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Aquatic and wetland plant communities of the Pusta River (Southern Serbia): floristic characteristics and syntaxonomic affiliation

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Abstract:

At the end of summer 2021, phytocenological research was conducted on aquatic and wetland vegetation of the Pusta River - left tributary of the South Morava River. Using UPGMA classification method and the Bray-Curtis distance on a set of 97 relevés and 44 species, degree of floristic differentiation between studied vegetation plots was quantified. It was established that 7 associations take part in composing vegetation of the Pusta River – *Myriophyllo-Potametum* Soó 1934, *Potametum nodosi* Soó (1928) 1960, Segal 1964, *Phragmitetum australis* Savič 1926, *Typhetum latifoliae* Nowiński 1930, *Glycerio-Sparganietum neglecti* Koch 1926, *Phalaridetum arundinaceae* Libbert 1931 and *Polygono-Bidentetum tripartitae* (W. Koch 1926) Lohm. 1950. The plant associations of vegetation class *Potamogetonetea* Klika in Klika et Novák 1941- *Potametum nodosi* and *Myriophyllo-Potametum*, are floristically the poorest and entirely consist of native plant species. The associations of vegetation class *Phragmito-Magnocaricetea* Klika in Klika et Novák 1941 - *Typhetum latifoliae* (34 taxa), *Glycerio-Sparganietum neglecti* (33 taxa), *Phragmitetum australis* (24 taxa) and *Phalaridetum arundinaceae* (20 taxa) consist of higher number of species, including invasive plants. Vegetation class *Bidentetea* Tx. Et al. ex von Rochow 1951 is represented by only one association - *Polygono-Bidentetum tripartitae*, which consists of 24 taxa, with a share of 16.67% of allochthonous species. Collected phytocenological data are going to be good basis for the future research of the vegetation of lotic ecosystems in the southern Serbia.

Key words:
aquatic and wetland vegetation, Pusta River, UPGMA classification

Apstrakt:

Vodene i močvarne biljne zajednice Puste reke (Južna Srbija): sintaksonomska pripadnost i florističke karakteristike

Krajem leta 2021. godine, sprovedena su fitocenološka istraživanja vodene i močvarne vegetacije Puste reke – leve pritoke Južne Morave. Korišćenjem UPGMA klasifikacione metode i Bray-Curtis-ove distance nad setom podataka od 97 fitocenoloških snimaka i 44 vrsta kvantifikovan je stepen florističke diferencijacije između proučavanih sastojina. Ustanovljeno je da u izgradnji biljnog pokrivača Puste reke učestvuje 7 biljnih zajednica - *Myriophyllo-Potametum* Soó 1934, *Potametum nodosi* Soó (1928) 1960, Segal 1964, *Phragmitetum australis* Savič 1926, *Typhetum latifoliae* Nowiński 1930, *Glycerio-Sparganietum neglecti* Koch 1926, *Phalaridetum arundinaceae* Libbert 1931 i *Polygono-Bidentetum tripartitae* (W. Koch 1926) Lohm. 1950. Asocijacije vegetacijske klase *Potamogetonetea* Klika in Klika et Novák 1941 - *Potametum nodosi* i *Myriophyllo-Potametum*, su floristički najsiromašnije i u potpunosti izgrađene od autohnotnih biljnih vrsta. U sastav zajednica vegetacijske klase *Phragmito-Magnocaricetea* Klika in Klika et Novák 1941 - *Typhetum latifoliae* (34 vrste), *Glycerio-Sparganietum neglecti* (33 vrste), *Phragmitetum australis* (24 vrste) i *Phalaridetum arundinaceae* (20 vrste) ulazi veći broj vrsta, uključujući i invazivne biljne vrste. Vegetacija klase *Bidentetea* Tx. Et al. ex von Rochow 1951 predstavljena je zajednicom *Polygono-Bidentetum tripartitae* izgrađenom od 24 vrsta, sa udelom alohtonih vrsta od 16.67%. Prikupljeni fitocenološki podaci predstavljaju svojevrsnu osnovu za buduća, intenzivnija istraživanja biljnog pokrivača lotičkih ekosistema južne Srbije.

Ključne reči:
vodena i močvarna vegetacija, Pusta Reka, UPGMA klasifikacija

Introduction

Macrophytes are a complex group of plants adapted to the life in water. They include all aquatic vascular plants and aquatic mosses, and some authors also include macroscopic algae (Stevanović & Janković, 2001). They form aquatic plant communities that, compared to terrestrial communities, consist of a smaller number of species and, in most cases, are dominated by one species. Macrophytes can be both submerged and floating, and can be further divided into morphoecological types of plants that are rooted and those that are not rooted, but whose roots float in water, or these types of plants don't develop roots at all (Stevanović & Janković, 2001). Communities of rooted, floating plants as well as submerged macrophytes belong to the vegetation class *Potamogetonetea* Klika in Klika et Novák 1941, while floating, non-rooted macrophytes of relatively still and nutrient-rich waters, belong syntaxonomically to the vegetation class *Lemnetea* O. de Bolòs et Masclans 1955 (Mucina et al., 2016). Aquatic vegetation in Serbia has been previously studied in lentic systems (Vukov et al., 2003; Topuzović et al., 2009; Stanković et al., 2009, Ranđelović & Zlatković, 2010; Marković et al., 2015), while in the lotic systems it has been studied only in a few rivers and channels (Stojanović et al., 2007; Vukov et al., 2008; Jenačković et al., 2010; Ljevnaić-Mašić, 2010; Džigurski et al., 2016).

Wetland vegetation belongs to the class *Phragmito-Magnocaricetea* Klika in Klika et Novák 1941 (Mucina et al., 2016). In contrast to aquatic vegetation, the structure and physiognomy of phytocenoses in wetlands is determined by emergent macrophytes. This type of vegetation develops in places where water dries out during the summer months but remains close to the ground surface, as well as in habitats that are flooded throughout the year (Ranđelović et al., 2007a). Wetland vegetation provides refuge for many species, often rare and endangered, that inhabit only habitats where wetland vegetation is present. They are considered very sensitive and one of the most endangered habitats in the world, and their degradation is continuous and uncontrolled (Svitok et al., 2011). Wetland vegetation in Serbia has been studied mainly in the plains of Vojvodina (Slavnić, 1956; Vukićević et al., 1966; Babić, 1971; Stojanović et al., 1987; Butorac & Crnčević, 1987; Parabućski & Butorac, 1994; Polić, 2006; Stojanović et al., 2007; Ljevnaić-Mašić, 2010; Džigurski et al., 2010; Džigurski et al., 2011), while it has been less researched in the southern parts of Serbia (Katić, 1910; Košanin, 1910; Mišić et al., 1987; Ranđelović, 1978; Ranđelović & Zlatković, 2010; Jenačković et al., 2010; Jenačković, 2017; Jenačković et al., 2019).

