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Ecological characteristics and distribution of *Potamogeton* species in the rivers of Pannonian ecoregion of Croatia

Master thesis

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Ekološke karakteristike i rasprostranjenost roda *Potamogeton* u rijekama panonske ekoregije Hrvatske

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Ovaj rad donosi uvid u rasprostranjenost i ekološke karakteristike mrijesnjaka (*Potamogeton* L.) u rijekama Panonske eko-regije Hrvatske. Podaci o rasprostranjenosti vrsta i njihovoj brojnosti, te fizikalno-kemijski parametri vode prikupljeni su na 166 postaja u razdoblju 2016.-2020. Podaci korišteni u radu su dijelom obrađeni u programskom jeziku R, dijelom u QGIS-u te u programima Canoco 5 i Juice 7. U radu su se koristile statističke multivarijantne metode: CCA, DCA, GAM i TWINSPAN. Fizikalno-kemijski parametri vode vezani za nalazišta vrsta mrijesnjaka pokazuju visoke razine trofije. Od devet vrsta koje se spominju u radu, 3 vrste su pokazale najveću pojavnost, ali i toleranciju na eutrofne uvjete. To su *P. nodosus*, vrsta koja je bila zastupljena u svim vrstama vodnih tijela s najvećom pojavnošću, te *P. crispus* i *P. pectinatus*. Ove vrste mogu poslužiti kao bioindikatori eutrofne vode. Druge vrste su pokazale manju pojavnost, ali i manju toleranciju na eutrofikaciju. Najosjetljivijom na eutrofikaciju se pokazala vrsta *P. lucens* koja može poslužiti i kao indikator bolje kvalitete vode.

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Ecological characteristics and distribution of *Potamogeton* species in the rivers of Pannonian ecoregion of Croatia

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This thesis gives an insight of ecological characteristics of pondweeds (*Potamogeton* L.) in the rivers in the Pannonian ecoregion of Croatia. Data on distribution of species and their abundances were collected on 166 sample sites in the period 2016-2020, as well as physicochemical parameters of water. The data used in the paper was processed partly in the R programming language, partly in QGIS and in the Canoco 5 and Juice 7 programs. Statistical multivariate methods were used in the paper: CCA, DCA, GAM and TWINSPAN. Physicochemical parameters of water related to pondweed species sites show high levels of trophy. Of the nine species mentioned in the paper, 3 species showed the highest incidence but also tolerance to eutrophic conditions. These are *P. nodosus*, the species that was present in all species of water bodies with the highest incidence, and *P. crispus* and *P. pectinatus*. These species can serve as bioindicators of eutrophicated water. Other species showed lower incidence, but also lower tolerance to eutrophication. The species *P. lucens* proved to be the most sensitive to eutrophication, which can also serve as an indicator of better water quality.

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Keywords: Pondweed, Statistical analysis, Sava-Drava interfluve, Rstudio, PCA, CCA, GAM

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Abbreviations

CCA – Canonical correlations analyses

CA – Correspondence analysis

DCA – Detrended correspondence analysis

DEM – Digital elevation model

GAM – Generalised additive model

TWINSPAN – Two-way indicator species analysis

1. Introduction

1.1. Water and aquatic plants

The Earth is called a blue planet because 70% of its surface consists of water. Yet not all of it is drinking water. Freshwater, the Earth's most precious resource, makes less than 3% of all the water on Earth, where more than 90% goes to ice glaciers and groundwater. Rivers and lakes contribute with less than 0.016% with a total of 225,000 km^3 of water (O'Sullivan and Reynolds, 2007).

Surface waters, especially rivers and marshlands, are important ecosystems. These water-rich areas are home to many species of plants. Some plants can grow in water, but not all year round. Others spend their entire lifecycle in water and are called macrophytes or hydrophytes. These plants form aquatic vegetation that has an important role in the ecosystem (Marion and Paillisson, 2003; Silva *et al.*, 2008). They can be found on riverbanks, lake margins, in small rivers, ponds, streams and marshes, as well as in coastal ecosystems, like mangroves. The roles of macrophytes are numerous; they provide shelter and food, form habitat and change the environment they live in.

1.2. Macrophytes

Except for contributing to the taxonomic diversity, aquatic vegetation is essential for the functional diversity or the number of new functions and niches in an ecosystem it offers. Macrophytes come in a great variety of forms, and one of the most accepted and most widely used classifications of main life-forms distinguishes four groups based on their relation to the water surface (Mitchell, 1974):

1. Free-floating plants
2. Submerged plants
3. Rooted plants with floating leaves
4. Emergent plants with leaves normally emerging out of waters

The adaptations of macrophytes to life in water are morphological, anatomical, physiological and ecological. Adjustments are different: stomata on the upper side of the floating leaves, shallow root system, long stems, leaves adapted to float on the surface, excretion of large amounts of water by gutting through stomata, adapted flowering cycle, etc. (Pevalek-Kozlina, 2003).

