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ECOLOGICAL ASSESSMENT AS A FIRST STEP IN THE EVALUATION OF ECOSYSTEM SERVICES PROVIDED BY LOTIC ECOSYSTEMS

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ABSTRACT: The ecosystems offer to the socio-economic system a series of goods and services derived from their processes and biodiversity. Ecosystem services offered by a river are at their highest potential when the river status is close to the natural one. Once the river is affected by human impact due to resources exploitation, hydro technical works, water abstraction or improper land use, the ecological status declines and the ecosystem services become scarce. This is why an ecological assessment is necessary in order to establish the connection between the ecosystem services and the human impact. In this paper, the ecological assessment of Timiş River was done, allowing the classification of the river in four sectors with different ecological statuses, associated with the various human impacts that differently affect the quality of the water, the riverbed and the flooding area.
KEY WORDS: Ecosystem services, human impact, ecological assessment, Timiş River

1. INTRODUCTION

Ecosystem services are the conditions and the processes through which natural ecosystems (together with the species that make them up) sustain human life (Daily, 1997). Ecosystem services represent the economical synonym of the ecosystem functions concept of ecology. The ecosystem services are quite difficult to approach because it tries to integrate the ecological way of thinking into the economic domain and in the decision-making processes of administration and politics (Constanza et al., 1997; Hawken et al., 1999; de Groot, 2002; Chee, 2004).

Ecosystems offer for free a series of goods and services that human kind used so far without taking into consideration the fact that they may be endangered due to human activities. Only when we got to the point of losing some of these services, we realized that this loss is going to be very expensive from various points of view. In his paper on the value of ecosystem services and natural capital, Constanza et al. (1997) considers that due to the fact that ecosystem services are not fully comprised in commercial markets and they're inadequately quantified in terms comparable with economic services, they are frequently underestimated in the political decision-making processes. So, this is how the idea of the economic quantification of the goods offered by nature should be done for a better appreciation and a sustainable use of ecosystem services. At the same time, in this manner, ecosystem services can be introduced on the agenda of the decision-makers.

Various types of classification of ecosystem services have been made; for example, Daily (1997) considers that the concept of ecosystem services encompasses the production of goods, regeneration services, stabilizing services, life-fulfilling services and options preservation, while de Groot (2002) says that the ecosystem services are represented by ecosystem functions classified in: regulation, habitat, production and information functions. According to Millennium Ecosystem Assessment (2003, 2005), ecosystem services have been classified into four categories that comprise the other classifications: provisioning services (ex. food and water), regulating services (ex. flood and disease control), cultural services (ex. spiritual benefits, recreation) and supporting services (ex. nutrient cycling).

If we analyse lotic ecosystems from the ecosystem services point of view, rivers have always provided important resources for human activities, being an important factor in human settlements due to the fact that water represents a vital resource with various uses in the economic sphere and not only. From a socio-economic perspective, rivers are natural capital elements that offer resources like water for consumption (drinking, domestic, industry and agriculture), water as energy source (for hydropower plants), building materials (sand, gravel, clay), biologic resources (aquatic organisms used for food production and medicine), genetic resources, as well as services: regulating services (maintaining water quality by natural filtering and cleaning, flood control, fire control, maintaining the quality of adjacent wetlands), supporting services (primary and secondary production, nutrient cycle, energy flux, prey-predator relationship and ecosystem resilience, water cycle) and cultural services (recreation: rafting, kayaking, sport fishing, etc., tourism, cognitive development, artistic inspiration, reflection and aesthetic enrichment).

The sustainable use of services provided by rivers to the socio-economic system requires the assessment of the resilience and support capacity of lotic systems. The ecological assessment of rivers, through indexes that reflect the structural complexity and ecosystem functions, represents a first step in establishing the resilience capacity of such systems.

In this context, this paper aims to evaluate the ecological state of Timiş River based on the benthic macroinvertebrate communities' structure in correlation with biotope characteristics, stepping forward towards the evaluation of ecosystem services provided by this river.

