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Integrated ecological assessment of the Drini i Bardhë River basin based on biological quality elements: preliminary studies

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Abstract. This preliminary study evaluated the ecological condition of selected river sections in the Drini i Bardhë basin, Kosovo. Marked spatial variation was observed: Burim–Istog, Drelaj, and Jasiq–Erenik showed comparatively high ecological quality, whereas downstream and urban-influenced sections had lower diversity and poorer condition. Nutrient enrichment and wastewater effects were evident at several sites. Of the 19 sites with complete classifications, 21.1% were in good, 26.3% in moderate, 47.4% in poor, and 5.3% in bad status. The findings confirm the value of biological quality elements for Water Framework Directive-oriented assessment in Kosovo and emphasize the need for standardized georeferencing, seasonal replication, quantitative fish records, and complete site-level datasets.

Key words: biological quality elements, ecological status, macroinvertebrates, macrophytes, fish fauna, Water Framework Directive.

Introduction

Freshwater ecosystems are among the most important and dynamic natural environments, supporting biodiversity, nutrient cycling, water supply, and wider ecosystem functioning. Nevertheless, these systems are increasingly affected by untreated wastewater discharge, agricultural runoff, hydromorphological modification, gravel extraction, water abstraction, and land-use change (European Parliament & Council of the European Union, 2000; Allan, 2004). The European Water Framework Directive (WFD) introduced an integrated approach in which ecological status is assessed through Biological Quality Elements (BQEs), supported by physicochemical and hydromorphological quality elements (European Commission, 2003a).

Among the BQEs, benthic macroinvertebrates are particularly effective indicators because they integrate environmental conditions over time and differ in sensitivity to organic pollution, habitat degradation, and hydrological disturbance (Alba-Tercedor & Sánchez-Ortega, 1988; AQEM Consortium, 2002). Metrics such as Biological Monitoring Working Party (BMWP), Average Score Per Taxon (ASPT), and Ephemeroptera–Plecoptera–Trichoptera (EPT) richness are widely used to characterize river quality. Macrophytes and fish communities provide complementary evidence of nutrient conditions, habitat structure, longitudinal connectivity, and cumulative ecological pressure (European Commission, 2003b; Zhushi Etemi et al., 2020). Recent evidence continues to emphasize the value of long-term, standardized macroinvertebrate monitoring for detecting changes in river biodiversity and diagnosing the effects of pollution and management interventions (Johnson et al., 2026).

The Drini i Bardhë River basin is Kosovo's largest river basin and one of the country's most important freshwater resources. Although upper mountain and spring-fed sections may retain relatively undisturbed conditions, many downstream reaches are exposed to wastewater pollution, nutrient enrichment, gravel extraction, water abstraction, and habitat alteration (Whalley & Faloutsos, 2020; World Bank, 2018). The aim of this study was therefore to provide a preliminary ecological assessment of selected river sections in the basin by applying macroinvertebrate, macrophyte, and fish indicators together with supporting environmental parameters, in accordance with the principles of the WFD.

Materials and methods

Study area and sampling design

Sampling was conducted during 2022 at 20 sites distributed across the Drini i Bardhë River basin. The sites represented mountain streams, spring-fed tributaries, and lowland river sections exposed to different degrees of anthropogenic pressure. Potential reference sites included Burim–Istog, Drelaj, Prevallë, and Burimi i Lumit Brod. A schematic overview of Kosovo and the principal rivers associated with the basin is shown in Fig. 1. Exact GPS coordinates were not available in the compiled dataset used for this preliminary manuscript; future surveys should record latitude, longitude, elevation, sampling date, and reach length for every station in a standardized site table.