1.3. The chemistry behind the abundance

Macrophytes influence water quality and *vice versa*. Their production releases nutrients which affect the metabolism and trophy of the water bodies, while water has the minerals essential for macrophytes (Marion and Paillisson, 2003). Water quality influences the composition, distribution and dynamics of aquatic vegetation. Macrophytes, as well as other organisms, are involved in nutrient cycles and affect their composition and concentration (Duarte, 1995). Nutrients which are dissolved in the surface waters have their biogeochemical cycles and their concentrations vary among different seasons as well as different types of water bodies. The most influential elements of aquatic ecosystems are the biogenic ones, i.e., hydrogen, oxygen, carbon, phosphorus, nitrogen, and sulphur. They build compounds that are fuel for the productivity of aquatic ecosystems. Regarding the productivity or trophy level, aquatic habitats can be classified from oligotrophic to eutrophic (Vollenweider and Kerekes, 1982). Eutrophication is a term that implies water enrichment with nutrients, mostly phosphorus and nitrogen. This leads to intensified growth of photosynthetic organisms and can result in algal blooms, extensive mats of floating macrophyte species and submerged macrophyte agglomerations. Moreover, decaying plant material causes depletion of oxygen, sometimes enhancing secondary problems such as increased fish mortality (Vollenweider, 1989).

Human activity has a heavy impact on eutrophication. Development of industry, agriculture, traffic and economy, as well as urbanisation leave a significant footprint in the water environment; shaping the water vegetation, directly or indirectly (Mitchell, 1974). On that account, aquatic vegetation is an indicator of water quality. Namely, plant species sensitive to water pollution and eutrophication die out from polluted water bodies so that their absence or low abundance can indicate poor water quality, while their presence, especially in greater abundance indicates a good water quality (O’Sullivan and Reynolds, 2007).

1.4. *Potamogeton* L.

The genus *Potamogeton* L. (pondweeds) is cosmopolitan and includes about 90 species, of which 18 come in Croatia. The name *Potamogeton* comes from old greek *Potamos* = river, and *geton* = close (Cirujano *et al.*, 2014). They are submerged or floating macrophytes, i.e., plants that grow in the beds of mostly shallow streams and rivers and in standing waters (Preston, 1995). They form an important component of aquatic vegetation, and form also several specific communities included in the vegetation class *Potamogetonetea* Klika in Klika et Novák 1941 (Mucina *et al.*, 2016). Due to the specific ecological requirements, species of this genus can serve as indicators of the ecological status of the waters in which they grow (Olodorff, Krautkrämer and Kirschey, 2017). They are important as a source of food in ecosystems, especially for waterfowl (Preston, 1995). As their distribution in Croatia is poorly known, this thesis will investigate the distribution and ecology of *Potamogeton* species in the Pannonian ecoregion of Croatia and analyse their indicator potentials based on recent field data.

The description of the main ecological requirements of the nine species (Preston, 1995) which will be analysed is given below.

Potamogeton berchtoldii Fieber is found in still or slow-moving water in a great variety of habitats. On the other hand, it is absent from the most oligotrophic habitats. It has submerged leaves that are very long, linear, narrow, straight, and apiculate. Floating leaves are absent (Figure 1).

Potamogeton crispus L. is found in a great variety of habitats but is confined to eutrophic and meso-eutrophic waters. It has long, narrow submerged leaves with undulate and serrate margins (Figure 1).

Potamogeton lucens L. is a lowland species that prefers deep and calcareous waters. It grows in lakes, sluggish rivers, canals and drains. Submerged leaves are elliptical, long and wide, while floating leaves are absent (Figure 1).

Potamogeton natans L. is the most tolerant *Potamogeton* species, it can grow from fast-moving streams to deep lakes and from oligotrophic to eutrophic habitats. It can grow in depths up to 6 m in clean waters. Leaves are elliptical, longer than wide, olive green or slightly brownish when mature (Figure 2).

Potamogeton nodosus Poir. is found in a great variety of habitats, mostly in slow and moderately moving water. It has long elliptical leaves, wider than in other *Potamogeton* species, and more or less apiculate. Submerged leaves are longer than floating leaves (Figure 2).

Potamogeton pectinatus L. is found in eutrophic and brackish waters and in a wide range of habitats. It is known to be more tolerant to pollution than other *Potamogeton* species. Submerged leaves can be very long, linear to filiform. Floating leaves are absent (Figure 2).

Potamogeton perfoliatus L. is a species of wide ecological tolerance, inhabiting oligotrophic to eutrophic lakes, canals, rivers and reservoirs. Usually grows in over 1 m deep water but can be found in shallower water as well. Submerged leaves are narrowly lanceolate to broadly ovate. Floating leaves are absent (Figure 3).

Potamogeton pusillus L. has similar ecological requirements as *P. berchtoldii* but has slightly more tolerance to brackish waters and may be more frequent in eutrophic waters. Submerged leaves are thin, long and linear. Floating leaves are absent (Figure 3).

