Habitat and Plant Species Diversity along the River Danube in Serbia

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Introduction

The Danube River enters Serbia in its middle course, 1433 kilometers upstream of its mouth, and it leaves Serbia at the mouth of the river Timok to the Danube (river km 845.5). Its flow through Serbia is 588 km long. In its upper region the Danube River mainly flows through the southeast part of the Pannonian Plane while in its lower region it flows through Đerdap Gorge (the Iron Gates). During the year 1972, the construction of the Power Plant and the dam Đerdap I, on the river km 943, was finished. The construction of the dam caused severe changes in the river hydrology: the flow velocity was reduced, the water level rose, and the sedimentation was increased (STEVANOVIĆ, 2001). Under conditions of mean water level, the reservoir Đerdap I reach upstream to river km 1155 (which is the mouth of river Tamiš). In contrast, during conditions of high water level conditions at the end of April a reduction of flow velocity is observed on its tributaries (Sava, Tisa, Tamiš, etc.). Under the high water level conditions the area of the littoral zone is increased and new backwaters are created favouring the occurrence of aquatic vegetation. During the 1980ies a second dam and Power Plant Đerdap II was going to be constructed. It is situated on the river km 863.4. Although it is not yet finished, its influence can be detected as far as 80 river km upstream. Downstream of the dam Đerdap II, the flow velocity of the River Danube is high, and the hydrological conditions are similar to the conditions found in the upper section of the Danube River in Serbia.

Methods

The survey of aquatic macrophytes was done during the period 2002-2004. Investigations included 358 river km along the left riverside of the main channel and 451 river km along the right riverside. Occurrence of aquatic macrophytes was assessed in survey units of one river km length. The method has a long tradition in the Danube catchment (KOHLER et al., 1971, KOHLER & JANAUER, 1995, CEN-Standard EN 1484, 2003). Habitat parameters (bank structure, sediment type, flow class, land use type and water transparency) were assessed in each survey unit. Field data were collected and processed according to the guidelines established during the project "Multifunctional Integrated Study Danube: Corridor and Catchment" (www.midcc.at).

Results and discussion

The aquatic vegetation of the River Danube in Serbia is influenced by the type of the sediment, the flow velocity, water transparency, bank structure, and the type of the land use. Fine inorganic material (pelal) in flat slopes is the dominant bank structure along the left riverside of the main channel; it is present in 49.2% of the investigated river km. In addition artificial material used for

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the embankment (such as concrete, stone blocks, etc.; 23.5%), sand (psammal; 14.3%), pelal on steep slopes (12.9%), and gravel (microlithal; 0.3%) have been recorded. Along the right riverside a higher diversity of different types of bank structures was recorded. In 28.2% of the investigated river km pelal was found on shallow areas. In addition artificial material (25.1%) was recorded upstream and downstream of two dams. Large rocks (megalithal; 23.3%), gravel (microlithal; 7.3%), pelal in deeper areas (10%) and send (psammal; 4.9%) were frequently recorded along the Đerdap Gorge (The Iron Gates).

Intermediate flow velocity was most frequently recorded. On the left riverside it was recorded in 76.8% river km, and on the right riverside in 62.3%. Lower velocity was recorded in 11.7% and 25.4% river km investigated at the left and right riverside, each. High velocity was recorded in 11.2% and 12.2% of the river km investigated at the left and right riverside, each. Stagnant water bodies were recorded in 0.3% of the river km on the left riverside but did not occur on the right riverside. Villages covered 6.4%, forests 5.2%, pastures 2.8%, while agriculture and industrial region had lowest proportions of approximately one percent. Along the right riverside riparian forests occurred less frequently (38.8%), while agriculture (17.3%), villages (15.1%) and forests (13.1%) were found more frequently. Industrial areas (3.3%) and urban areas (3.6%) were also found more frequently. Water transparency was generally increasing from upstream to downstream. Minima and maxima were 30 cm and 120 cm on the left riverside and 45 cm and 150 cm on the right riverside.