Biological and supporting measurements

Macroinvertebrates were sampled using a modified AQEM/STAR multi-habitat approach (AQEM Consortium, 2002; European Committee for Standardization, 2012). Sixteen subsamples were collected at each surveyed reach with a hand net of 0.5-mm mesh size, and BMWP, ASPT, and EPT richness were calculated. Macrophytes were surveyed during summer campaigns using semi-quantitative abundance estimates following Suárez et al. (2005). Fish assemblages were assessed by electrofishing within representative reaches. The available field records support a presence/composition-based interpretation; the total number of fish individuals caught was not recorded consistently across all sites and therefore cannot be reported reliably. Future monitoring should report total catch, catch per unit effort, reach length, electrofishing time, and species-specific abundance.

Physicochemical measurements included dissolved oxygen, pH, electrical conductivity, nitrate, ammonium, phosphate, five-day biochemical oxygen demand (BOD_5), and chemical oxygen demand (COD). Hydromorphological observations included substrate composition, channel condition, and riparian vegetation. Ecological-status interpretation followed the WFD framework (European Parliament & Council of the European Union, 2000; European Commission, 2005).

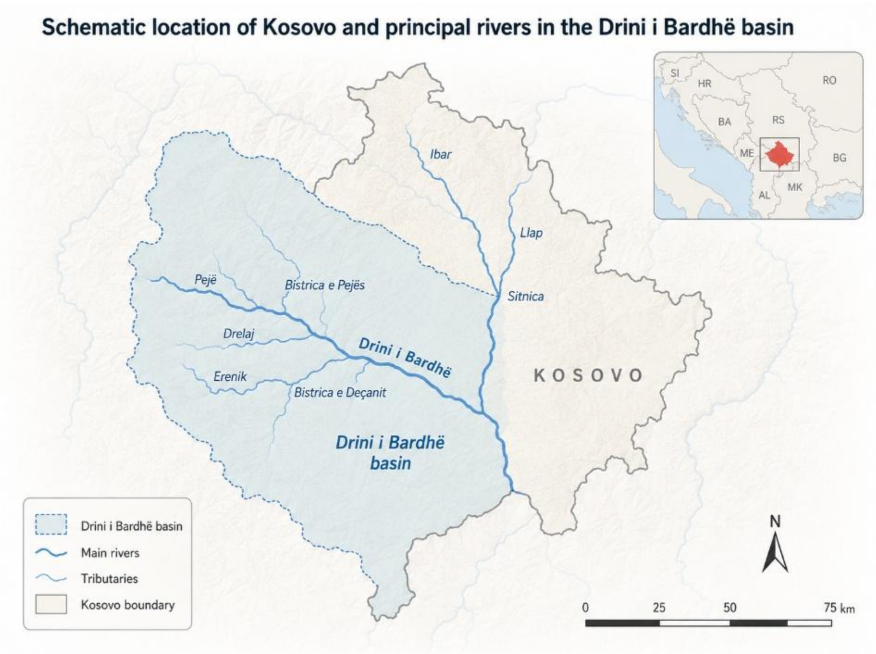

Fig. 1. Schematic location of Kosovo and principal rivers associated with the Drini i Bardhë basin. The figure is intended as a geographic overview and not as a substitute for station-level GPS coordinates.

Data analysis

Descriptive analyses included ranges for BMWP and ASPT, taxonomic totals, and frequencies and percentages of ecological-status classes. Mean values and standard deviations require complete site-level observations. Because the compiled manuscript dataset contained only index ranges and categorical totals rather than the full numerical values for each site, means and standard deviations for BMWP, ASPT, nutrients, and other physicochemical parameters could not be reconstructed without introducing unsupported values. This limitation is stated explicitly, and future analyses should present site-level data and report the mean ± standard deviation (or median and interquartile range for non-normally distributed variables).

Results

Frequently recorded macroinvertebrate groups included Baetidae, Perlidae, Gammaridae, and Hirudidae. Burim–Istog and Drelaj showed the highest biological quality, with higher BMWP and ASPT values and the presence of pollution-sensitive taxa. BMWP values ranged from 10 at Lumi i Plavës to 69 at Burim–Istog, while ASPT values ranged from 2.5 to 10.0. Sites classified as good generally displayed greater taxonomic richness and biological diversity than sites classified as moderate, poor, or bad. Overall, 32 macroinvertebrate families and 57 macrophyte taxa were recorded throughout the study area.