Benthic macroinvertebrates represent good bio-monitors of lothic habitats quality due to their presence along the river, their limited mobility and their relatively long live span, sensitivity to pollution, to river bed changes and to hydrological variations; they're abundant in number, so that they can be used for statistical studies and their presence/absence can be used for stating pollution loads (Bae et al., 2005; Navarro-Llácer et al., 2010; Varnosfaderany, 2010; Curtean-Bănăduc and Olosutean, 2013).

2. STUDY AREA AND METHODS

Timiş River is the main drainage basin in South-West Romania, having its springs on the eastern part of Semenic Mountains – 1135 m altitude, and flows into the Danube in Serbia, at Pančevo, having a total length of 359 km (241 km in Romania) (www.wikipedia.org). It drains a total surface of 7319 kmp, out of which 5795 kmp are in Romania (INMH, 1971, ***, 2011), passing through three types of landforms: mountains, plains and lowlands.

Consequently, Timiş River represents an important source of goods and services which are exploited from the upper river sector until the river mouth, like the Trei Ape dam lake used for hydroenergy production, water abstraction for potable water or usage in agriculture and industry, alluvial deposits used as building materials, exploited mostly from the middle sector of the river, aquatic organisms as food source, self-cleaning processes of discharge waters, tourism services and others. This resources could be lost if their exploitation is not done under the sustainability concept, within the resilience capacity of the river. These are a few of the reasons that make Timiş River a good case study for highlighting the role of the ecological status assessment in the ecosystem services concept.

The ecological assessment of Timiş River has been done based on the analysis of benthic macroinvertebrates communities and biotope factors (physico-chemical characteristics of water, land use, riparian vegetation, substrate, channel hydromorphological characteristics, riverine land use) from 21 sampling stations along the Romanian part of the river (Fig. 1), stations selected according to riverbed morphology, main tributaries, hydrotechnical works, main pollution sources, position of gravel plants extracting building materials and land use (Curtean- Bănăduc, 2001). The sampling has been done during three field campaigns in 2011: June, August and November.

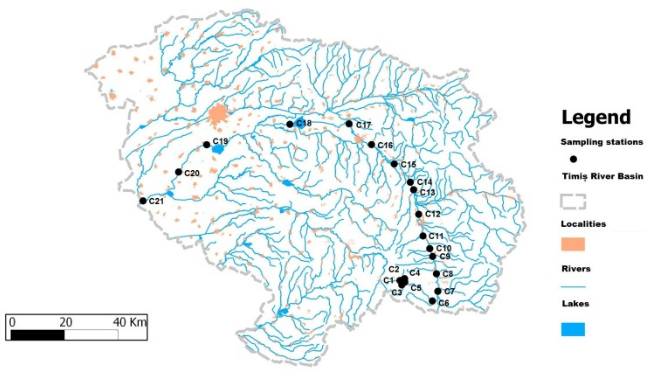


Figure 1. Timiș River basin and the location of the sampling stations (C1-C21 sampling stations).

A Surber sampler (catching area - 887 cm^2) was used in the sampling process for benthic macroinvertebrates in all 21 stations (for each sampling station we had between 3 and 5 take-off points according to the variety of substrate type) with a mesh size of 250 μ. The samples have been conserved in formaldehyde 4% with sodium hydrogen carbonate. The identification and quantification of benthic invertebrates was done in the laboratory (after washing) with a Zeiss (65X) stereo-microscope to the order level, and, in the case of Ephemeroptera, Plecoptera, Trichoptera and molluscs, to species level. The samples are stored in 70% ethanol and are kept in the hydrobiology laboratory of "Lucian Blaga" University of Sibiu.

For the analysis of the physical habitat characteristics, the visual approach method (Roth et al., 1996; Infante et al., 2009) was used. Habitat descriptors used were: altitude, slope, riverbed width (m), depth (m), type of substrate (%), hydrotechnical works from the riverbed (in terms of presence/absence), bank vegetation (in terms of presence/absence), channel modification (%) and riverine land use type according to Corine Land Cover.

