ASSESSMENT OF THE ECOLOGICAL STATUS/ECOLOGICAL POTENTIAL FOR DESIGNATED WATER BODIES ON THE JIU RIVER ACCORDING TO THE WATER FRAMEWORK DIRECTIVE

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Abstract. The structure and composition of the communities present in an aquatic ecosystem is a consequence of both the characteristics of the environment and the anthropic pressures exerted on it, information that lies at the basis of the evaluation of the ecological status, respectively of the ecological potential for water bodies. The identification, delimitation and classification of surface water bodies is carried out in order to determine the main elements that form the basis for the process of evaluating the quality of water resources and establishing the environmental objectives that must be met by them. The concept regarding the evaluation of the ecological status/ecological potential using the methodology proposed by the Water Framework Directive differs fundamentally from previous approaches in the field of water quality carried out at the national level. Thus, the present study describes the current approach according to which biological elements represent the integrator of all types of pressures, and hydro-morphological, general physical and chemical indicators, specific synthetic and non-synthetic pollutants are only supporting elements in establishing the ecological status. The main objective of this study is to establish the ecological status/ecological potential for all designated water bodies on the Jiu River, from its source to the confluence with the Danube River, with an emphasis on the impact of anthropic pressures, on the measures that can be implemented to improve water quality, as well as their classification in quality classes and categories of use.

Keywords: Water Framework Directive 60/2000/CE, environmental objectives, water body, multimetric index, anthropic pressures.

Rezumat. Evaluarea stării ecologice/potențialului ecologic pentru corpurile de apă desemnate pe râul Jiu în contextul Directivei Cadru pentru Apă. Structura și componența comunităților prezente într-un ecosistem acvatic reprezintă o consecință atât a caracteristicilor mediului cât și a presiunilor antropice exercitate asupra acestuia, informații ce stau la baza evaluării stării ecologice, respectiv a potențialului ecologic pentru corpurile de apă. Identificarea, delimitarea şi clasificarea corpurilor de apă de suprafață se efectuează în scopul determinării principalelor elemente ce stau la baza procesului de evaluare a calității resurselor de apă și a stabilirii obiectivelor de mediu ce trebuie îndeplinite de acestea. Conceptul privind evaluarea stării ecologice/potențialului ecologic folosind metodologia propusă prin Directiva Cadru pentru Apă diferă fundamental de abordările anterioare în domeniul calității apei realizate la nivel național. Astfel, în prezentul studiu este descrisă abordarea actuală conform căreia elementele biologice reprezintă integratorul tuturor tipurilor de presiuni, iar indicatorii hidromorfologici, fizico-chimici generali, poluanţii specifici sintetici şi nesintetici sunt doar elemente suport în stabilirea stării ecologice. Obiectivul principal al acestui studiu îl constituie stabilirea stării ecologice/potențialului ecologic pentru toate corpurile de apă desemnate pe râul Jiu, de la izvor până la confluența cu fluviul Dunărea cu accent pe impactul presiunilor antropice, pe măsurile ce pot fi implementate în vederea îmbunătățirii calității apei precum și încadrarea acestora în clase de calitate și categorii de folosință.

Cuvinte cheie: Directiva Cadru pentru Apă 60/2000/CE, obiective de mediu, corp de apă, indice multimetric, presiuni antropice.

INTRODUCTION

Rivers are vital components of the Earth's ecosystem, serving as crucial habitats for countless species, sources of freshwater for human consumption and as channels for transportation and commerce. They are also key indicators of environmental health, reflecting the state of the surrounding ecosystems. The ecological status of rivers is assessed based on a variety of indicators, including biological diversity, chemical composition, hydrological conditions and physical habitat quality. This paper examines the ecological status/potential of Jiu River, the factors affecting its health and the importance of preserving the ecosystem.

Rivers provide a multitude of ecosystem services, including the supply of drinking water, irrigation for agriculture, habitat for fish and wildlife and recreational opportunities for communities. They play a critical role in the nutrient cycling of surrounding landscapes and help mitigate flooding by absorbing excess rainfall. Furthermore, rivers are cultural landmarks, often holding historical significance and providing spiritual value to local communities.

The ecological status/potential of rivers is assessed using various indicators that collectively provide a comprehensive picture of river health. These indicators can be categorized into biological, chemical and physical parameters (CIOBOIU et al., 2019; GAVRILESCU et al., 2020; GAVRILESCU & CIOBOIU, 2021).

