



# Evaluation of the Water Quality of the Prizren River (Kosovo) using Benthic Macroinvertebrates as Bioindicators

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**Abstract:** This research evaluated the water quality of the Prizren River using macroinvertebrates as bioindicators, given their sensitivity to environmental changes and their utility in assessing aquatic ecosystem health. Sampling was conducted at six sites (L1-L6) along the main course of the river and two macroinvertebrate-based ecological indices were employed to determine the water quality status: the Family Biotic Index (FBI) and the richness of taxa of orders Ephemeroptera, Plecoptera and Trichoptera (EPT). We identified macroinvertebrate taxa of 28 families (22 taxa of class Insecta and six - belonging to other macroinvertebrate groups). The values of the indices across the six sampling stations ranged between 1.3 and 9.2 for EPT family richness and between 3.4 and 6.6 for FBI. According to the data concerning macroinvertebrates, the water of the Prizren River was, overall, of good quality. There was severe water quality degradation at two downstream locations, emphasizing the necessity for enhanced water resource management. The findings indicated that the diversity and abundance of macroinvertebrates varied across different sites, reflecting the ecological health of the river and, indirectly, the impacts of human activities on water quality. This research provided insights into the ecological health of the Prizren River, offering a valuable basis for future conservation and remediation efforts.

**Key words:** biotic index, ecological status, Kosovo, macroinvertebrates, Prizren River, water quality

## Introduction

Water quality in rivers is crucial to the vitality and biodiversity of aquatic ecosystems, directly impacting the health of rivers and their surrounding basins. Freshwater ecosystems in Kosovo have experienced considerable degradation in recent years due to various human-induced pressures, including

sewage discharges, industrial effluents, water extraction and riverbed erosion (Kosovo Environmental Protection Agency, Annual Report 2022). These activities have significant impacts on freshwater biota, particularly those serving as bioindicators.

Aquatic macroinvertebrates are widely used for assessing aquatic ecosystems (Rosenberg & Resh 1993, Barbour et al. 1995, Davis & Simon

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1995, Bohmer et al. 2004, Bennetti et al. 2012). The Water Framework Directive (Directive 2000/60/EC 2000) advocates the use of benthic macroinvertebrates as an effective method for assessing river water quality. The Directive aims to prevent further degradation of aquatic ecosystems and to protect and enhance their ecological status, to achieve “good ecological status” for all surface waters by 2027 (Directive 2000/60/EC 2000).

The insect orders Ephemeroptera, Plecoptera and Trichoptera (EPT) are particularly sensitive indicators of water quality due to their sensitivity to various stressors (Lenat 1988, Hering et al. 2004). These indices are particularly useful in lotic ecosystems, where EPT taxa dominate (Wallace et al. 1996, Herman et al. 2015). The evaluation of river and stream quality frequently employs EPT metrics, which are widely utilised by state agencies as part of their bioassessment programmes that incorporate macroinvertebrate communities (Barbour et al. 1995, Bonada et al. 2006, Hering et al. 2006). These metrics are among the best indicator metrics for measuring effects related to urbanisation (Wang & Kanehl 2003, Deacon et al. 2005, Cuffney et al. 2010) and for documenting recovery of water quality after decline of activities triggering pollution (Crawford et al. 1992, Lydy et al. 2000).

Although numerous studies on freshwater ecosystems in Kosovo have been carried out in recent years, the majority of them focused primarily on the taxonomy and ecology of specific groups (Gashi et al. 2016, Ibrahimli et al. 2014, 2015, 2019, Xërxa et al. 2019, Bilalli et al. 2020). A significant gap exists in water quality assessment research in Kosovo, particularly regarding the application of macroinvertebrate-based biotic indices (Etemi et al. 2020, Ibrahimli et al. 2021, Bilalli et al. 2022, Bucinca et al. 2024).

This study aims to assess the water quality of the Prizren River (Kosovo) using two macroinvertebrate-based indices: the Family Biotic Index (FBI) and EPT richness. By applying these biological metrics, we seek to contribute to the understanding of river health in Kosovo and to highlight the critical role of bioindicators in freshwater monitoring and management. The results, which range from poor to excellent ecological conditions across different sites, highlight the need for ongoing biomonitoring and targeted restoration efforts, particularly in the lower reaches of the river. This research contributes to the larger subject of freshwater ecology in Kosovo by emphasising the need to use bioindicators for effective water quality monitoring and management.