Aquatic and wetland vegetation show high floristic and ecological similarity, which is why they are often studied together. These types of vegetation on the South Morava River and its tributaries have not been sufficiently investigated in terms of their floristic composition and ecological differentiation. Wetland vegetation south of the Autonomous Province of Vojvodina was examined near Vlaško polje (Jovanović, 1958), in the valley of the Velika Morava River (Jovanović, 1965), near Kragujevac (Veljović, 1967), in the valley of the Južna Morava River (Ranđelović, 1988), in the Moravica River (Milenović & Ranđelović, 2005), in the Batušinačke swamps located to the left of the South Morava River (Ranđelović et al., 2007a), on the banks of the Murina River, Brestovac (Ranđelović et al., 2007b), also on the banks of Vlasina Lake, Cvetkova River, Dedina Dolina (Ranđelović & Zlatković, 2010), in the Svrljiški and Beli Timok rivers (Jenačković et al., 2010), Smilovsko Lake, Krupac Lake, Oblačina Lake, wetland habitats in surroundings of the cities of Bela Palanka and Prokuplje, as well as near the villages of Žitkovac, Vrtište, Medoševac, Lepaja, Bresničić, Lalinac and Levosoje which have been investigated by Jenačković (2017). Aquatic vegetation was also investigated in the Beli and Svrljiški Timok rivers (Jenačković et al., 2010). The classification of aquatic and semi-aquatic vegetation of lakes in Serbia was also carried out by Laketić (2013), as well as the review of complete aquatic vegetation studied so far in Serbia (Cvijanović et al., 2018).

The main objectives of this paper are to determine:

- the diversity of aquatic and wetland phytocenoses of the Pusta River,
- the degree of floristic differentiation among the communities,
- the syntaxonomic affiliation of the registered communities.

Materials and Methods

Research area

Phytocenological research was conducted on the aquatic and wetland vegetation of the Pusta River along its course from the municipality of Bojnik to the municipality of Doljevac (**Fig. 1**). The Pusta River is located in the southern part of Serbia and is a left tributary of the South Morava River. The river's spring is located near the village of Donji Statovac. It is 71 km long and its catchment is 569 km^2. It flows into the South Morava River near the village of Pukovac (Gavrilović & Dukić, 2002).

Phytocenological research of aquatic and wetland communities was conducted during September 2021,

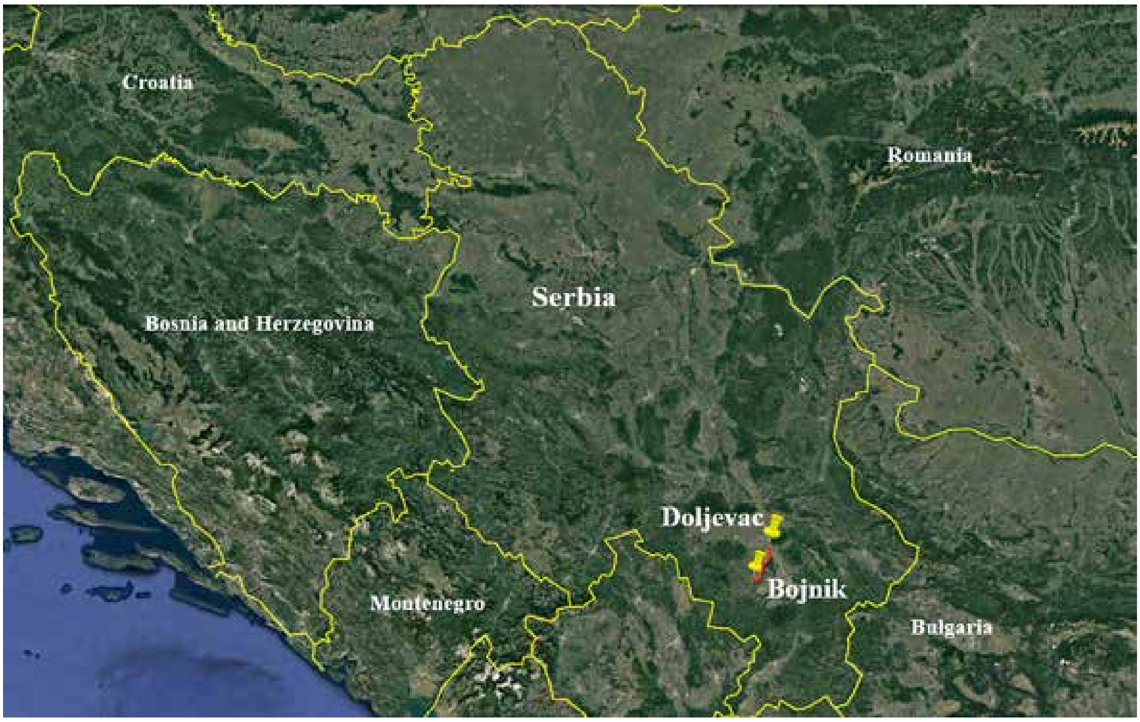

Fig. 1. Map of the investigated area on the Pusta River, start point (Bojnik) and end point (Doljevac)

as this part of the vegetation season is considered optimal for their sampling (Jenačković et al., 2019). Phytocenological relevés were recorded in the lower course of the Pusta River, from its confluence with the South Morava River to the municipality of Bojnik, along a river length of about 35 km. The largest number of phytocenological relevés were recorded in the part of the river stream near the villages of Pukovac and Kočane, as in these localities the phytocenoses of aquatic and wetlands were fully developed.

In the part of the river course between the village of Pukovac and the municipality of Bojnik, the areas with wetland vegetation were drastically reduced. The wetland phytocenoses were represented only by a few smaller patches of vegetation plots that were several kilometers apart. The cleaning of the riverbed significantly destroyed the wetland vegetation in Bojnik, which is believed to have developed in the riparian zone.

The phytocenological surveys were carried out according to the principle of the Swiss-French Braun-Blanquet school (Braun-Blanquet, 1964). The areas of the sampled stands had a standard size of 4 m^2 for aquatic vegetation and 16 m^2 for wetland vegetation. Sampling points were georeferenced using the GPS device (Global Positioning System). The plant material collected in the sampled stands was deposited in the herbarium collection “Herbarium Moesiacum” of the Faculty of Natural Sciences and Mathematics (HMN) of the University of Niš. The determination was performed with the help of dichotomous identification keys: “Flora SR Srbije I-X” (Josifović, 1970-1980, Sarić, 1986, 1992), “Флора на НР България” (Йорданов, 1963-1986, Велчев, 1989), and “Flora Europaea” (Tutin et al., 1964-1980).

The nomenclature and taxonomy of plant species were standardized according to the Euro+MedPlantBase database (https://www.emplantbase.org). Nomenclature of syntaxa, at the level of vegetation classes, orders and alliances was standardized according to Mucina et al. (2016). The names of associations, and their syntaxonomic positions, have been adjusted with Tzonev (2009), Cvijanović (2018) and Landucci et al. (2020).

Statistical analyses

The TURBOVEG software package was used to digitize 97 phytocenological relevés recorded during field research (Hennekens & Schaminée, 2001). Classification analysis was performed using the UPGMA (Unweighted pair group method with arithmetic mean) classification method and the Bray-Curtis similarity index. The value of the “Crispness of Classification” (Botta-Dukát et al., 2005) was used to determine the optimal number of clusters. Groups of phytocenological relevés belonging to one or more associations, identified by the hierarchical classification analysis as a separate group (cluster), are characterized by diagnostic species. Diagnostic species were determined based on the phi-coefficient, which expresses the degree of taxon fidelity to a particular cluster (Chytrý et al., 2002). In addition, virtual standardization of all vegetation groups was performed to eliminate the dependence of the phi-coefficient on the size of the vegetation groups – clusters (Tichý & Chytrý, 2006). Fisher's accuracy test was used to exclude all phi-coefficient values that were not statistically significant at the significance level $p<0.05$. Species with a phi-coefficient greater than 0.20 were considered as diagnostic species, while species with a phi-coefficient greater than 0.50 were considered as highly diagnostic species.