Potamogeton trichoides Cham. & Schltdl. is found in a wide range of habitats, it often behaves like pioneer species. It is tolerant of and may even favour eutrophic waters. Submerged leaves are long, narrow and linear ending with an acuminate apex. Floating leaves are absent (Figure 3).

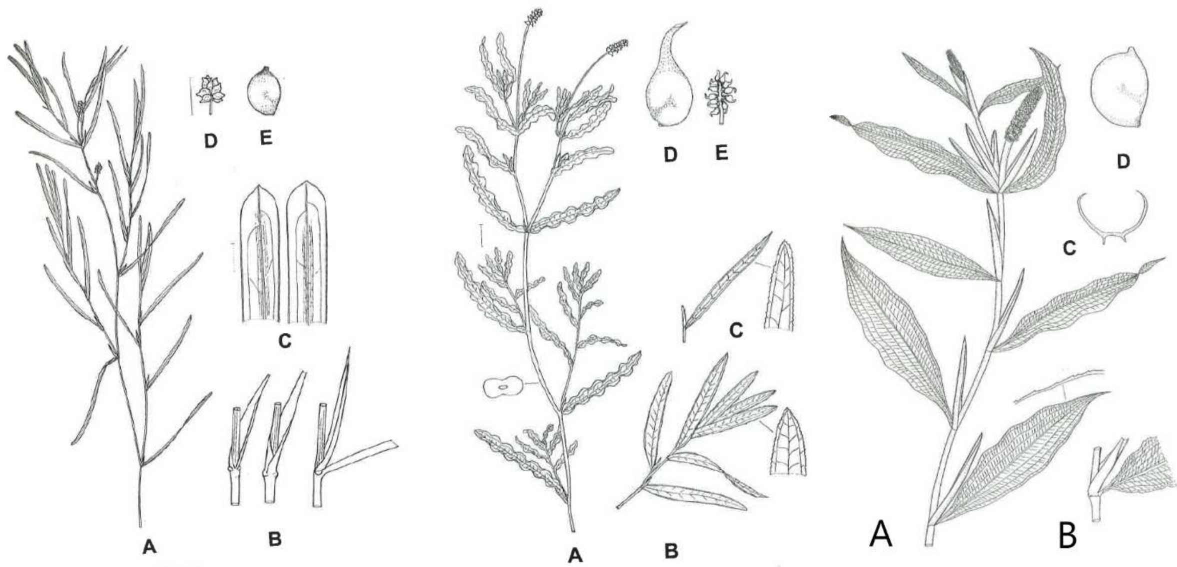

Figure 1. From left to right – *P. berchtoldii*, *P. crispus* and *P. lucens* (Weyer *et al.*, 2018)

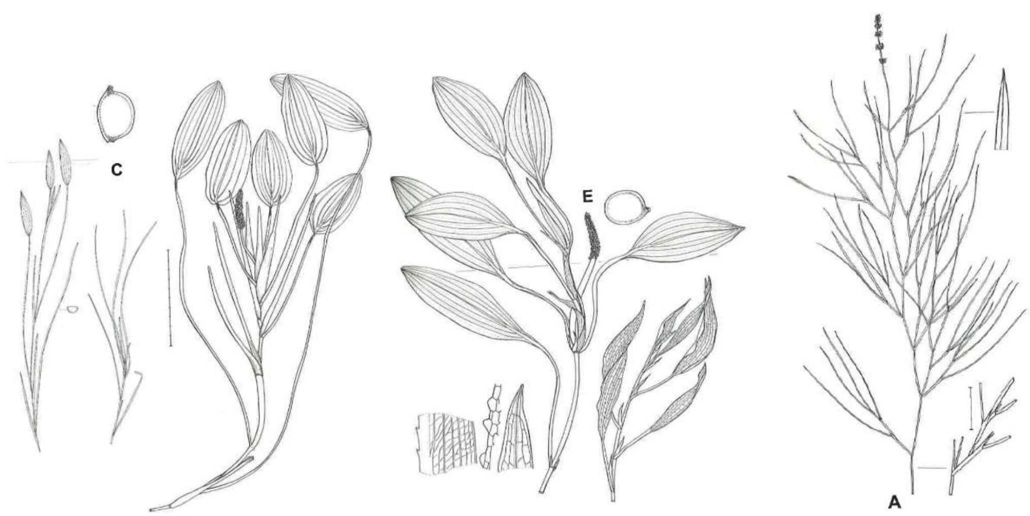

Figure 2. From left to right – *P. natans*, *P. nodosus* and *P. pectinatus* (Weyer *et al.*, 2018)

Figure 3. From left to right – *P. perfoliatus*, *P. pusillus* and *P. trichoides* (Weyer *et al.*, 2018)

2. Goals of the thesis

The main aims of this thesis are:

- to analyse the distribution of species of the genus *Potamogeton* in the Pannonian ecoregion of Croatia
- to analyse the species composition of communities in which species of the genus *Potamogeton* occur
- to analyse the water physicochemical parameters in the habitats of species of the genus *Potamogeton*
- to analyse the dependence of the occurrence and abundance of the species from the genus *Potamogeton* on environmental parameters
- to determine possible indicator potentials of certain species from the genus *Potamogeton*

3. Studied area

3.1. Pannonian ecoregion of Croatia

The study area is the Pannonian ecoregion of Croatia situated in the Sava-Drava interfluve. This area is characterized by low altitude, high groundwater levels and a wide reign of river land and river valleys. A large amount of available freshwater and a great number of different water bodies supports the growth of lush aquatic vegetation. The geological base of the Pannonian rivers of Croatia is mostly Holocene alluvium, i.e., silicate sediment. Not all the Pannonian ecoregion is river lowland, this area is cut in half by Pannonian hills and mountains. Relief representation of the Pannonian Croatia along with the distribution of *Potamogeton* species is shown in Figure 4.

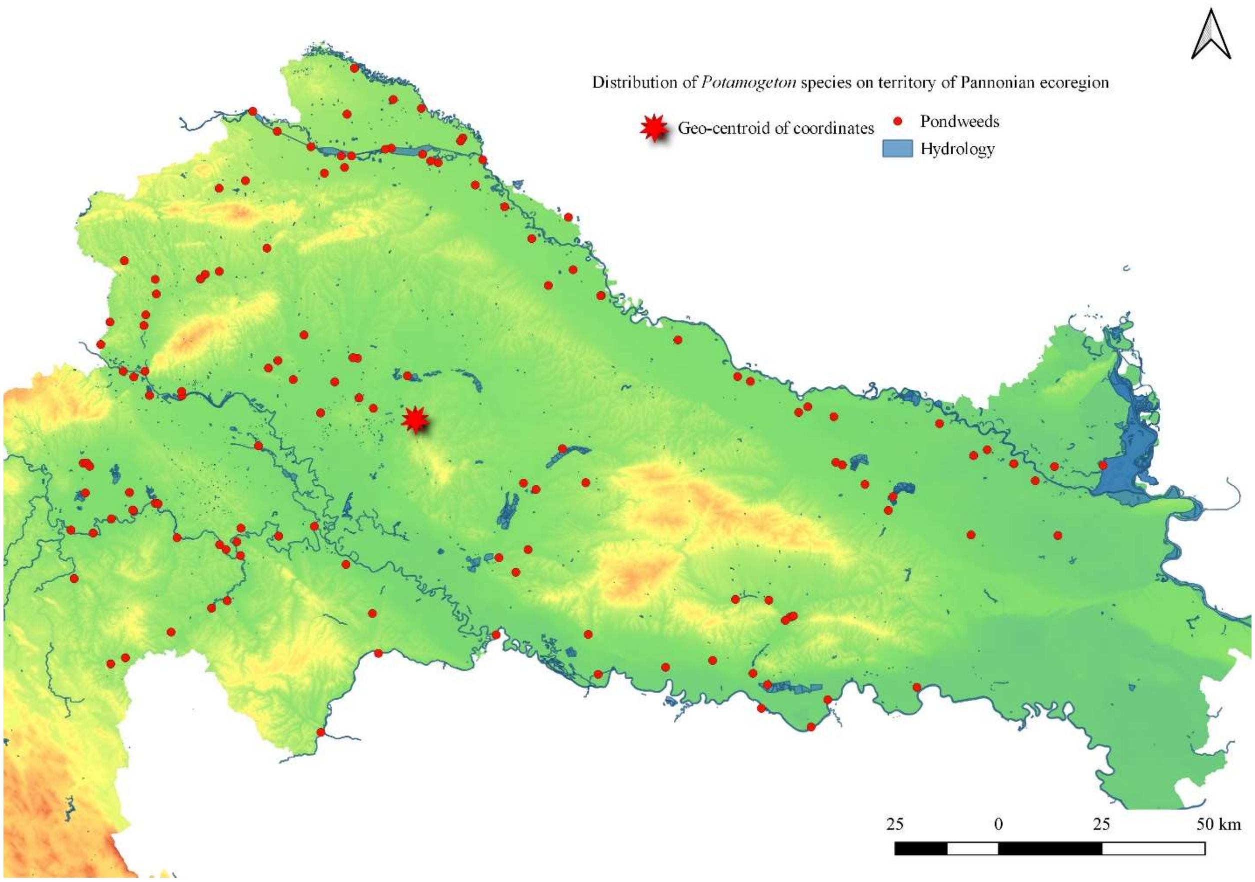

Figure 4. Pannonian ecoregion of Croatia. Distribution of all *Potamogeton* species found during the aquatic vegetation survey in Croatia.

In Croatia, the water bodies are classified according to the classification developed for the Water Framework Directive purposes. This classification is based on abiotic parameters such as catchment area, geological and lithological substrate, elevation, substrate size. Types and descriptions of water bodies present in the Pannonian ecoregion are given in Table 1 (NN 96/2019).