## Materials and Methods

### Study area and sampling

The surface waters in Kosovo belong to the drainage basins of three seas: the Black Sea, the Adriatic Sea or the Aegean Sea. The Prizren River belongs to the Adriatic Sea Basin and it is located in Southern Kosovo and spans a total length of 31 kilometres. The Prizren River originates from the Sharr Mountains and flows through the Sreckë Village before passing through the city of Prizren. It ultimately joins the Drini i Bardh River (Fig. 1). Sampling was conducted once per month in the Prizren River at six locations along its main course, ranging from higher to lower altitudes. The localities (L1–L6) were selected based on altitude, habitat characteristics and ease of access to ensure representative sampling of water quality variation along the main course of the Prizren River. All six sampling sites are a part of Ecoregion (ER) 6-Hellenic sensu Illies (1978).



**Fig. 1.** Map of Kosovo with location of the six sampling localities (L1-L6) in the main course of the Prizren River.

**Table 1.** Characteristics of sampling sites (L1-L6) including geographic references and habitat.

Code	Sampling site	Altitude (m a.s.l.)	Latitude	Longitude	Habitat
L1	Prevall	1664	42°16.10'N	20°95.33'E	Lotic
L2	Sredska	1242	42°41.31'N	20°04.38'E	Lotic
L3	Reçan	532	42°17.03'N	21°21.74'E	Lotic
L4	Marash	410	42°14.71'N	21°20.66'E	Lotic
L5	Park Qyteti	402	42°10.00'N	20°14.47'E	Lotic
L6	Vlashnje	364	42°08.02'N	20°11.05'E	Lotic

These sites cover a range of altitudes and geographic coordinates, reflecting a broad spectrum of environmental conditions and are described in terms of key attributes, including altitude, latitude, longitude and habitat type (Table 1).

Measurements were taken during an eight-month period (March-October) in 2019. Macroinvertebrate specimens were collected with a D-frame net with dimensions of 30×20 cm (600 cm<sup>2</sup>), following EN ISO 10870:2012 and EN 16150:2012 standards. Samples were taken once a month from all available habitats that represented more than 5% of the total habitat area on the sampling stretch (multi-habitat sampling procedure) from each of the six sampling sites. The habitats included riffles (flowing water over gravel or cobble substrate); non-flowing (depositional substrate in margins or pools with no flow) and root mats (hanging roots from bank vegetation and accumulations of organic debris).

Samples from each habitat were processed separately, but data from each habitat were combined within a site or replicated to provide site-level estimates of abundance, richness and EPT and FBI metric values. The biological material was pooled and transferred to sample containers (250 ml) and preserved in 90% ethanol. The benthic macroinvertebrates were identified to family level based on their morphological characteristics using a stereomicroscope and relevant family keys (Merritt & Cummins 1996). Identification of macroinvertebrate samples for this purpose was done up to the family level.

### Biotic indices

Diversity, abundance and ecological indices derived from macroinvertebrates were used to assess water quality at several sampling sites. In this study, the water quality was classified based on two indices, the EPT Family Richness (Bode et al. 1997) and the Hilsenhoff Family-level Biotic Index (FBI: Hilsenhoff 1988, Bode et al. 1996).

The Hilsenhoff FBI is calculated by multiplying the number of individuals in each family by an as-

signed tolerance value for that family. Assigned tolerance values range from 0 to 10 and increase as water quality declines (Hilsenhoff 1988, Bode et al. 1996):

$$FBI = \frac{\sum_{i=1}^S n_i \times t_i}{\sum_{i=1}^S n_i}$$

where  $n_i$  and  $t_i$  were the number of individuals and the tolerance, respectively, of the  $i^{\text{th}}$  family and  $S$  = the number of families included in the analysis.

The EPT taxa richness index (number of EPT taxa: Bode et al. 1997) uses the insect groups which are considered to be sensitive to pollution and, therefore, should increase with increasing water quality. The index is mostly suited for assessing the impact of organic pollution, degradation in stream morphology, acidification, as well as general degradation. The EPT index is equal to the total number of families represented within these three orders in the sample. It levels are: < 2; 2-5; 6-10 and > 10.