In addition to the classification analysis, where the optimal number of clusters was determined, one more cluster analysis was performed to better understand the floristic similarity between individual phytocenological relevés. Second cluster analysis was performed without determining the optimal number of clusters.

The dominant and constant species were determined for the vegetation groups identified using the results of the classification analysis. Dominant species were determined by calculating the average cover values in relevés within the groups using the cover index (Ic) (Lausi et al., 1982) and the share in total cover ($D_{\%}$) (Surina, 2005). Dominant species were determined to be those that were present in at least 10% of the relevés with a cover of at least 25%. Constant species were considered those that occurred in at least 40% of the relevés within the clusters.

The determination of diagnostic, constant and dominant species within the clusters, as well as the determination of the optimal number of clusters during classification analysis, were performed using the software package JUICE 7.0 (Tichý, 2002, http://www.sci.muni.cz/botany/juice). The software package JUICE 7.0 was also used to create the combined synoptic table. The combined synoptic table contains information about the floristic composition of the studied communities and the quantitative proportion of species in each of them.

Results and discussion

Based on the results of the classification analysis, with determined optimal number of clusters (**Fig. 2**) and the composition of the diagnostic species within the clusters defined (**Tab. 1**), four main vegetation groups (clusters) were distinguished. The results of classification analysis, performed without determining optimal number of clusters, are presented in **Fig. 3**, and illustrate the floristic similarities between individual relevés more clearly. Based on the results of these analyses, it can be noticed that cluster II (**Fig. 2**) is clearly divided into 3 subclusters (**Fig. 3**), and cluster IV (**Fig. 2**) into 2 subclusters (**Fig. 3**), resulting in 7 vegetation groups that participate in the construction of the plant cover of the investigated part of the Pusta River.

The first cluster (**Fig. 2**) corresponds with relevés of *Typhetum latifoliae* Nowiński 1930 (**Fig. 3**), second one (**Fig. 2**), divided into 3 subclusters (**Fig. 3**), unifies relevés of *Phalaridetum arundinaceae* Libbert 1931, *Polygono-Bidentetum tripartitae* (W. Koch 1926) Lohm. 1950 and *Glycerio-Sparganietum neglecti* Koch 1926, third cluster corresponds with relevés of *Phragmitetum australis* Savič 1926, and fourth, divided into two subclusters, unifies relevés of *Potametum nodosi* Soó (1928) 1960, Segal 1964 and *Myriophyllo-Potametum* Soó 1934.

Classification analysis showed that the greatest floristic similarity exists between the clusters I and II, i.e., the communities *Typhetum latifoliae* Nowiński 1930 (cluster I) and *Phalaridetum arundinaceae* Libbert 1931, *Polygono-Bidentetum tripartitae* (W. Koch 1926) Lohm. 1950 and *Glycerio-Sparganietum*

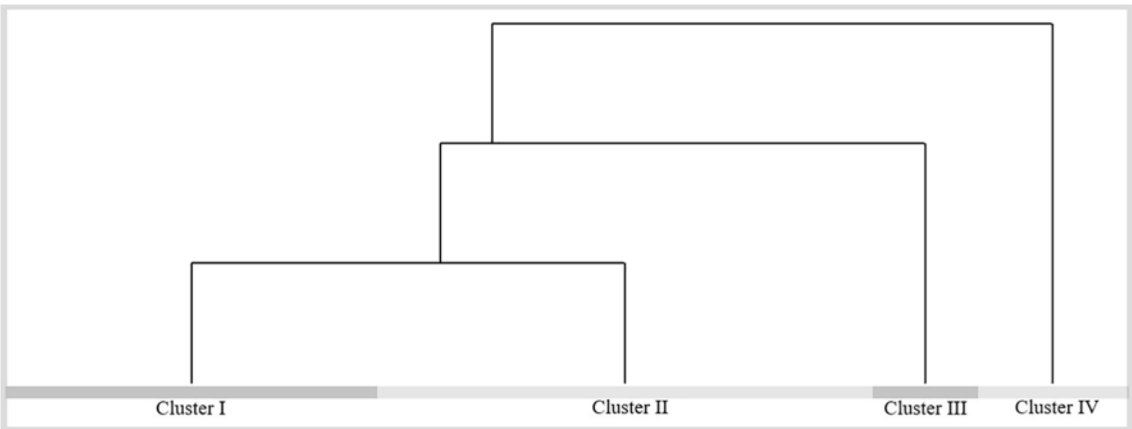

Fig. 2. Dendrogram obtained as a result of the hierarchical UPGMA classification on Bray-Curtis resemblance matrix along with determining optimal number of clusters.

Table 1. The combined synoptic table with the information on frequency and phi-coefficient values (x100) for species occurring in four optimal cluster groups defined by UPGMA classification analysis. The values for the frequency are represented by the base, while the values for fidelity are given in the form of superscripts

Species	Clusters			
	I	**II**	**III**	**IV**
Typha latifolia L.	**100** $^{85.6}$	14	11	.
Salix alba L.	**50** $^{31.3}$	33	22	.
Sparganium erectum L.	16	**91** ^{69}	22	8
Lythrum salicaria L.	62	**77** $^{42.8}$	22	.
Mentha aquatica L.	16	**47** $^{42.1}$	11	.
Polygonum mite Schrank	22	**37** $^{29.8}$	11	.
Phalaris arundinacea L.	6	**28** ^{40}	.	.
Tanacetum vulgare L.	3	**21** $^{24.7}$	11	.
Phragmites communis Trin.	.	.	**100** ^{100}	.
Urtica dioica L.	25	26	**56** $^{37.9}$	.
Echinocystis lobata (Michx.) Torr. & A. Gray	3	2	**33** $^{46.1}$	.
Robinia pseudoacacia L.	6	9	**33** $^{37.2}$	.
Myriophyllum spicatum L.	6	19	.	**92** $^{79.9}$
Potamogeton nodosus Poir.	16	28	11	**85** $^{60.4}$
Bidens tripartitus L.	47	47	56	.
Polygonum lapathifolium L.	28	25	22	.
Salix euxina I. V. Belyaeva	31	21	33	.
Xanthium strumarium L.	28	35	11	.
Populus sp.	16	9	11	.
Epilobium hirsutum L.	12	12	11	..
Lycopus europaeus L.	9	21	22	
Rubus caesius L.	6	12	22	.
Galium aparine L.	6	9	11	.
Potamogeton crispus L.	3	2	.	15
Lemna minor L.	3	7	.	8
Calystegia sepium (L.) R. Br.	19	23	.	.
Leersia oryzoides (L.) Sw.	12	19	.	.
Solanum dulcamara L.	12	19	.	.
Amorpha fruticosa L.	9	9	.	.
Echinochloa crus-galli (L.) P. Beauv.	3	9	.	.
Humulus lupulus L.	9	.	11	.
Rumex conglomeratus Murray	3	2	.	.
Lysimachia vulgaris L.	3	2	.	.
Erigeron canadensis L.	.	5	11	.
Scutellaria galericulata L.	.	5	.	.
Aristolochia clematitis	.	2	.	.
Chenopodium album L.	.	2	.	.
Lathyrus latifolius L.	.	2	.	.