In total 40 plant species were recorded and many species showed a specific occurrence pattern: 24 in the upper region, 37 in the impoundment of Đerdap I, 17 in Đerdap II, and 11 in the lower region of the river. *Mentha aquatica* was found in the upper part only, *Alisma gramineum, Azolla filiculoides, Lemna gibba, Najas minor, Nuphar lutea, Nymphaea alba, Nymphoides peltata, Oenanthe aquatica* and *Sparganium erectum* were recorded in Đerdap I reservoir only. *Zannichellia palustris* occurred only in Đerdap II, and the amphibian form of *Plantago lanceolata* was only found in the lower region of the river. Aquatic species recorded exclusively in the impoundment areas were: *Acorus calamus, Elodea nuttallii, Potamogeton natans and Potamogeton zizii.* Although the number of the species were comparable between the left (35) and the right (36) riverside, both sides differed significantly in the species composition and abundance (Tab. 1, Fig. 1, Fig. 2). *Lemna gibba, Mentha aquatica,* and *Nymphaea alba* were recorded on the left riverside only, while *Alisma gramineum, Myriophyllum verticilatum, Nymphoides peltata, Plantago lanceolata*, and *Zannichellia palustris* were found exclusively on the right riverside.

Table 1. List of aquatic plant species recorded and their absence/presence in the investigated river sections: 1-upper region, 2- Đerdap I, 3- Đerdap II, 4-lower region, Abbrev.-abbreviations of the species names

	Species	left riverside		right riverside				Abbrev.
		1	2	1	2	3	4	
1.	*Acorus calamus* L.							Aco cal
2.	*Alisma gramineum* Lej.							Ali gra
3.	*Alisma plantago-aquatica* L.							Ali pla
4.	*Azolla filiculoides* Lam.							Azo fil
5.	*Butomus umbellatus* L.							But umb
6.	*Ceratophyllum demersum* L.							Cer dem
7.	*Elodea canadensis* Michx							Elo can
8.	*Elodea nuttallii* (Planchon) St John							Elo nut

9.	*Hydrocharis morsus-ranae* L.							Hyd mor
10.	*Iris pseudacorus* L.							Iri pse
11.	*Lemna gibba* L.							Lem gib
12.	*Lemna minor* L.							Lem min
13.	*Mentha aquatica* L.							Men aqu
14.	*Myriophyllum spicatum* L.							Myr spi
15.	*Myriophyllum verticillatum* L.							Myr ver
16.	*Najas marina* L.							Naj mar
17.	*Najas minor* All.							Naj min
18.	*Nuphar lutea* (L.) Sibth. & Sm.							Nup lut
19.	*Nymphaea alba* L.							Nym alb
20.	*Nymphoides peltata* (Gmelin) Kuntze							Nym pel
21.	*Oenanthe aquatica* (L.) Poiret.							Oen aqu
22.	*Plantago lanceolata* L.							Pla lan
23.	*Polygonum amphibium* L.							Pol amp
24.	*Potamogeton crispus* L.							Pot cri
25.	*Potamogeton gramineus* L.							Pot gra
26.	*Potamogeton lucens* L.							Pot luc
27.	*Potamogeton natans* L.							Pot nat
28.	*Potamogeton pectinatus* L.							Pot pec
29.	*Potamogeton perfoliatus* L.							Pot per
30.	*Potamogeton pusillus* L.							Pot pus
31.	*Potamogeton x fluitans* Roth.							Pot flu
32.	*Potamogeton zizii* Koch ex Roth							Pot ziz
33.	*Rorippa amphibia* (L.) Besser							Ror amp
34.	*Sagittaria sagittifolia* L.							Sag sag
35.	*Salvinia natans* (L.) All.							Sal nat
36.	*Sparganium erectum* L.							Spa ere
37.	*Spirodela polyrhiza* (L.) Schleiden							Spi pol
38.	*Trapa natans* L.							Tra nat
39.	*Vallisneria spiralis* L.							Val spi
40.	*Zannichellia palustris* L.							Zan pal

