecological condition of the Potpeć Reservoir over three monitoring periods. Variations in index values reflect changes in fish community structure and the effects of environmental pressures. Although some features are typical for such habitats, low IBI scores indicate the need for continuous monitoring and proactive management. Integrating tools like the IBI into long-term programs supports informed decisions and actions to preserve or improve the reservoir's ecological integrity.

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