Species	Clusters			
	I	II	III	IV
Scrophularia nodosa L.	.	2	.	.
Berula erecta (Huds.) Coville	.	2	.	.
Stellaria neglecta (Lej.) Weihe	.	2	.	.
Eleocharis palustris (L.) R. Br.	.	2	.	.
Stachys palustris L.	3	.	.	.
Althaea officinalis L.	3	.	.	.

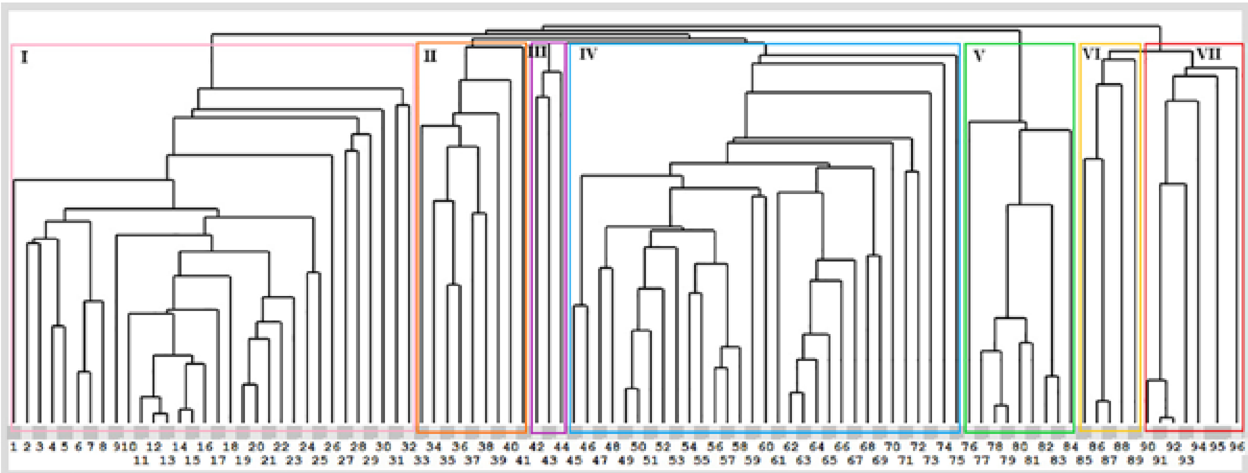

Fig. 3. Dendrogram obtained as a result of the hierarchical UPGMA classification on Bray-Curtis resemblance matrix without identifying optimal number of clusters

neglecti Koch 1926 (cluster II). Cluster IV differs the most as this cluster consists of associations *Potametum nodosi* Soó (1928) 1960, Segal 1964 and *Myriophyllo-Potametum* Soó 1934 presenting aquatic vegetation (**Fig. 2**).

Association *Typhetum latifoliae* is characterized by presence of highly diagnostic species - *Typha latifolia* (**Tab. 1**). It is floristically rich, includes 34 taxa, and its constant species are *Lythrum salicaria*, *Salix alba* and *Bidens tripartitus* (**Appendix 1**). The stands of this community have been developed in the coastal zone, where *T. latifolia* has been partly in the water and borders with the stands of *Myriophyllo-Potametum* and *Potametum nodosi* (**Fig. 4**). On the banks of the river, it forms a dense, impassable cover, and is intersected in some places by the *Glycerio-Sparganietum neglecti*. In southern part of Serbia, stands of this association were recorded in the Batušinačke swamps (Ranđelović et al., 2007a), on the banks of the Grlište hydro-accumulation (Stanković et al., 2009), Vlasina Lake (Ranđelović & Zlatković, 2010). In Ribinac, the stands in which *Typha latifolia* is the dominant species together with *Phragmites communis* were recorded (Ranđelović et al., 2007b). The spectrum of accompanying species is diverse and depends on the habitat. According to Šumberová (2011), short-term floodplains are usually much richer in the number of taxa and include not only common wetland plants (e.g. *Lycopus europaeus* L. and *Lythrum salicaria* L.) but also tall sedges (e.g. *Carex riparia* Curtis) and species typical for meadow vegetation (e.g. *Equisetum palustre* L., *Galium palustre* L. and *Symphytum officinale* L.). In long-term floodplains, especially in highly eutrophic wetlands, the macrophyte *Lemna minor* L. is common (Šumberová, 2011), which is also recorded in the studied stands of the Pusta River.

It is necessary to stress that high values of phi-coefficient for species *Salix alba* (**Tab. 1**) is related with including one relevé characterized by high percentage value of cover of *Salix alba* in database. On the territory investigated, *Salix alba* occurs frequently within stands of the *Typhetum latifoliae*, at its upper border or at the elevated parts of the bank where it occurs mainly with one or two individuals. In some places, one to two individuals of *Salix alba* can be found due to the lack of wetland vegetation. *Salix alba* represents the remnants of once-present floodplain forests that developed near the Pusta River. Today, the remains of flooded forests in the lower course of the river, are represented only by certain species of the genus *Salix* and *Populus*, some

Fig. 4. The stands of associations *Typhetum latifoliae* Nowiński 1930 (**1**,**2**), *Phalaridetum arundinaceae* Libbert 1931 (**3**), *Phragmitetum australis* Savič 1926 (**4**), *Glycerio-Sparganietum neglecti* Koch 1926 (**5**) and *Potametum nodosi* Soó (1928) 1960, Segal 1964 (**6**) developed in riverbed and on the banks of Pusta River, as well.

of which extend into the wetland vegetation.

The stands of *Phalaridetum arundinaceae* (**Fig. 4**) have been developed on the raised banks of the riverbed, exposed only to occasional floods, after which the surface water stagnates for a short time. The diagnostic species of this association is *Phalaris arundinacea*, while the constant species are *Mentha aquatica*, *Lythrum salicaria*, *Sparganium erectum*, *Salix alba* and *Xanthium strumarium*. It is floristically rich and consists of 20 taxa (**Appendix 2**). This plant community occurs in habitats with pronounced fluctuations of the flood level. The development is conditioned by the hydrological regime of groundwater along the river course (Ranđelović & Zlatković, 2010). It is present in nutrient rich habitats, on sandy-gravelly to clay substrates. With its strong organic production, this community contributes to the overgrowth of ponds and shallow depressions (Panjković, 2005). Sometimes it occurs in deeper depressions where shallow (<0.3 m) surface water is retained during most of the growing season (Jenačković, 2017).

Phalarietum arundinaceae is only fragmentarily developed in several localities in southern Serbia. According to Ranđelović et al. (2007b), the best developed stands are along the Šaranica stream near the villages of Brestovac, Pukovac and Bubanj, in the valleys of the Vlasina River and Murina River. Also, stands of this association were recorded on seasonally flooded habitats near the villages of Gornje Međurovo, Levosoje, Podvis, Vrtište and Žitkovac (Jenačković et al., 2017).

Association *Polygono-Bidentetum tripartitae* consists of 24 taxa (**Appendix 3**). Its dominant species are *Polygonum lapathifolium* and *Bidens tripartitus* (**Appendix 3**). Since there are only three vegetation plots, a large number of constant species is noticeable, with a proportion of 16.67% of allochthonous species. This community develops on the banks of the river, where the water occasionally floods the banks, and retreats during the summer months. It is widespread in places along the banks of the Pusta River especially where wetland vegetation is absent. Also, this community was phytosociological described in Svrljiški Timok River and Beli Timok River, where it had a similar species composition (Jenačković et al., 2010). Similar floristic composition was recorded in nitrophilous stands developed on the shores of artificial lakes placed near the city of Tuzla (Barudanović & Kamberović, 2011).