## Results

We recorded 28 families of macroinvertebrate taxa collected across all study sites, 22 of which were of class Insecta (orders Diptera, Coleoptera, Odonata, Trichoptera, Ephemeroptera and Plecoptera) and six were non-insect taxa (Gastropoda, Hirudinea, Oligochaeta, Amphipoda). We collected 2305 individuals of two phyla (Arthropoda and Annelida) from the six sampling stations. The total richness of macroinvertebrate taxa within a sample replicate ranged from 1.3 to 9.2 for EPT richness and from 3.4 to 6.6 for the FBI score. In the benthic fauna of the River Prizren, the predominant taxonomic group consisted of insects from the order Ephemeroptera, which accounted for 880 individuals or 38.17% of the total number of collected organisms. The order Trichoptera was the subdominant group, with 386 individuals, representing 14.22% of the total sample. Other notable orders include Plecoptera with 286 individuals (12.41%) and Diptera with 285 individuals (12.36%).

We recorded taxa of Hirudinea (9%), Amphipoda (7%) and Oligochaeta (5%). Some groups, on the other hand, were underrepresented, accounting for less than 2% of all taxa, such as order Odonata (11 individuals), class Gastropoda (14 individuals) and order Coleoptera (19 individuals). The family

Baetidae (Ephemeroptera) exhibited the widest ecological distribution, occurring at all sampling sites with a total of 454 individuals. The distribution of the 22 insect families was as follows: Ephemeroptera (5 families), Plecoptera (4 families), Trichoptera (6 families), Diptera (4 families), Coleoptera (2

**Table 2.** Macroinvertebrate composition, presence and percentage in the six localities.

Taxa composition	L1	L2	L3	L4	L5	L6	%
<b>Families of Ephemeroptera</b>	+	+	+	+	-	-	38.17
Baetidae	+	+	+	+	+	+	51.8
Caenidae	+	+	+	+	-	-	8
Heptageniidae	+	+	+	-	-	-	13.2
Ephemeridae	+	+	+	-	-	-	11
Ephemerellidae	+	+	+	+	+	-	16
<b>Families of Plecoptera</b>	+	+	+	-	-	-	12.41
Perlidae	+	+	+	-	-	-	16.5
Peltoperlidae	+	+	+	-	-	-	22.7
Capniidae	+	+	+	-	-	-	24.8
Nemouridae	+	+	-	-	-	-	36
<b>Families of Trichoptera</b>	+	+	+	-	-	-	14.22
Limnephilidae	+	+	+	-	-	-	23.8
Philopotamidae	+	+	-	+	-	-	19.2
Rhyacophilidae	+	+	+	-	-	-	25.5
Leptoceridae	+	+	+	-	-	-	10
Hydropsychidae	+	+	+	-	-	-	12
Glossosomatidae	+	+	+	+	-	-	9.5
<b>Families of Diptera</b>	+	+	+	+	+	-	12.36
Chironomidae	-	-	-	-	+	+	21.4
Simuliidae	-	-	-	-	+	+	32.6
Tipulidae	-	-	-	-	+	+	31
Blephariceridae	-	-	-	-	+	+	15
<b>Families of Odonata</b>	-	-	-	+	+	+	0.3
Gomphidae	-	-	-	+	+	+	0.3
<b>Families of Coleoptera</b>	+	+	+	+	-	-	0.7
Elmidae	+	+	-	+	-	-	0.5
Psephenidae	+	+	+	-	-	-	0.2
<b>Families of Oligochaeta</b>	-	-	-	+	+	+	5
Lumbriculidae	-	-	-	+	+	+	2.3
Tubificidae	-	-	-	+	-	+	3.7
<b>Families of Amphipoda</b>	+	+	+	+	+	+	7
Gammaridae	+	+	+	+	+	+	7
<b>Families of Hirudinea</b>	-	-	-	+	+	+	9
Erpobdellidae	-	-	-	+	+	+	9
<b>Families of Gastropoda</b>	-	-	+	+	-	-	1
Lymneidea	-	-	+	+	-	-	0.3
Physidae	-	-	+	+	-	-	0.7

**Table 3.** Values of the FBI for the six sampling sites in the Prizren River.

Localities (L1-L6)	Family Biotic Index (FBI)	Water quality
Prevalla-L1	FBI=3.4	Excellent
Sredska-L2	FBI=3.9	Very good
Reçan-L3	FBI=5.5	Moderate
Marash-L4	FBI=4.7	Good
Park Qyteti-L5	FBI=6.6	Bad
Vlashnje-L6	FBI=6	Bad