Table 1. List of surface water types according to Regulation on water quality standards (NN 96/2019).

Type name	Type label
Pannonian ecoregion	
1. Small mountain and sub-mountain watercourses	HR-R_1
2. Small lowland watercourses	
2. a. Small lowland watercourses on a clayey-sandy substrate	HR-R_2A
2.b. Small lowland watercourses on gravel substrate	HR-R_2B
3. Small alluvial watercourses	
3.a. Small alluvial watercourses with gravel substrate	HR-R_3A
3.b. Small, medium and large alluvial watercourses with a clayey-sandy substrate	HR-R_3B
4. Medium and large lowland watercourses	HR-R_4
5. Very large lowland watercourses	
5.a. Very large lowland watercourses with the source in Dinaric ecoregion	HR-R_5A
5.b. Very large lowland watercourses with silicate and carbonate geology – the lower reach of Mura and middle reach of Drava and Sava	HR-R_5B
5.c. Very large lowland watercourses with silicate geology – lower reaches of Drava and Sava	HR-R_5C
5.d. Very large lowland watercourses silicate base – Danube	HR-R_5D

3.2. Rivers of Pannonian ecoregion of Croatia

The Sava River is the longest river passing through Croatia with a length of 946 km, having a catchment area of 95,835 km^2. It is a significant river for Croatian river traffic – it is navigable for heavy shipment up to Sisak and lightships up to Zagreb. Except for the Danube, historically there has been more industry concentrated on the Sava River than on any other river that flows through Croatia. A lot of pollutants are released into it, and it is rich in organic matter (Hrvatska Enciklopedija, 2021c).

The Drava River with a length of 707 km and a catchment area of 40,150 km^2 is the second longest river in Croatia. At the beginning of the lower basin, in eastern Slovenia and northern Croatia, several dams have changed its course, have influenced the influx of sediment in the lower course, as well as the appearance of the landscape and the composition of vegetation around the Drava River and overall river continuum. On average, Drava is cleaner and less polluted than Sava (Hrvatska Enciklopedija, 2021a).

The Kupa River is the third longest river in Croatia with a total length of 294 km and a catchment area of 10,226 km^2. From the source in the Gorski Kotar Region, it flows through Croatia at its full length reaching the confluence with the Sava River in Sisak (Hrvatska Enciklopedija, 2021b).

The Danube River is the second longest river in Europe and widest and the biggest river in Croatia, with only 137,50 km of its 2,850 km long flow making a national border between Croatia and Serbia. It has always been an important corridor for river traffic through Europe and is home to many species. It is one of the most polluted rivers in Europe today.

Other small, medium-sized or large rivers situated in the Pannonian ecoregion belonging to the Black Sea Basin represent significant parts of water ecosystems, which harbour different water habitats supporting the macrophyte diversity. These are Mura, Una, Korana, Dobra, Mrežnica, Bednja, Česma, Bosut etc.

4. Materials and methods

4.1. The input data

Input data used in this paper are vegetation collected in river macrophyte survey from 2016 to 2020 and annual averages of monthly measurements of physicochemical parameters for each survey station.

The first part of the input data consists of 166 vegetation relevés ultimately representative of most of the territory of the Pannonian ecoregion of Croatia. Field research was conducted during the summer months, i.e., during the vegetation season. In that period macrophyte vegetation is fully developed, which ensures macrophyte species identification and cover and abundance estimation. Furthermore, low water levels and sunny days are the most appropriate weather conditions for macrophyte survey. The extended nine-degree Braun-Blanquet scale (Barkman *et al.*, 1964; Braun-Blanquet, 1964; Dierschke, 1994) was used to estimate species cover and abundance and plot size was determined according to the macrophyte vegetation sampling standard (Alegro, 2019). The extended Braun-Blanquet scale is shown in Table 2.

Table 2. Extended Braun – Blanquet scale used for the estimation of the species abundance and cover in the vegetation relevés.

Scale	Range of plot covered
r	Less than 1%, 1-2 individuals
+	Less than 1%, 3-5 individuals
1	1-5 % cover, 6-50 individuals
2m	1-5% cover, over 50 individuals
2a	5-15% cover
2b	15-25% cover
3	25-50% cover
4	50-75% cover
5	75-100% cover

The vegetation survey's sampling plots were 50 m long transects. The starting point for each transect was geo-location of sampling station of Hrvatske vode. These geo-locations were later used in the analysis. If there were no new plants species after the 25 m of the inspected transect the sampling was stopped, or it was continued up to 100 m, if an increase in the number of plant species was present after 50 m (Hrvatske vode, 2016). Collected plant material was examined and determined in the laboratory of Division of Botany of the Department of Biology and stored in Herbarium Croaticum (ZA).