Monitoring the ecological status of rivers is essential for effective management and conservation efforts. Various methodologies and frameworks have been established globally to assess river health, including the European Water Framework Directive (WFD) and the United States Clean Water Act. These frameworks promote a holistic approach to river management emphasizing the integration of biological, chemical, and physical assessments.

Community involvement in monitoring efforts can also enhance the effectiveness of ecological assessments. Citizen science initiatives, where local residents participate in data collection and monitoring have gained popularity and can provide valuable insights into river health while fostering a sense of stewardship among communities.

The Water Framework Directive (WFD) aims to protect water resources across Europe. This paper examines the ecological status/potential assessment of Jiu River under the WFD, detailing the methodologies, indicators, challenges and implications for water management and conservation. The paper argues that, while the WFD has made significant strides in improving water quality and ecological health, ongoing efforts are necessary to address emerging challenges such as climate change, pollution and habitat degradation.

Study area. The Jiu River is formed by the union of the two streams, West Jiu and East Jiu in the Petroșani Depression (Figs.1; 2). The West Jiu has a length of 51km and a hydrographic basin area of 534 km2. It stems from the Retezat Mic at an altitude of 1760m, the glacier bucket to Scorota. The West Jiu is bordered to the right by the Vâlcan massif and to the left by the Retezat. Due to the presence of limestone rocks, the river and its tributaries have dug impressive gorges and waterfalls. The most important tributaries on the right are Oslea, Gîrbovul and Valea de Pești, and on the left Buta, Crevedia and Aninoasa. The East Jiu has a length of 28 km and its basin covers an area of 479 km2. The river is born in the eastern part of the Petrosani Depression between Șureanu and Parâng and the main tributaries on the right are: Răscoala, Voievodul, Bilele and Taia (IORDACHE et al., 2015).

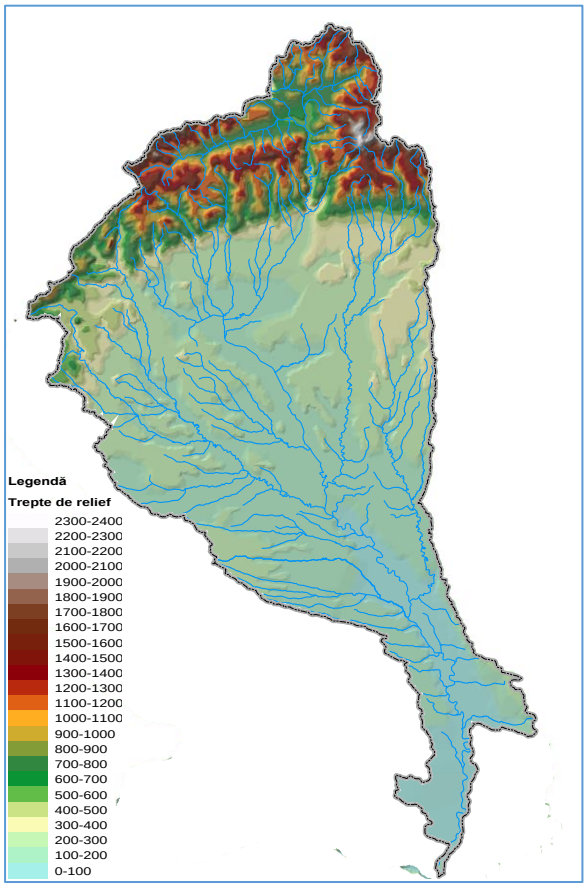

Figure 1. Study area (Hypsometric map) (original).