**Table 4.** Values of the EPT index for the six sampling sites in the Prizren River.

Localities	Biotic Index-EPT Family Richness	Water quality
Prevalla-L1	EPT=9.2	Excellent
Sredska-L2	EPT=8.1	Very good
Reçan -L3	EPT=4	Good
Marash-L4	EPT=3.6	Good
Park Qyteti-L5	EPT=1.3	Bad
Vlashnje-L6	EPT=1.5	Bad

families) and Odonata (1 family). Non-insect families included Oligochaeta (2 families), Amphipoda (1 family), Hirudinea (1 family) and Gastropoda (2 families) (Table 2). Aquatic insects constituted the predominant faunal group, representing over 79% of all collected individuals and accounted for approximately 78.5% of all identified families. Spatial patterns in taxonomic composition indicated that EPT families, known for their sensitivity to pollution, were primarily associated with upstream (L1 and L2) and midstream (L4) sampling locations. In contrast, pollution-tolerant families, such as Chironomidae, Tubificidae and Lumbriculidae, were more prevalent at downstream sites (L5 and L6), which were situated near densely populated areas. Notably, environmentally sensitive families such as Nemouridae, Rhyacophilidae, Limnephilidae and Leptoceridae were dominant in the less disturbed sections.

The findings provide an understanding of the river’s ecological status. The comparison of mean values for the EPT family richness, across six sampling stations in the Prizren River indicated variations between these parameters (Table 4). These indices, as defined by Schmidt-Kloiber & Nijboer (2004) reflect the sensitivity of taxa to variations in water quality conditions. Moderate levels of anthropogenic impact were observed at station L3 (Table 3) likely attributable to their proximity to urban areas.

The EPT index scores at monitoring site L1 indicated “excellent” water quality. Similarly, the FBI

values for this site also placed it within the highest water quality category, further confirming its classification as “excellent.” At monitoring station L2, the EPT index suggested “very good” water quality, a classification confirmed by the corresponding FBI score. In contrast, the FBI scores at sampling sites L3 and L4 indicated “moderate” and “good” quality categories, respectively. The values of the EPT index at these sites consistently classified the water quality as “good.” However, the two downstream sampling sites, L5 and L6, exhibited substantially lower water quality. Both EPT and FBI indices classified these sites within the “bad” water quality category, indicating significant environmental degradation (Tables 3, 4).

In L1, the upstream sampling site, the FBI is 3.4, the dominance of good and very good families aligns with the “Excellent” ecological status. Instead, at L5 and L6 with an FBI of 6.6 and 6, the prevalence of very poor families corresponds to the “Bad” ecological status (Table 3).

Our findings on the biotic indices in the Prizren River offer significant insights into the ecological health of the sampled locations (Tables 3, 4). For instance, at site L1, where the EPT value was 9.2, the relatively high abundance of sensitive organisms reflected the *excellent water quality*. In contrast, at site L5, an EPT value of 1.3 indicated a notable absence of these taxa, suggesting poor water quality and corroborating the overall classification of “Bad” ecological status.



a) Ephemerellidae



b) Ephemeridae

**Fig. 2.** Representatives of families of Ephemeroptera.

## Discussion

Freshwater macroinvertebrates are widely recognised as key bioindicators of riverine ecosystem health, with changes in their community structure serving as reliable indicators for the ecological status of aquatic systems (Menezes et al. 2010). Numerous studies have established that sensitive insect taxa of the orders Ephemeroptera, Plecoptera and Trichoptera (EPT) are particularly robust indicators of high ecological quality, often exhibiting elevated levels of taxonomic richness, diversity and abundance (Metcalf 1989, Rosenberg & Jackson 1993, Berlin & Thiele 2002, Wallin et al. 2003). These taxa are commonly associated with clean, well-oxygenated waters and minimal anthropogenic disturbance. Slavevska-Stamenković et al. (2011) further emphasised that high EPT species richness typically characterises natural or near-natural aquatic environments.

In the present study, a total of 28 macroinvertebrate families were identified, indicating considerable biodiversity. Insect taxa, and particularly members of the EPT orders, dominated the assemblages, accounting for 79% of all identified taxa. This mirrors findings from the Lepenc River study by Etemi et al. (2020) which reported 34 families with insects comprising 79.41% of the community. However, a marked decline in EPT richness was observed at the downstream sites (L5 and L6), accompanied by a concurrent increase in pollution-tolerant taxa such as Chironomidae, Tubificidae and Lumbriculidae. These taxa are well-documented indicators of poor water quality and are associated with low dissolved oxygen levels and high organic pollution (Rosenberg & Resh 1993). This pattern of community composition is also consistent with findings from BUCINCA et al. (2024) who reported similar faunal shifts in downstream tributaries of the Ibër River, particularly near urban settlements.