Glycerio-Sparganietum neglecti is floristically rich association (33 taxa) (**Appendix 4**) and develops on the banks of the river, in the form of narrow belts, some of which extend into the riverbed, and some on slightly elevated banks (**Fig. 4**). Its diagnostic and, at the same time, dominant species is *Sparganium erectum*, while the constant species of association are *Lythrum salicaria* and *Bidens tripartitus*. Native species have the largest share in the composition of this phytocenosis, but invasive, non-native species such as *Echinocystis lobata*, *Echinochloa crus-galli*, *Amorpha fruticosa* and *Robinia pseudacacia* (Lazarević et al., 2012) were also recorded. A few years ago, in the part of the Pusta River which flow through the village of Pukovac and suffering strong anthropogenic influence via discharge of waste water, the stands of this association were phytocoenological described (Jenačković, 2017). Stands recorded in Svrljiški Timok River and Beli Timok River (Jenačković et al., 2010), whose the most common species are *Sparganium erectum* and *Mentha aquatica*, show a remarkable floristical similarity with the stands developed in the Pusta River. So far, communities with domination of *Sparganium erectum* have been recorded in the Batušinačke swamps (Ranđelović et al., 2007a), on suitable habitats near the village of Bubanj (Ranđelović, 1988), Žitkovac, Vrtište, Prokuplje, Gornje Međurovo, Podvis, Rgošte, Levosoje (Jenačković et al., 2019) and on the banks of Vlasina Lake (Ranđelović & Zlatković, 2010) and Smilovsko Lake (Jenačković et al., 2019). The stands of the association *Glycerio-Sparganietum neglecti* Koch 1926 are frequently involved in the establishment of the plant cover of lowland rivers, not only in our country, but also in the other European countries (Gecheva et al., 2013). The dominant species of this community – *Sparganium erectum*, is considered a reliable bioindicator of eutrophic waters (Schneider & Melzer, 2003), which explains the frequent occurrence of its monodominant communities in the lower reaches of the river, where high concentrations of nutrients, especially nitrogen, accumulate and are maintained as a result of anthropogenic influence. *Sparganium erectum* shows exceptional frequency in the studied rivers of Bulgaria, where it occurs in no less than 80 of 223 studied sites, with a frequency of 35% (Gecheva et al., 2013). The taxa *Sparganium erectum* and *Typha latifolia* show ecological preferences for wetlands with similar physicochemical properties. They find optimal growing conditions in habitats characterized by relatively deep, slightly acidic water with low electrical conductivity. They prefer habitats where the substrate has the following characteristics: low pH, low values of conductivity values and concentration of carbonates, bicarbonates and potassium (Jenačković, 2017).

On the area investigated, stands of *Phragmitetum australis* (**Fig. 4**) develops on the highest parts of the riverbanks, often along the road. They have been recorded in only 9 localities in the villages of Kočane and Pukovac. This community is floristically rich and consists of 24 taxa (**Appendix 5**), and its highly diagnostic species is *Phragmites communis* (**Tab. 1**). In addition to the species *Phragmites communis*, high values of phi-coefficient were established for the species *Urtica dioica*, *Echinocystis lobata* and *Robinia pseudoacacia*. These values probably reflect reduced substrate moisture and increased concentrations of nutrients, primarily nitrogen. Abundant presence of individuals of *Echinocystis lobata* and *Robinia pseudacacia* can be explained by their high invasive capacity (Lazarević et al., 2012). Often, in nature, stands of *Phragmitetum australis* are bordered to the stands of *Typhetum latifoliae*. They usually prefer mineral sand, mineral-organic, as well as organic substrate (Pełechaty, 1999). In terms of water depth and degree of soil moisture, they successfully develop on diverse habitat types - completely flooded, occasionally flooded and non-flooded. According to Jenačković (2017), dominant species of association *Phragmitetum* *australis* shows affinities to the habitats with high values of substrate pH. Stands of *Phragmitetum australis* are widespread in the central Balkans. In Serbia, they have been recorded in the Velika Morava River (Jovanović, 1958; Veljović, 1967), on the slopes of Stara Planina (Mišić et al., 1987), in the South Morava basin (Ranđelović, 1988), in the Toplica River (Perišić et al., 2003), on the shores of Vlasina Lake (Ranđelović & Zlatković, 2010), Smilovsko Lake, Oblačina Lake, near the villages of Žitkovac, Lalinac, Vrtište, Rgošte and Levosoje, on habitats placed in suburb of the city of Bela Palanka (Jenačković et al., 2019). Otherwise, the communities *Phragmitetum australis*, *Typhetum latifoliae* and *Glycerio-Sparganietum neglecti* belong to the phytocenoses that most frequently overgrow the wetland habitats of the central Balkans (Jenačković, 2017).

The stands of the *Myriophyllo-Potametum* develop in the riverbed itself and form a relatively stable submerged community, consisting mainly of rooted hydrophytes (*Myriophyllum spicatum* and *Potamogeton crispus*) and floating hydrophytes (*Lemna minor*). The association develops on a muddy waterbed at depths of up to 2 m, forming a dense cover. In some parts of the Pusta River, the stands of this association form small, separated groups which look like islands composed of plants, while in other parts of the stream they cover the entire water surface from one bank to the another. They prefer slow to moderately slow water flow, but they also tolerate strong water strikes, and are indicators of mesotrophic and eutrophic waters. The association is floristically poor and consists of 3 taxa (**Appendix 6**). *Myriophyllum spicatum* is the highly diagnostic species (**Tab. 1**), while the status of constant species have *Potamogeton nodosus* and *Potamogeton crispus* (**Appendix 6**). Study conducted on the aquatic vegetation of rivers in Slovenia (Germ et al., 2021) have shown that *Myriophyllum spicatum* and *Potamogeton nodosus* are the most common aquatic species in undisturbed aquatic ecosystems, while investigation of Slovakian rivers have confirmed that the highest relative mass in rivers has *Myriophyllum spicatum* (Hrivnak et al., 2006). The species *Myriophyllum spicatum*, *Potamogeton crispus* and *Lemna minor* have taken part in composing aquatic vegetation of the Svrljiški and Beli Timok rivers (Jenačković et al., 2010), river systems and channels in the northern part of Serbia (Radulović et al., 2010; Vukov et al., 2012; Džigurski et al., 2016; Vukov et al., 2017) as well. Otherwise, *Myriophyllum spicatum* and *Potamogeton nodosus* are indicators of eutrophic waters (Schneider & Melzer, 2003), which explains their occurrence in the lower parts of the river, where high nutrient concentrations accumulate and remain.

Potametum nodosi develops in the riverbed itself, mainly along the coast, and partly invades coastal vegetation where water flow is slower. In deeper parts of the riverbed, however, the community borders with *Myriophyllo-Potametum*. The highly diagnostic species of this community is *Potamogeton nodosus* (**Tab. 1**), and the constant species is *Myriophyllum spicatum* (**Appendix 7**). The community is relatively species-poor and is composed of only 4 taxa (**Appendix 7**). A similar floristic composition have had stands developed in the Svrljiški and Beli Timok rivers (Jenačković et al., 2010). Floristically, this community is also described in the Moravica River, highlighting rare and endangered species (Ljevnaić-Mašić et al., 2016). The stands noted in the Danube-Tisa-Danube Canal in Vojvodina, in the northern part of Serbia, have had a slightly richer floristic composition compared to the stands recorded in Pusta River (Džigurski et al., 2016).