The community structure indices used were relative abundance (AR%) and Shannon-Wiener diversity index (H - showing the diversity in taxonomical groups of each sampling station, offering the possibility to compare the sampling stations between each other for a better reflection on how the anthropic impact affects the biodiversity on Timiş River) (Krebs, 1989). The Belgian Biotic Index (IBB) was used for the determination of the ecological state of river sectors based on the presence and abundance of 7 macroinvertebrate groups sensitive to changes in their aquatic habitats (De Pauw et al., 1992).

3. RESULTS

The analysis of the benthic macroinvertebrate communities (Curtean-Bănăduc and Farcaş, 2013) in correlation with the biotope characteristics (Fig. 2 and Fig. 3) emphasized the following ecological classes along Timiş River:

I. The river sector upstream Trei Ape dam lake until Petroşniţa (C1-C7) has a good ecological status. The benthic macroinvertebrate communities' structure (qualitative and quantitative) is close to natural.

Right after the Trei Ape Dam Lake (C5), the presence of organic matters reflects the high influence that the barrier lake has on the river.

In this area, the self-cleaning capacity of the river is good due to the variation of specific micro-habitats (runs with pools and riffles), and due to the present stable populations of filtrators.

In this sector, the most important human impact is caused by the Trei Ape dam lake, which catches around 80% of the water flow and is used for energy production, for water supply and for recreational activities. The dam lake has a major impact on this river sector because it brings changes into the water flow, changing the water speed, transforming the lothic system into a lenthic one, disrupting the longitudinal connectivity on the river, affecting the sediment transport and the biota migration. In this way, the dam lake affects the matter and energy cycle and the longitudinal migration of aquatic organisms, which leads to a decrease in biodiversity.

II. From upstream Sadova Veche to Lugojel (sampling stations C8-C16), the river sector has a moderate ecological status.

In this sector, the water quality is affected by the wastewater discharge from localities, especially from Caransebeş, where there is an installed wastewater treatment plant, but only half of the collected water from the city is treated, the other half being driven directly into the river, the same situation for other localities nearby that don't have wastewater treatment plants.

Dams situated on Timiş's tributaries Feneş and Armeniş (upstream Sadova Veche) affect indirectly the Timiş River due to flow fluctuations.

Besides this, many gravel plants are extracting building materials from this river sector, which affects the riverbed, changing the natural river flow, increasing the sediment transport and deepens the riverbed.

III. In the Coşteiu sector (C17), the natural conditions of the river are strongly modified due to hydrotechnical works (river embankments, etc.) and the Timiș-Bega Canal, which changes the hydrological state. The wastewater discharges from Lugoj (due to a semi-functional wastewater treatment plant), as well as the gravel plants exploiting sand and gravel upstream Lugoj pollute and disturb the river water.

IV. The sector between Coşteiu and the Romanian-Serbian border (C18-C21) has a moderate to poor ecological status due to the hydrotechnical works placed upstream, which influence the flow regime, due to river embankments, sand and gravel exploitation, wastewater discharge and land use.

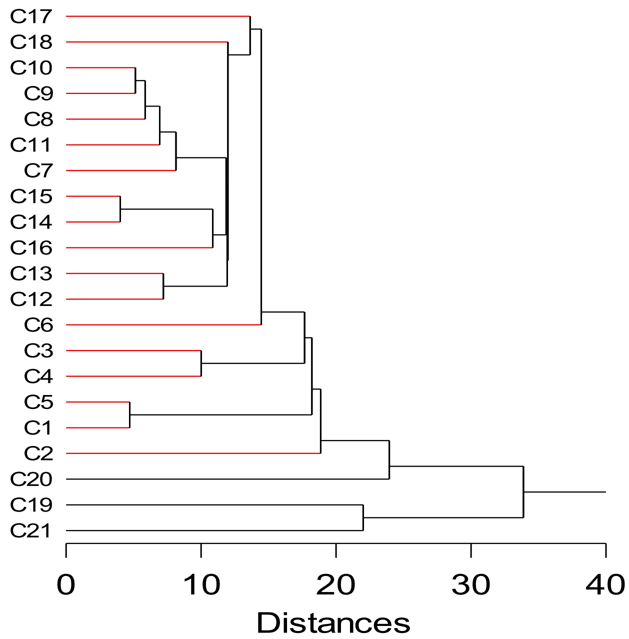
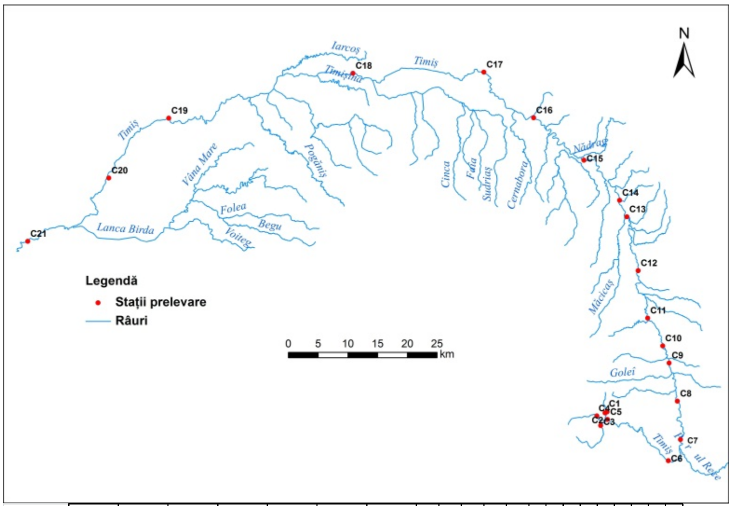