EPT taxa comprised more than 64% of all collected insect specimens (Table 2, Fig. 2) a pattern consistent with previous findings from similar regional studies. For instance, Etemi et al. (2020), Ibrahim et al. 2021, Bilalli et al. 2022, Bucinca et al. 2024) reported a dominance of EPT taxa in upstream sections of rivers in Kosovo, reflecting water quality conditions ranging from good to moderately impacted. Earlier research on the Prizren River by Shukriu (1979) identified 96 macroinvertebrate species, with EPT taxa representing the most diverse and abundant groups, findings that closely align with those of the current study. In both cases, Ephemeroptera emerged as the order with the highest taxonomic richness, particularly the family Baetidae, underscoring their ecological versatility and adaptive capacity across varying conditions.

The spatial trends in biotic index values further support these findings. The Family Biotic Index (FBI) and the EPT Family Richness Index provided complementary assessments of water quality. Upstream sites exhibited low FBI values and high EPT richness, indicative of clean water and minimal human impact. In contrast, downstream sites were characterised by elevated FBI scores and diminished EPT richness, classifying them as having poor to bad water quality. These biotic index results underscore the ecological consequences of intensified urban pressures at downstream locations. Intermediate sites (L3 and L4) reflected transitional ecological conditions, where the beneficial influence of upstream conservation was gradually offset by growing pollution loads. The coexistence of sensitive families such as Nemouridae, Rhyacophilidae and Limnephilidae with more tolerant taxa suggests a degree of ecological resilience, although signs of stress were evident.

The ecological degradation of downstream segments can be attributed to several anthropogenic stressors, including urban runoff, direct sewage dis-

charge and alterations to physical habitat structure. The downstream sampling sites are located near urban areas and are characterised by intensive urbanisation (Fig. 1), conditions commonly associated with significant environmental stressors – similar to the findings reported by Ibrahim et al. 2021. These findings corroborate the conclusions of (Wang & Kanehl 2003) who reported a negative correlation between watershed urbanisation and EPT richness. Field observations during the current study confirmed the presence of solid waste, untreated or poorly treated wastewater discharge and other forms of pollution particularly near densely populated or industrialised areas.

Despite the river's inherent capacity for self-purification, the cumulative effects of sustained anthropogenic pressures have led to a pronounced decline in macroinvertebrate diversity in downstream reaches. At sites L5 and L6, macroinvertebrate assemblages were composed almost exclusively of highly tolerant oligochaetes, reflecting a severe reduction in ecological quality. This degradation is clearly captured by both the EPT richness and FBI metrics. These findings are consistent with established ecological principles and previous research (Lenat & Penrose 1996, Schmidt-Klöber & Nijboer 2004) which emphasises the vulnerability of EPT taxa to environmental degradation and the efficacy of biotic indices in monitoring water quality changes.

The results of this study highlight the significant impact of anthropogenic activities on the ecological status of the Prizren River. Upstream reaches serve as ecological reference points, supporting diverse and sensitive macroinvertebrate communities under relatively undisturbed conditions. In contrast, downstream areas underscore the urgent need for targeted water quality management strategies, including pollution control and habitat restoration. The observed spatial variation in macroinvertebrate community structure, taxonomic diversity and biotic index values across the six sampling sites reveals a clear environmental gradient: from relatively pristine upstream habitats to ecologically degraded downstream sections. The observed variation in biotic indices clearly demonstrates their differential sensitivity to environmental degradation and their utility in detecting spatial changes in environmental conditions and assessing the ecological health of riverine ecosystems.. Overall, these indices proved effective for assessing spatial variations in water quality and for informing future river basin management efforts.

The current study offers critical insights into the ecological integrity of the Prizren River and the

extent of anthropogenic impacts on water quality along its course.

## Conclusion

The presence and composition of macroinvertebrate taxa identified in this study suggested that the water quality of the Prizren River could be classified as good. This study constitutes a preliminary effort to evaluate the water quality of the Prizren River in Kosovo using biological quality elements derived from macroinvertebrates. While offering valuable macroinvertebrate bioindicator data for assessing water quality, the research highlights the critical need for future studies to incorporate more frequent monitoring and a broader range of biological indicator groups. Such approaches are essential for a comprehensive understanding of the ecological status of these freshwater ecosystems.

The results emphasize the urgent need for conservation measures, particularly in urban and downstream areas, to address pollution sources and preserve the ecological integrity of the Prizren River. Future research could focus on exploring temporal variations in biotic indices and expanding the spatial scope of sampling to include additional tributaries and potential pollution sources.

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