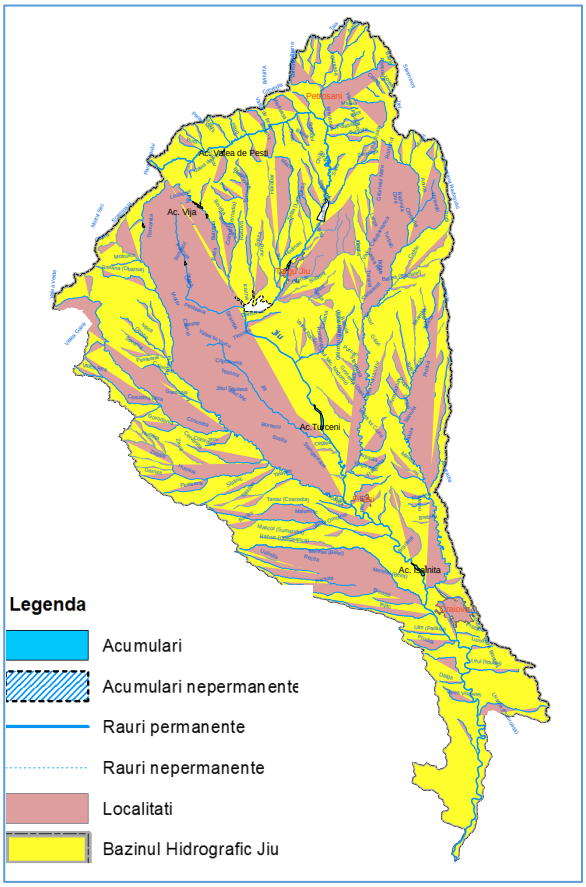

Figure 2. Study area (Hydrographic network) (original).

MATERIAL AND METHODS

The Water Framework Directive (WFD) is a pivotal piece of legislation enacted by the European Union (EU) in 2000, designed to ensure the sustainable management of water resources across member states. One of the central tenets of the WFD is the delineation of surface water bodies, which is crucial for the effective monitoring, assessment and management of water quality and ecosystem health. This comprehensive approach integrates environmental, economic and social considerations, aiming to achieve "good status" for all water bodies by established deadlines.

Surface water bodies, as defined by the WFD, include lakes, rivers, transitional waters (estuaries), and coastal waters.

The directive classifies these water bodies into distinct categories, each with its own specific criteria for status assessment. The delineation of these bodies is fundamental because it influences the management strategies employed to protect and enhance water quality. The delimitation of the water bodies is a continuous process, which can undergo changes over time. Therefore, a body of water belongs to a single quality class (ZANFIR et al., 2019).

The delineation of surface water bodies under the WFD follows a systematic approach which involves several critical steps:

a) to gather relevant data which includes hydrological data (flow rates, water levels), biological data (present species, habitat types) and chemical data (nutrient levels, contaminants).

b) to establish the physical boundaries of each water body which involves determining the upstream and downstream limits for rivers, the perimeter of the lakes, and the transition zones for estuaries. The boundaries should be defined in a manner that reflects the natural hydrological processes and the ecological integrity of the water body.

c) once the boundaries are established, the ecological status of each water body is assessed according to specific criteria outlined in the WFD. This assessment considers biological, physical and chemical indicators, allowing for a comprehensive understanding of the water body's health.

d) the classification system to categorize water bodies based on their ecological status. The status of water bodies can be classified as "high", "good", "moderate", "poor" and "bad". This classification guides management decisions and resource allocation, ensuring that efforts are focused where they are most needed.

e) public consultation and stakeholder involvement. The WFD emphasizes the importance of public participation in the delineation process. Stakeholders, including local communities, environmental organizations and industries are encouraged to contribute their knowledge and insights. This collaborative approach not only enhances the accuracy of the delineation but also fosters a sense of ownership and responsibility towards water resources.

Despite the structured approach outlined by the WFD, several challenges can complicate the delineation of surface water bodies, such as: lack of comprehensive and consistent data on water bodies, hydrological alterations meaning dam construction, land reclamation and urban development that significantly alter natural water flows and boundaries and climate, a significant threat to the integrity of surface water.

The Water Framework Directive (WFD), adopted by the European Union in 2000, aims to protect and enhance the quality of water resources across Europe. One of the key concepts of the WFD is the classification of water bodies, which includes two main categories: "natural water bodies" (NWBs) and "heavily modified water bodies" (HMWBs).

According to the Water Framework Directive (WFD) a "natural water body" is defined as a body of water that is not significantly altered by human activity such as dams, channelization or other alterations that would affect its ecological status and flows in its natural state.

A heavily modified water body is defined as a water body that has been significantly altered in its physical characteristics due to human activity, which affects its ecological status. Despite these modifications, it is still capable of supporting a specific set of ecological functions.

Once the designation of water bodies is made, the evaluation of their ecological status/potential follows, which is carried out by assessing the next water quality indicators:

1. Biological indicators are typically focused on the diversity and abundance of aquatic organisms, particularly fish, macroinvertebrates and phytoplankton. Healthy rivers support a diverse range of species, while diminished biodiversity often indicates pollution or habitat degradation. The presence of indicator species, such as mayflies and stoneflies can signify good water quality, while the dominance of pollution-tolerant species suggests degraded conditions.