Figure 2. Similarity cluster between sampling stations (C1-C21) on Timiș River based on Shannon-Wiener Index, Belgian Biotic Index, physic and chemical features (pH, conductivity, O2, Cd, SO4, NH4, NO2, NO3, CCOCr, CCOMn, CBO5, chloride, river width, depth, channel modification, substrate type - silt, sand, gravel, pebbles, boulders and boulders on rocky substrate).

Belgian Biotic Index was calculated for each of the 21 sampling stations and the obtained values allow a classification of the river on sectors corresponding to quality classes. All the studied sectors from Timiș River belong to the middle quality classes (II., III. and IV.), the extreme classes (I.-high ecological status and V.-bad ecological status) do not appear (Fig. 3).

According to IBB values, sampling stations C1-C4, C6 and C7, correspond to the second quality class, with good ecological status, most of the stations reflect a moderate ecological status (C5, C8-C16, C18, C20), while the rest of the stations correspond to the fourth quality class, the water having a poor ecological status (C17, C19, C21).



	C21	C20	C19	C18	C17	C16	C15	C14	C13	C12	C11	C10	C9	C8	C7	C6	C5	C4	C3	C2	C1
IBB	3	6	4	5	4	5	5	5	6	5	7	7	6	6	7	7	6	7	7	7	7
	IV	III	IV	III	IV	III									II		III	II			

Figure 3. The classification on quality classes of Timiș River on the basis of the Belgian Biotic Index (five water quality classes I.-V., which are marked with different colors (I. – blue, high ecological status; II. - green, good ecological status; III. - yellow, moderate ecological status; IV. – orange, poor ecological status and V. – red, bad ecological status) (C1-C21 sampling stations

4. CONCLUSIONS

The ecological assessment of Timiș River status allows the classification of the river in four sectors with different ecological statuses, which represents as well a reflection of the various human impacts that affect differently the quality of the water, the riverbed and the flooding area.

The sector upstream the river has as major impact factor, the dam lake from Trei Ape, whose influence is well reflected on the sampling station immediately downstream. Because there are no other major human influences on this river sector, the ecological status is good. In the second sector, the human impact is higher and more frequent, due to wastewater discharge and gravel plants and the river quality declines. In the third sector, the embankments, water abstraction, water discharges, all in all – a big exploitation of the goods and services offered by the river, lead to a poor ecological status and a decline of ecosystem services use in the following sector.

Ecosystem services are at their highest potential when the river status is closest to natural. Once the river is affected by human impact due to resources exploitation, hydrotechnical works, water abstraction, improper land use, the ecological status declines and the ecosystem services become scarce. This is why an ecological assessment is necessary in order to establish the connection between the ecosystem services and human impact.

A sustainable management of the ecosystem services is based on the assessment of the self-regulation and support capacity of the ecosystem and the use of goods and services within the limits of these capacities.

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