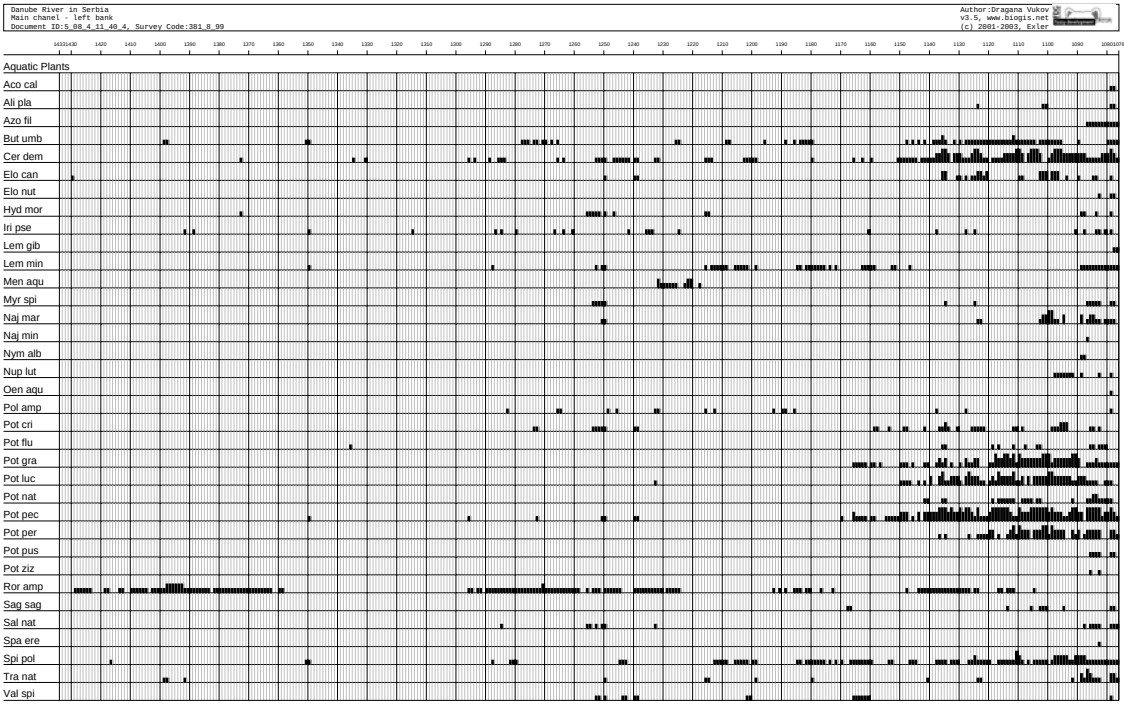

Fig. 1.Distribution of aquatic plant species, Danube-main channel, left riverside. The vertical lines indicate the investigated river km. The abundance of each species is shown semi quantitatively by the black columns differing in height (low height, rare and occasional occurrence; medium height, frequent occurrence; high columns, abundant and very abundant).