The second part of the input data represents the data on monthly measured water physicochemical parameters provided by Hrvatske vode, i.e. Central Water Management Laboratory (Hrvatske vode, 2021). The most important parameters are temperature, conductivity, alkalinity, ammonium, pH, dissolved oxygen, nitrates, total nitrogen, orthophosphates and total phosphorus. These were later tidied, calculated and shown as annual mean values. These data wrangling operations were carried through R studio software (RStudio Team, 2021), which is based on R programming language (R Core Team, 2019), as well as some further steps of analysis.

In the context of data science, data consists of variables and observations. Each observation presents one finding of a plant on the location. Variables are characteristics or what describes each observation such as abundance of each plant, name of station where plant was found, year of sampling, mean annual pH of water etc.

The second part of data was partly problematic due to the lack of observations for some stations. Such measurements were not taken into analysis and are not considered as existing. This is achieved by using function $drop\_na()$ or by using $na.rm = T$ argument in base r functions. NA or “Not Available” is a programmatic way to describe non-existing data.

The two parts of the input data were joined. Each observation of data vegetation was joined with the parameters of the measuring station. The basis for joining were location names and codes. Joining is a simple operation that was carried through $join()$ function family from the dplyr package that is part of Wickham’s Tidyverse mega package (Wickham *et al.*, 2019). The combined data now includes location names, coordinates, abundance and incidence of species, type of water body and physicochemical parameters. This data was further used in the analysis (Appendix 1).

4.2. Geodata

QGIS software (QGIS, 2021) was used for geographic data, their analysis and display. Geographical data primarily served to make cartographic representations of the distribution of *Potamogeton* species. Base layer of each map is Digital elevation model (DEM) made by State Geodetic Administration of Croatia (DGU, 2021). DEM simplifies the representation of the surface of the Earth. On top of the base layer was added hydrology layer, taken from Open Street Map (OSM). The hydrology layer represents larger or smaller surface water bodies. Points on maps are locations of stations where *Potamogeton* species were found. Since each observation has geo-location, point data were easily added to GIS. Geo-centroid from the station points was calculated using $Mean\ coordinate(s)$ function from vector analysis package. Therefore, centroid is mean of coordinates, it shows the central tendency or gravitation point of data.

4.3. Analysis

Statistical analyses included univariate statistics to describe ecological parameters in habitats of individual species, and a range of multivariate statistics methods such as canonical correlations analysis (CCA), detrended correspondence analysis (DCA) and generalized additive model (GAM) to establish a connection between species occurrences or abundances and environmental parameters. Two-way indicator species analysis (TWINSPAN) was used for vegetation classification.

Graphic representations, which summarize the data and describe its interrelationship, were partly created in the ggplot2 package (Wickham, 2009). DCA and CCA were made in Canoco 5 (Šmilauer, 2012).

4.3.1. GAM

The generalized additive model is a generalized linear model where a linear predictor involves smoothing functions of covariates (Hastie and Tibshirani, 2017; Wood, 2017). This makes it more suitable for some sets of data because, unlike general linear models, it incorporates nonlinear forms of predictors. It also incorporated other data distributions as a type of generalized linear model. This way it is not a limiting model for some data, unlike standard linear regression models (Wood, 2017). Poisson distribution was used in this GAM analysis.

4.3.2. DCA

Detrended correspondence analysis is a modification of correspondence analysis (CA) that overcomes two major drawbacks (Hill and Gauch, 1980). The first modification – detrending - gives the technique its name, it attempts to remove the "arch effect" of the data. The second modification is rescaling of the axes which provides interpretable units of length and removes distortion (Peet *et al.*, 1988). The positions of the points in the DCA graph are calculated and based on the composition of species communities. Environmental variables are projected on an ordination graph.

4.3.3. CCA

Canonical correlation analysis serves for finding a relationship between two sets of variables. It addresses the question of explaining or predicting one set of two or more variables with another set of two or more variables (Thompson, 1985). This is a type of constrained analysis or direct gradient analysis. It tries to explain the variability of data directly through the set of explanatory variables, unlike DCA, which is why it needs to take only the most significant environmental parameters to keep the variation well fit. To achieve this, $step\ forward\ selection$ in Canoco 5 was used since CCA becomes less reliable with more parameters selected.

4.3.4. TWINSPAN

In order to investigate whether vegetation relevés can be grouped into statistically significant groups, a TWINSPAN analysis (Hill, 1979) modified according to Roleček *et al.* (2009) was carried out in the program Juice 7.1 (Tichý, 2011). Initially, the division into a maximum of 10 groups was selected, and those that were statistically the most significant were retained. Relationships between the groups are shown by the dendrogram.

Based on the groups obtained in the TWINSPAN analysis, a synthetic vegetation table was made in which vegetation groups are summarized, and for each species the frequency of occurrence in each group expressed as a percentage, and a fidelity index indicating how much is a single species related to a vegetation group were calculated (Tichy and Chytry, 2006). Furthermore, in order to visualize the relationship between the groups, they were included in the detrended correspondence analysis (DCA) conducted in R 3.5.2. through the Juice program.