Macrophyte records included *Amblystegium fluviatile*, *Equisetum fluviatile*, *Mentha aquatica*, and *Cladophora* sp. The increased abundance of filamentous algae at several locations suggested localized nutrient enrichment (Dodds & Welch, 2000). Fish assemblages also reflected a longitudinal ecological gradient: upper reaches were dominated by *Salmo trutta* m. *farioides*, associated with cold, oxygen-rich waters, whereas lower sections supported species such as *Barbus rebeli*/*balcanicus*, *Rhodeus amarus*, and *Alburnoides ohridanus*. Because fish counts were not consistently retained in the compiled field dataset, these results describe species composition rather than abundance or catch per unit effort.

Physicochemical observations indicated elevated nitrate, ammonium, and phosphate concentrations at several urban- and agriculture-influenced sites. A complete ecological-status class was available for 19 of the 20 investigated sites: four were classified as good, five as moderate, nine as poor, and one (Lumi i Plavës) as bad. Thus, poor status was the most frequent class (47.4%), followed by moderate (26.3%), good (21.1%), and bad (5.3%). One site lacked sufficient information for a final categorical assignment.

Table 1. Frequency distribution of ecological-status classes. Percentages are calculated using the 19 sites with a complete classification.

Ecological status	Number of sites	Percentage of classified sites
Good	4	21.1%
Moderate	5	26.3%
Poor	9	47.4%
Bad	1	5.3%
Total classified	19	100.0%

Discussion

The results demonstrate substantial ecological variation within the Drini i Bardhë River basin. BQEs, especially macroinvertebrates, effectively distinguished relatively undisturbed upper reaches from more strongly affected downstream sections. Similar patterns have been reported in Balkan and European rivers, where upstream habitats generally support more sensitive and diverse biological communities (Mihaljević et al., 1998; AQEM Consortium, 2002). The elevated nutrient concentrations observed at several locations indicate continuing anthropogenic pressure associated with untreated wastewater and agricultural runoff (Zhushi Etemi et al., 2020; Korça & Demaku, 2022).

Macrophyte communities reflected environmental heterogeneity, and the occurrence of *Cladophora* sp. at multiple sites was consistent with nutrient enrichment and eutrophic tendencies. Fish assemblages showed expected longitudinal differentiation, with brown trout in colder upper streams and more heterogeneous cyprinid assemblages in lower sections (Karr, 1981; Schiemer & Waidbacher, 1992). However, the absence of consistently recorded fish counts prevents quantitative comparison of abundance among sites. Likewise, the lack of a complete site-level numerical matrix prevented calculation of robust means, standard deviations, confidence intervals, or inferential statistics. These gaps should be addressed in subsequent monitoring campaigns.

The study should therefore be interpreted as a preliminary basin-scale screening rather than a complete WFD classification exercise. Seasonal variability was not fully captured, hydromorphological assessment was not standardized against all WFD requirements, exact station coordinates were unavailable in the compiled dataset, and one site lacked a complete ecological-status category. Nevertheless, the combined biological and environmental evidence provides a useful basis for prioritizing future monitoring, wastewater-control measures, and the protection of potential reference reaches.

Conclusions

Biological Quality Elements provide a practical and scientifically defensible basis for preliminary ecological assessment in the Drini i Bardhë River basin. Macroinvertebrate communities were especially informative and reflected clear differences between less disturbed upper reaches and downstream or urban-influenced sections. Among the 19 classified sites, most were in poor or moderate condition, while only four achieved good status. The findings support the progressive implementtation of WFD principles in Kosovo and highlight four priorities for future work: standardized GPS documentation, complete site-level databases, replicated seasonal sampling, and quantitative fish-abundance reporting. Long-term monitoring, improved wastewater treatment, and protection of ecologically valuable spring-fed and mountain sites are essential for conserving the basin's freshwater ecosystems.

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