So, a multimetric index (MMI) is used to assess the ecological health or biological integrity of an ecosystem, particularly in aquatic environments. This index integrates multiple biological indicators, often derived from different taxa (such as fish, macroinvertebrates, or algae) in order to provide a more comprehensive evaluation of ecosystem condition than single metrics would.

2. Chemical indicators are critical for determining the ecological status of water bodies. Key parameters include nutrient levels (nitrogen and phosphorus), dissolved oxygen, pH, and the presence of harmful substances like heavy metals and pesticides. Elevated nutrient levels can lead to eutrophication, resulting in harmful algal blooms that deplete oxygen and create dead zones.

3. Physical indicators, such as flow regime, substrate composition, and habitat complexity are essential for supporting aquatic life. Changes in flow patterns due to dam construction or water extraction can alter habitats and disrupt the life cycles of aquatic organisms. Additionally, the presence of physical barriers, such as dams and weirs can impede fish migration and reduce genetic diversity.

The results from biological, chemical and physical assessments are integrated to classify the ecological status/potential of water bodies. The classification system for natural water bodies (NWBs) includes five quality classes (1-5), as defined in the WFD: High Ecological Status (Nearly natural conditions with minor human influence), Good Ecological Status (Minor deviations from natural conditions, supporting healthy biological communities), Moderate Ecological Status (Moderate deviations, with some negative impacts on aquatic life), Poor Ecological Status (Significant alterations, resulting in impaired ecosystems) and Bad Ecological Status (Severe degradation, with substantial loss of biodiversity).

Assessing the ecological potential of heavily modified water bodies (HMWBs) is a critical process in managing and restoring these ecosystems while recognizing the constraints imposed by human modifications. The goal is to restore and enhance the ecological health of these water bodies while acknowledging the constraints imposed by human activities. Through systematic assessment and adaptive management, it is possible to improve the ecological potential of heavily modified water bodies and ensure they continue to provide valuable ecosystem services. The classification system for heavily modified water bodies (HMWBs) includes three quality classes (1-3): Maximum Ecological Potential, Good ecological Potential and Moderate Potential.

Evaluating the ecological status and potential of water bodies serves several important purposes, such as: environmental protection (allowing the protection of biodiversity and the preservation of habitats), regulatory compliance with European environmental regulations, resource management (ensuring that water bodies can support various uses, such as drinking water supply, agriculture, recreation, and industry), pollution control (to identify sources of pollution and degradation, guiding efforts to mitigate these impacts and improve water quality), ecosystem services valuation (the ecosystem services provided by water bodies, such as carbon sequestration, flood regulation, and recreational opportunities, which can inform economic assessments and decision-making), climate change adaptation (understanding that the current ecological status helps predict how water bodies may respond to climate change and informs strategies for adaptation and resilience) and public awareness and education with the main purpose for the community to engage and support the conservation initiatives.

RESULTS AND DISCUSSIONS

The determination of the ecological status for the natural water bodies (NWBs) delineated for the Jiu River (Table 1) is achieved based on the quality elements monitored in 2022 by the Water Quality Laboratory (Jiu River Basin Administration) which provides assessment tables for each quality element.

Table 1. Ecological assessment for NWBs in the Jiu River.

Natural Water body	Water body length (skm)	Biological indicators (class)	Chemical indicators (class)	Physical alterations (class)	Ecological status (class)
Jiu de Vest-spring- Parosșeni and tributaries Pârâul Boului, Garbov, Buta, Lazăr, Pârâul Morii, Pilug, Sterminos, Valea de Pești, Balomir, Mierleasa, Braia, Baleia	162.27	2	2	2	2
Jiu de Vest - Parosșeni-confl. Jiu de Est	11.24	3	3	3	3
Jiu confl. Jiu de Est - Vădeni reservoir	50.25	2	2	2	2
Jiu Tg. Jiu - Rovinari	22.93	2	2	2	2
Jiu Rovinari - Turceni reservoir	27.89	3	2	3	3
Jiu Turceni reservoir - Ișalnița reservoir	56	2	2	2	2
Jiu Ișalnița reservoir - Bratovoiești	46.59	2	2	3	2
Jiu- Bratovoiești - Danube confluence	55	2	2	2	2

The ecological assessment for heavily modified water bodies (HMWBs) in the Jiu River (Table 2) is a critical process for understanding and managing ecosystems that have been significantly altered by human activities. These modifications can include urbanization, agriculture, industrial activities, dam construction, and other alterations that impact the natural flow, habitat and water quality of aquatic systems.