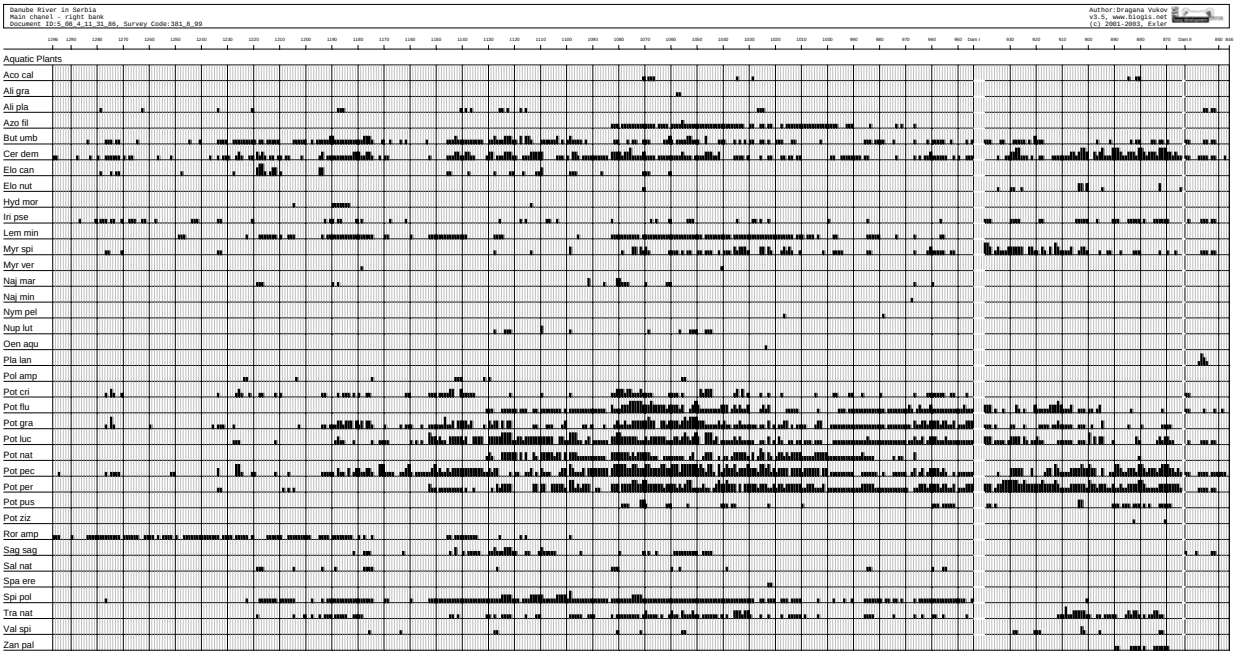

Fig. 2. Distribution of aquatic plant species, Danube-main channel, right riverside. The vertical lines indicate the investigated river km. The abundance of each species is shown semi quantitatively by the black columns differing in height (low height, rare and occasional occurrence; medium height, frequent occurrence; high columns, abundant and very abundant).

With regard to the species diversity the left riverside showed two distinct regions: the upper region was characterised by general low species diversity. Except of *Rorippa amphibia* which is almost continually distributed, all other species occurred in low abundance and at a rather few sampling sites only. In contrast the region downstream of river km 1155 showed a much higher species diversity with many species occurring in high abundance and continuously throughout the whole region. This threshold coincides with the beginning of the impoundment area Đerdap I. Consequently the high species diversity and high abundance of the aquatic plants in the region downstream of river km 1155 was caused by the hydrological changes induced by the impoundment, i.e. a decreased flow velocity, larger littoral areas and higher sedimentation rates. In contrast to the left riverside the species diversity and the abundance of aquatic plants on the right riverside was high throughout the whole study area (Fig. 2). Some regions showed an extremely high species diversity, such as the impoundment areas of Đerdap I and II.

Summary

The flow stretch of the River Danube through Serbia is 588 km in length. The distribution and abundance of forty aquatic plant species was recorded at 809 sampling sites each one river km in length (358 river km on the left and 451 river km on the right riverside). The sampling sites were characterized with regard to the sediment type, the flow velocity and the adjacent terrestrial vegetation. The flow stretch of the river was divided into four main sections that could be differentiated with regard to the occurrence of specific plant species and species diversity: the upper region, the impoundments Đerdap I and Đerdap II, and the lower region of the river. Species diversity was lowest in the upper region and highest in the impoundment areas of Đerdap I and Đerdap II. In the upper region the left riverside differed significantly in species diversity from the right riverside. The results of this study provide basic information to solve applied tasks of water management as well as a research questions related to other aquatic organisms.

Acknowledgements

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