5. Results

5.1. Incidence and frequency of species

Figure 5 shows the results of incidence of *Potamogeton* species on sampling sites. The most found species was *P. nodosus*, followed by *P. crispus* and *P. pectinatus*. The least found species were *P. lucens* and *P. trichoides* which along with *P. natans, P. pusillus* and *P. berchtoldii* had frequencies below 5%. There was one undetermined species as well.

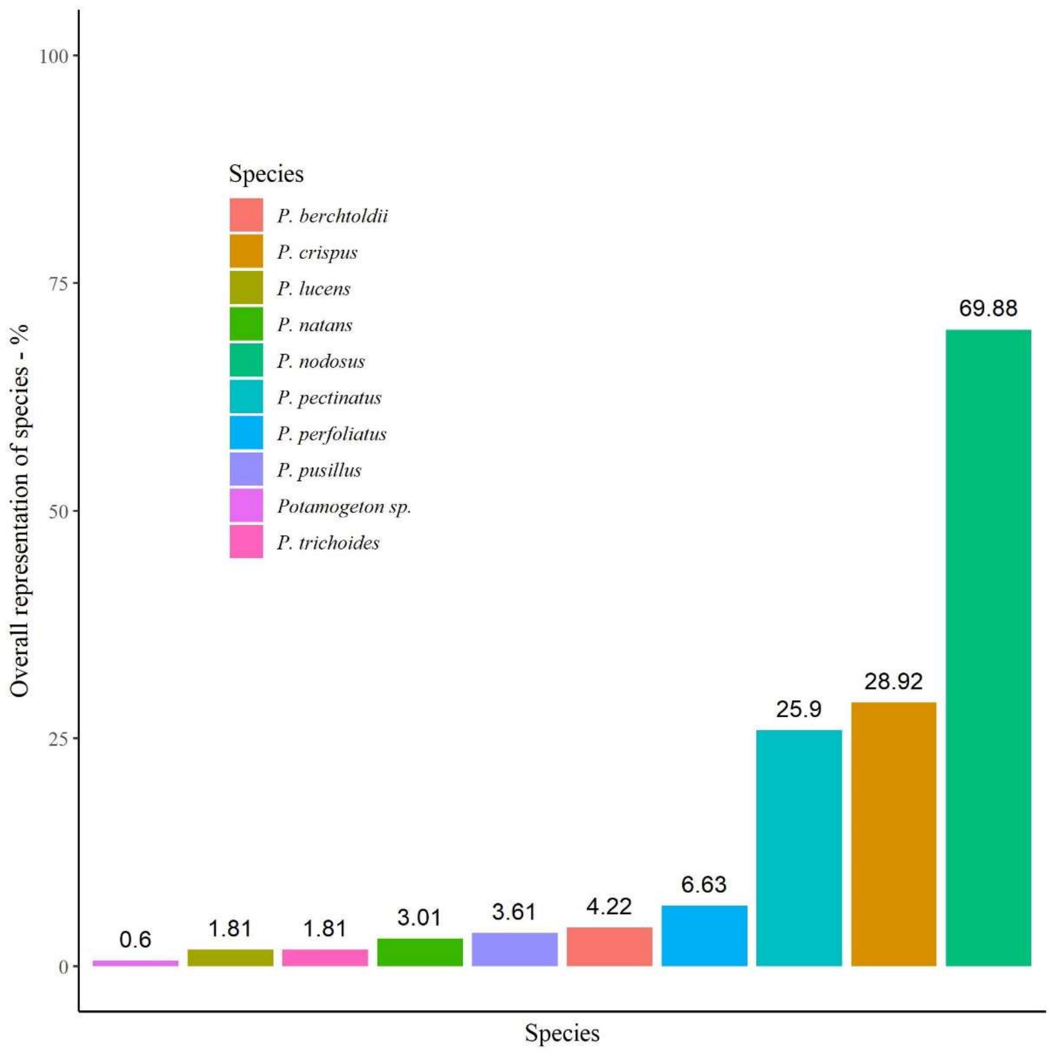

Figure 5. Incidence of *Potamogeton* species in the Sava Drava interfluve. The value of each bar represents the percentage of the species found in the total number of findings. *Potamogeton* sp. (0.6%) represents the samples that were not identified to the species level.

The occurrences of *Potamogeton* species found in different surface water types (classification given in Table 2) are presented in Table 3.

Table 3. Occurrences of species in different surface water types.