Conducting an ecological assessment of heavily modified water bodies is vital for understanding their current conditions, restoring ecological integrity and managing them sustainably. It requires an interdisciplinary approach, integrating ecological science, community engagement, and effective management practices to support biodiversity and ecosystem health in modified aquatic environments (IONUȘ, 2014).

Table 2. Ecological assessment for HMWBs in Jiu River.

Heavily modified water body	Water body length (skm)	Biological indicators (class)	Chemical indicators (class)	Physical alterations (class)	Ecological potential (class)
Vădeni and Târgu Jiu reservoir	1.08	2	3	3	3
Turceni reservoir	2.14	2	2	3	2
Ișalnița reservoir	1.8	1	2	3	2

The ecological status for water bodies is determined according to the 'one out, all out' principle. This principle implies that a water body can only achieve good status if all biological and supporting quality elements are assessed at least as good (ȘERBAN, 2011).

Several anthropogenic and natural factors influence the ecological status of rivers, leading to degradation and decline in their health, such as:

1. Pollution: One of the most pressing threats to the Jiu River ecosystems is pollution from agricultural runoff, untreated sewage and industrial discharges. Nutrient pollution leads to eutrophication, while toxic pollutants can bioaccumulate in aquatic organisms, posing risks to both wildlife and human health.

2. Habitat alteration: Urbanization, agriculture, and industrial activities often result in habitat destruction and alteration. Riverbank stabilization, drainage of wetlands and the construction of levees can reduce the natural complexity of river systems, negatively impacting biodiversity and ecosystem functions. This phenomenon is manifested on 3 Jiu River water bodies.

3. Water extraction: Jiu River is increasingly tapped for human water supply, irrigation and industrial purposes, leading to reduced flows and altered hydrological regimes. Over-extraction can cause significant ecological changes, including the loss of wetlands, alteration of sediment transport processes and increased water temperature, all of which affect aquatic life.

4. Climate change poses a significant threat to Jiu River ecosystems. Altered precipitation patterns and increased temperatures can lead to changes in river flow regimes, affecting the timing of fish migrations and the availability of habitats. Additionally, extreme weather events, such as floods and droughts, can have devastating impacts on river health.

Climate change scenarios estimate a 20% probability of severe droughts in the next 10 years, especially in the south-west of the country (Jiu River catchment). This affects almost 50% of the total agricultural land. The scenarios calculate that droughts by decreasing river flows will become more frequent and more severe (Jiu River Basin Management Plan).

CONCLUSIONS

The ecological status/potential of rivers has become a pressing concern, as environmental degradation, climate change, and biodiversity loss threaten the balance of ecosystems. To improve the ecological status/potential, a multifaceted approach is essential. This involves governmental policies, community initiatives, technological innovations and individual actions.

Following the assessment of the ecological state for the NWBs-Jiu River, it was found that 25% of the water bodies are in moderate status and the rest of 75% in good ecological status. For the HMWBs, only one water body has a moderate potential (Vădeni and Târgu Jiu reservoir).

In order to enhance the ecological health for the Jiu River, several measures, such as: conservation of biodiversity, sustainable land use and agriculture, restoration of ecosystems, pollution reduction and climate change mitigation must be adopted.

The Jiu River has faced various pollution challenges over the years, primarily due to industrial activities, agricultural runoff and urban development. Some common water pollutants found in the Jiu River include:

1. Nutrients from agricultural runoff that often leads to elevated levels of nutrients like nitrogen and phosphorus. This can cause eutrophication, leading to algal blooms that deplete oxygen in the water.

2. Wastewater from untreated or inadequately treated wastewater from municipalities can contribute to overall pollution levels.

3. Organic pollutants from agricultural practices, such as pesticides and herbicides that may enter the river through runoff.

4. Microbial contaminants which include contamination with bacteria from wastewater discharges, especially in urban areas with high risks to human health and aquatic life.

5. Plastic and solid waste from improper waste disposal can introduce plastics and other solid waste into the river.

Efforts to monitor and mitigate pollution in the Jiu River are ongoing, and various environmental agencies and organizations work to address these issues through regulations and remediation projects.

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Received: February 29, 2024
Accepted: June 10, 2024