It is known that both, wetlands and aquatic vegetation, have developed over the years on the once disturbed river. Since the vegetation along the entire course of the river has never been described completely so far, but only sporadically, we do not have the possibility to compare the data. What is certain is that this area has been disturbed several times and has changed due to the needs of agriculture. Nowadays, the river is surrounded on all sides by fields and arable land, and thus exposed to constant anthropogenic influences.

The previously described associations belong to the following vegetation classes, orders and alliances:

Potamogetonetea Klika in Klika et Novák 1941
Potamogetonetalia Koch 1926
Potamogetonion Libbert 1931
Myriophyllo-Potametum Soó 1934
Potametum nodosi Soó (1928) 1960, Segal 1964
Phragmito-Magnocaricetea Klika in Klika et Novák 1941
Pragmitetalia communis Koch 1926
Phragmition communis Koch 1926
Phragmitetum australis Savič 1926
Typhetum latifoliae Nowiński 1930
Glycerio-Sparganietum neglecti Koch 1926
Phalaridetum arundinaceae Libbert 1931
Bidentetea Tx. Et al. ex von Rochow 1951
Bidentetalia Br.-Bl. et Tx. Ex Klika et Hadač 1944
Bidention tripartitae Nordhagen ex Klika et Hadač 1944
Polygono-Bidentetum tripartitae (W. Koch 1926) Lohm. 1950

Conclusions

Based on the results of the classification analyses and composition of diagnostic species per clusters, 7 associations - *Typhetum latifoliae* Nowiński 1930, *Phalaridetum arundinaceae* Libbert 1931, *Polygono-Bidentetum tripartitae* (W. Koch 1926) Lohm. 1950, *Glycerio-Sparganietum neglecti* Koch 1926, *Phragmitetum australis* Savič 1926, *Potametum nodosi* Soó (1928) 1960, Segal 1964 and *Myriophyllo-Potametum* Soó 1934, are described on the territory researched. The stands of *Typhetum latifoliae* Nowiński 1930 are abundantly developed in the part of the flow from the confluence of the Pusta River to South Morava River all the way upstream to the village of Pukovac, where they are the most developed and occupies the largest recorded area on the Pusta River. The stands of *Glycerio-Sparganietum neglecti* Koch 1926 were developed in some places along the whole studied part of the river, and they were mainly developed 2-3 km upstream from the village of Pukovac. The stands of *Phalaridetum arundinaceae* Libbert 1931, *Polygono-Bidentetum tripartitae* (W. Koch 1926) Lohm. 1950, *Phragmitetum australis* Savič 1926, diverse in size, occur sporadically. In the village of Pukovac and a few kilometers upstream, the aquatic vegetation is more abundantly developed and in some places forms a dense cover that covers the entire water surface. This is one of the first complete research of this kind conducted on the Pusta River, and it represents a good basis for future research on the vegetation of lotic ecosystems in Southern Serbia.

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Appendices

Appendix 1. Phytocoenological table of *Typhetum latifoliae* Nowiński 1930. Ic - coverage index according to Lausi et al. (1982); $D_{\%}$ - share in total coverage according to Surina (2005); $S_{\%}$ - species percentage frequency within the cluster

Number of relevés	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**Ic**	**$D_{\%}$**	**$S_{\%}$**
Locality	Kočane																					Pukovac									Bojnik				
Recording date	08 Sep												12 Sep									16 Sep									25 Sept				
Elevation (m)	195																					200									251				
Latitude	43.1136	43.1141	43.1143	43.1149	43.115	43.1152	43.1131	43.113	43.1126	43.1126	43.1894	43.189	43.1885	43.1884	43.1879	43.1877	43.1871	43.1862	43.1855	43.1842	43.1668	43.1673	43.1681	43.1673	43.1662	43.1657	43.1653	43.1639	43.1629	43.1621	43.1611	43.0129			
Longitude	21.5029	21.5028	21.503	21.5034	21.5035	21.5035	21.503	21.5031	21.5034	21.5034	21.8434	21.8437	21.8435	21.8437	21.8436	21.844	21.8444	21.8447	21.845	21.8461	21.8559	21.8556	21.8555	21.8554	21.857	21.858	21.8587	21.8618	21.8618	21.8618	21.8627	21.7245			
Typha latifolia	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	99.3	52	100
Lythrum salicaria	+	+	+	+	+	+	+	+	+	.	.	+	+	+	.	1	.	.	.	r	.	r	r	.	r	r	r	.	r	.	.	.	11.8	6.2	62.5
Salix alba	+	.	r	+	+	.	+	+	+	+	.	.	.	.	+	.	+	.	+	+	.	+	.	1	.	1	.	.	.	+	.	.	11.5	6	50
Bidens tripartitus	.	1	.	r	+	.	.	+	+	+	.	r	+	.	.	.	.	.	r	.	.	r	.	r	.	r	.	.	r	.	r	+	8	4.2	46.9
Salix euxina	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	1	+	+	1	+	.	.	+	+	7.6	4	31.2
Polygonum lapathifolium	.	1	.	.	+	+	.	.	.	.	+	r	+	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.	r	.	5.2	2.7	28.1
Xanthium strumarium	.	.	.	.	+	.	.	.	.	+	1	.	r	.	+	.	.	.	r	.	.	r	.	r	.	.	.	.	.	.	+	.	5.2	2.7	28.1
Polygonum mite	.	+	.	.	+	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	r	.	3.8	2	21.9
Sparganium erectum	.	.	.	+	+	+	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3.8	2	15.6
Urtica dioica	.	.	.	.	.	+	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.	r	r	r	.	.	+	3.5	1.8	25
Calystegia sepium	.	+	.	.	.	r	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	r	.	.	.	.	r	.	.	.	.	.	3.1	1.6	18.9
Mentha aquatica	.	.	r	r	.	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.8	1.5	15.6
Populus sp.	.	.	.	.	.	.	+	r	.	+	.	.	.	.	r	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.8	1.5	15.6

Number of relevés	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**Ic**	**D%**	**S%**
Leersia oryzoides	.	+	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	2.4	1.3	12.5
Solanum dulcamara	.	+	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	2.4	1.3	12.5
Potamogeton nodosus	+	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	r	.	.	.	.	2.1	1.1	15.6
Epilobium hirsutum	.	.	+	.	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	2.1	1.1	12.5
Amorpha fruticosa	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	1.7	0.9	9.4
Humulus lupulus	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	r	.	1.4	0.7	9.4
Phalaris arundinacea	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.4	0.7	6.3
Lycopus europaeus	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	1	0.5	9.4
Stachys palustris	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	0.5	3.1
Robinia pseudoacacia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	.	1	0.5	6.3
Rumex conglomeratus	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.7	0.4	3.1
Lysimachia vulgaris	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.7	0.4	3.1
Tanacetum vulgare	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.7	0.4	3.1
Myriophyllum spicatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.	.	0.7	0.4	6.3
Rubus caesius	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	0.7	0.4	6.3
Galium aparine	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	0.7	0.4	6.3
Althaea officinalis	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.3	0.2	3.1
Potamogeton crispus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	0.3	0.2	3.1
Echinochloa crus-galli	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	0.3	0.2	3.1

Number of relevés	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	Ic	$D_{\%}$	$S_{\%}$
Lemna minor	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	0.3	0.2	3.1
Echinocystis lobata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	0.3	0.2	3.1

Appendix 2. Phytocoenological table of *Phalaridetum arundinaceae* Libbert 1931. Ic - coverage index according to Lausi et al. (1982); $D_{\%}$ - share in total coverage according to Surina (2005); $S_{\%}$ - species percentage frequency within the cluster

Number of relevés	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Ic**	**D%**	**S%**
Locality	Kočane							Kosančić			
Recording date	8 Sep				12 Sep			25 Sep			
Elevation (m)	194	194	194	195	195	195	195	222			
Latitude	43.1143	43.1153	43.113	43.1124	43.1893	43.1885	43.1874	43.0788			
Longitude	21.503	21.5035	21.5031	21.5035	21.8435	21.8437	21.8443	21.7864			
Phalaris arundinacea	5	5	5	5	5	5	4	5	99	41	100
Mentha aquatica	r	+	+	1	+	.	2	.	21	8.6	75
Lythrum salicaria	r	+	+	+	+	.	+	.	15	6.3	75
Sparganium erectum	+	+	+	+	.	1	.	.	15	6.3	63
Salix alba	+	+	+	+	.	.	.	+	14	5.7	63
Xanthium strumarium	.	.	+	+	+	.	+	.	11	4.6	50
Populus sp.	+	r	.	.	1	.	.	.	8.3	3.4	38
Leersia oryzoides	+	.	+	+	.	.	.	.	8.3	3.4	38
Typha latifolia	+	.	.	.	+	.	+	.	8.3	3.4	38
Urtica dioica	r	.	+	.	r	.	.	.	8.3	3.4	38
Epilobium hirsutum	r	.	.	.	+	.	.	.	4.2	1.7	25
Polygonum mite	+	.	.	.	r	.	.	.	4.2	1.7	25
Calystegia sepium	.	.	+	.	.	r	.	.	4.2	1.7	25
Tanacetum vulgare	.	.	1	.	.	.	.	.	4.2	1.7	13
Bidens tripartitus	.	.	.	.	.	.	r	+	4.2	1.7	25
Salix euxina	+	.	.	.	.	.	.	.	2.8	1.1	13
Amorpha fruticosa	.	+	.	.	.	.	.	.	2.8	1.1	13
Lycopus europaeus	.	.	.	.	+	.	.	.	2.8	1.1	13
Polygonum lapathifolium	.	.	.	.	+	.	.	.	2.8	1.1	13
Myriophyllum spicatum	.	.	.	.	.	.	.	+	2.8	1.1	13

Appendix 3. Phytocoenological table of *Polygono-Bidentetum tripartitae* (W. Koch 1926) Lohm. 1950. Ic - coverage index according to Lausi et al. (1982); $D_{\%}$ - share in total coverage according to Surina (2005); $S_{\%}$ - species percentage frequency within the cluster

Number of relevés	**1**	**2**	**3**	**Ic**	**$D_{\%}$**	**$S_{\%}$**
Locality	Kočane					
Recording date	08 Sep					
Elevation (m)	195					
Latitude	43.1141	43.1143	43.1129			
Longitude	21.5028	21.503	21.5031			
Polygonum lapathifolium	4	5	4	93	23	100
Bidens tripartitus	1	1	4	52	13	100
Polygonum mite	2	+	+	33	8.4	100
Lythrum salicaria	1	+	.	19	4.7	67
Xanthium strumarium	+	1	.	19	4.7	67
Leersia oryzoides	.	2	.	19	4.7	33
Sparganium erectum	+	+	.	15	3.7	67
Calystegia sepium	+	+		15	3.7	67
Echinochloa crus-galli	r	+	.	11	2.8	67
Erigeron canadensis	.	r	+	11	2.8	67
Tanacetum vulgare	.	r	+	11	2.8	67
Lysimachia vulgaris	1	.	.	11	2.8	33
Mentha aquatica	+	.	.	7.4	1.9	33
Lycopus europaeus	+	.	.	7.4	1.9	33
Aristolochia clematitis	+	.	.	7.4	1.9	33
Urtica dioica	+	.	.	7.4	1.9	33
Phalaris arundinacea	+	.	.	7.4	1.9	33
Solanum dulcamara	+	.	.	7.4	1.9	33
Rubus caesius	+	.	.	7.4	1.9	33
Amorpha fruticosa	.	+	.	7.4	1.9	33
Salix euxina	.	+	.	7.4	1.9	33
Chenopodium album	.	+	.	7.4	1.9	33
Robinia pseudoacacia	.	.	+	7.4	1.9	33
Rumex conglomeratus	.	.	+	7.4	1.9	33

Appendix 4. Phytocoenological table of *Glycerio-Sparganietum neglecti* Koch 1926. Ic - coverage index according to Lausi et al. (1982); $D_{\%}$ - share in total coverage according to Surina (2005); $S_{\%}$ - species percentage frequency within the cluster

Number of relevés	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Ic	$D_{\%}$	$S_{\%}$
Locality	Kočane															Pukovac													Donje Brijanje		Bojnik			
Recording date	08 Sep								12 Sep							16 Sep													25 Sep					
Elevation (m)	195											196				200													218		251			
Latitude	43.11356	43.11404	43.11429	43.11311	43.11255	43.11239	43.11222	43.18922	43.18825	43.18822	43.18779	43.18643	43.18616	43.18478	43.16677	43.16702	43.16714	43.16611	43.16495	43.16474	43.16388	43.16378	43.16343	43.16296	43.16218	43.16152	43.16073	43.16055	43.09847	43.0984	43.01257			
Longitude	21.50288	21.50282	21.50307	21.50306	21.50336	21.5034	21.50352	21.84363	21.84367	21.84347	21.84394	21.84498	21.84496	21.84558	21.85568	21.85548	21.85567	21.85677	21.86029	21.86074	21.86166	21.86159	21.86172	21.86183	21.86182	21.8619	21.8626	21.86237	21.81782	21.81832	21.72439			
Sparganium erectum	5	5	5	5	5	5	5	5	5	5	5	5	4	5	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	98.6	48.8	100
Lythrum salicaria	1	1	+	+	+	+	+	+	.	1	+	r	+	+	2	+	r	+	.	r	.	+	r	+	r	r	.	r	.	.	.	16.8	8.3	77.4
Polygonum mite	.	+	+	1	.	.	.	.	.	.	.	.	.	+	.	.	+	.	r	.	.	.	+	.	.	r	.	.	+	4	+	9.7	4.8	35.5
Bidens tripartitus	.	+	r	.	+	+	.	.	.	.	.	.	.	+	.	.	+	.	+	r	r	.	+	r	r	.	.	.	+	+	+	9	4.4	48.4
Polygonum lapathifolium	.	1	+	+	.	.	+	.	.	.	.	.	.	+	.	.	1	.	r	r	.	.	+	.	.	.	.	.	+	.	1	8.2	4.1	35.5
Mentha aquatica	.	+	.	+	1	.	.	.	+	+	.	+	+	.	r	r	.	r	.	.	r	.	.	.	.	r	.	.	.	.	.	7.2	3.6	38.7
Salix alba	.	.	+	r	+	.	+	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	5.7	2.8	25.8
Potamogeton nodosus	.	.	.	.	.	+	r	+	.	.	.	+	r	.	.	.	.	r	r	r	r	.	.	.	r	.	r	r	.	.	.	5.4	2.7	38.7
Salix euxina	.	r	.	.	.	.	.	.	.	.	.	.	1	.	.	+	.	.	.	.	r	.	.	.	.	+	.	.	+	+	.	4.7	2.3	22.6
Xanthium strumarium	.	.	.	.	.	r	.	.	+	.	.	.	.	+	.	.	r	.	r	.	.	.	.	r	.	r	.	.	.	r	+	4.3	2.1	29

Number of relevés	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Ic	$D_{\%}$	$S_{\%}$
Lycopus europaeus	.	+	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	r	r	.	.	.	.	.	.	r	.	r	.	r	.	2.9	1.4	22.6
Phalaris arundinacea	1	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.5	1.2	9.7
Typha latifolia	+	.	.	+	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.5	1.2	9.7
Urtica dioica	.	.	.	r	.	.	.	r	.	.	.	.	r	.	r	.	.	r	.	.	.	.	.	.	.	r	.	.	.	.	r	2.5	1.2	22.6
Myriophyllum spicatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	r	.	.	r	r	.	r	r	.	.	.	2.5	1.2	22.6
Tanacetum vulgare	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	r	.	.	r	.	r	.	.	.	2.2	1.1	16.1
Calystegia sepium	.	.	.	.	.	.	.	.	.	.	.	r	.	.	r	.	.	r	.	.	.	.	.	.	.	r	.	.	.	r	r	2.2	1.1	19.4
Robinia pseudoacacia	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	+	.	.	.	1.8	0.9	9.7
Solanum dulcamara	.	r	.	.	.	.	.	.	.	.	.	.	.	.	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.4	0.7	9.7
Amorpha fruticosa	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.4	0.7	6.5
Leersia oryzoides	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.	.	.	.	.	1.4	0.7	9.7
Galium aparine	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	r	.	.	.	.	r	.	.	r	.	.	.	.	.	1.4	0.7	12.9
Rubus caesius	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	r	.	r	.	.	.	.	.	.	.	.	.	1.4	0.7	12.9
Epilobium hirsutum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	.	.	r	.	.	.	.	.	1.1	0.5	9.7
Lemna minor	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	r	.	.	.	.	.	r	.	1.1	0.5	9.7
Echinochloa crus-galli	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	0.7	0.4	6.5
Potamogeton crispus	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.7	0.4	3.2
Scutellaria galericulata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	.	.	.	.	.	.	0.7	0.4	6.5
Scrophularia nodosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	0.4	0.2	3.2

Number of relevés	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**Ic**	**D%**	**S%**
Berula erecta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	0.4	0.2	3.2
Stellaria neglecta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	0.4	0.2	3.2
Echinocystis lobata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	0.4	0.2	3.2
Eleocharis palustris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	0.4	0.2	3.2

Appendix 5. Phytocoenological table of *Phragmitetum australis* Savič 1926. Ic - coverage index according to Lausi et al. (1982); $D_{\%}$ - share in total coverage according to Surina (2005); $S_{\%}$ - species percentage frequency within the cluster

Number of relevés	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Ic**	**$D_{\%}$**	**$S_{\%}$**
Locality	Kočane					Pukovac						
Recording date	08 Sep	12 Sep				16 Sep						
Elevation (m)	195				200							
Latitude	43.1127	43.188	43.1853	43.1848	43.1645	43.1636	43.1635	43.1631	43.163			
Longitude	21.5033	21.8438	21.8453	21.8455	21.8612	21.8616	21.8617	21.8618	21.8621			
Phragmites communis	5	5	5	5	5	5	5	5	5	100	56	100
Bidens tripartitus	+	.	.	.	+	r	r	r	.	9	5	56
Urtica dioica	r	.	r	.	+	r	r	.	.	7	4	56
Salix.euxina	.	.	.	.	+	+	+	.	.	7	4	33
Robinia pseudoacacia	.	r	+	.	.	.	.	.	+	6	4	33
Salix alba	+	+	.	.	.	.	.	.	.	5	3	22
Echinocystis lobata	.	.	.	.	+	.	.	r	r	5	3	33
Typha latifolia	1	.	.	.	.	.	.	.	.	4	2	11
Lythrum salicaria	+	.	.	.	.	r	.	.	.	4	2	22
Polygonum lapathifolium	+	.	.	.	.	.	.	r	.	4	2	22
Sparganium erectum	.	.	.	r	+	.	.	.	.	4	2	22
Humulus lupulus	+	.	.	.	.	.	.	.	.	3	1	11
Mentha aquatica	+	.	.	.	.	.	.	.	.	3	1	11
Polygonum mite	.	.	.	.	+	.	.	.	.	3	1	11
Epilobium hirsutum	.	.	.	.	+	.	.	.	.	3	1	11
Galium aparine	.	.	.	.	+	.	.	.	.	3	1	11
Rubus caesius	.	.	.	.	.	r	r	.	.	3	1	22
Lycopus europaeus	.	.	.	.	.	r	r	.	.	3	1	22
Populus sp.	.	r	.	.	.	.	.	.	.	1	1	11
Potamogeton nodosus	.	.	.	r	.	.	.	.	.	1	1	11
Erigeron canadensis	.	.	.	.	.	r	.	.	.	1	1	11
Tanacetum vulgare	.	.	.	.	.	r	.	.	.	1	1	11
Xanthium strumarium	.	.	.	.	.	.	r	.	.	1	1	11

Appendix 6. Phytocoenological table of *Myriophyllo-Potametum* Soó 1934. Ic - coverage index according to Lausi et al. (1982); $D_{\%}$ - share in total coverage according to Surina (2005); $S_{\%}$ - species percentage frequency within the cluster

Number of relevés	**1**	**2**	**3**	**4**	**5**	**Ic**	**$D_{\%}$**	**$S_{\%}$**
Locality	Kočane	Pukovac						
Recording date	08 Sep	16 Sep						
Elevation (m)	195	200						
Latitude	43.1146	43.1645	43.164	43.1623	43.1668			
Longitude	21.5032	21.8612	21.8616	21.8617	21.8558			
Myriophyllum spicatum	5	5	4	5	5	98	69	100
Potamogeton crispus	1	.	.	.	4	24	17	40
Potamogeton nodosus	+	.	2	+	.	20	14	60

Appendix 7. Phytocoenological table of *Potametum nodosi* Soó (1928) 1960, Segal 1964. Ic - coverage index according to Lausi et al. (1982); $D_{\%}$ - share in total coverage according to Surina (2005); $S_{\%}$ - species percentage frequency within the cluster

Number of relevés	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Ic**	**$D_{\%}$**	**$S_{\%}$**
Locality	Pukovac										
Recording date	16 Sep										
Elevation (m)	200										
Latitude	43.1668	43.1663	43.1653	43.1649	43.1647	43.1617	43.1608	43.1606			
Longitude	21.8558	21.8567	21.8591	21.8598	21.8609	21.8622	21.8626	21.8627			
Potamogeton nodosus	5	5	5	4	4	5	5	5	97	63	100
Myriophyllum spicatum	.	4	1	+	1	1	2	4	44	29	87.5
Sparganium erectum	.	.	.	3	.	.	.	.	10	6	12.5
Lemna minor	.	.	.	.	+	.	.	.	3	2	12.5