Species / Abiotic type	HR-R_2A	HR-R_3B	HR-R_4	HR-R_5A	HR-R_5B	HR-R_1	HR-R_2B	HR-R_3A
Potamogeton berchtoldii Fieber	2	1	1	2	1			
Potamogeton crispus L.	18	1	15	1		2	11	
Potamogeton lucens L.	1		2					
Potamogeton natans L.			4				1	
Potamogeton nodosus Poir.	34	8	49	5	3	1	12	2
Potamogeton pectinatus L.	6	2	17	4	6		6	1
Potamogeton perfoliatus L.	2		1	5	3			
Potamogeton pusillus L.	3	1		2				
Potamogeton trichoides Cham. & Schltdl.		1			1		1	
Total	66	14	89	19	14	3	31	3

Most of the species were found in the following abiotic types of surface waters: small lowland watercourses on gravel substrate (HR-R_2B), small lowland watercourses on a clayey-sandy substrate (HR-R_2A) and medium and large lowland watercourses (HR-R_4). The lowest number of the species was found in small mountain and sub-mountain watercourses (HR-R_1) and small alluvial watercourses with gravel substrate (HR-R_3A).

5.2. Distribution of species

Potamogeton species are well distributed in the Pannonian ecoregion in Croatia, as seen in Figure 4. The distribution is not even, they were mostly found in the western part of the Pannonian ecoregion. The centroid of the distribution falls in the central-western part of the region.

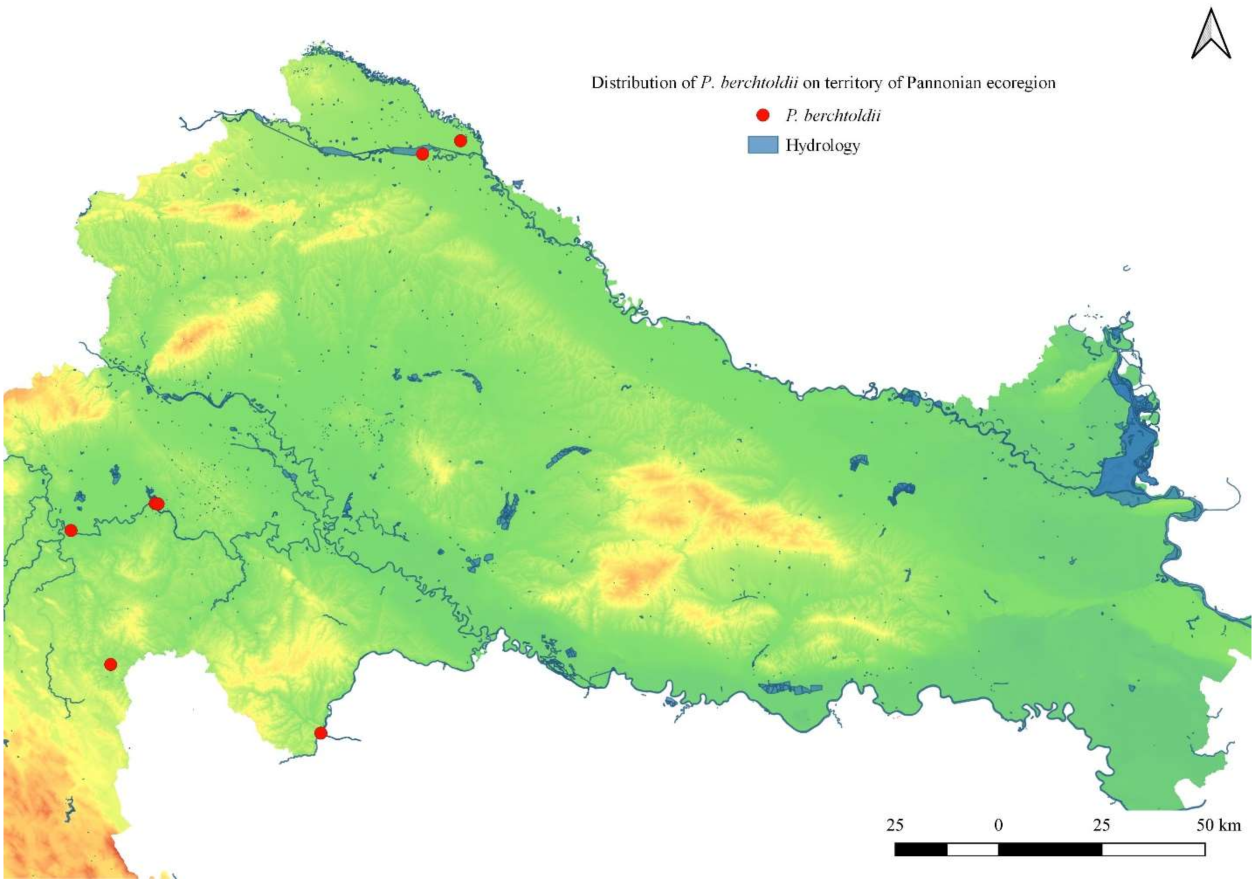

Figure 6. Distribution of *P. berchtoldii* found in Pannonian ecoregion of Croatia.

Potamogeton berchtoldii was found in the middle streams of the Drava and the Kupa rivers as well as small water bodies around these rivers. There was also one finding in the Ruševica River, near the Korana River, and one in the Una River.

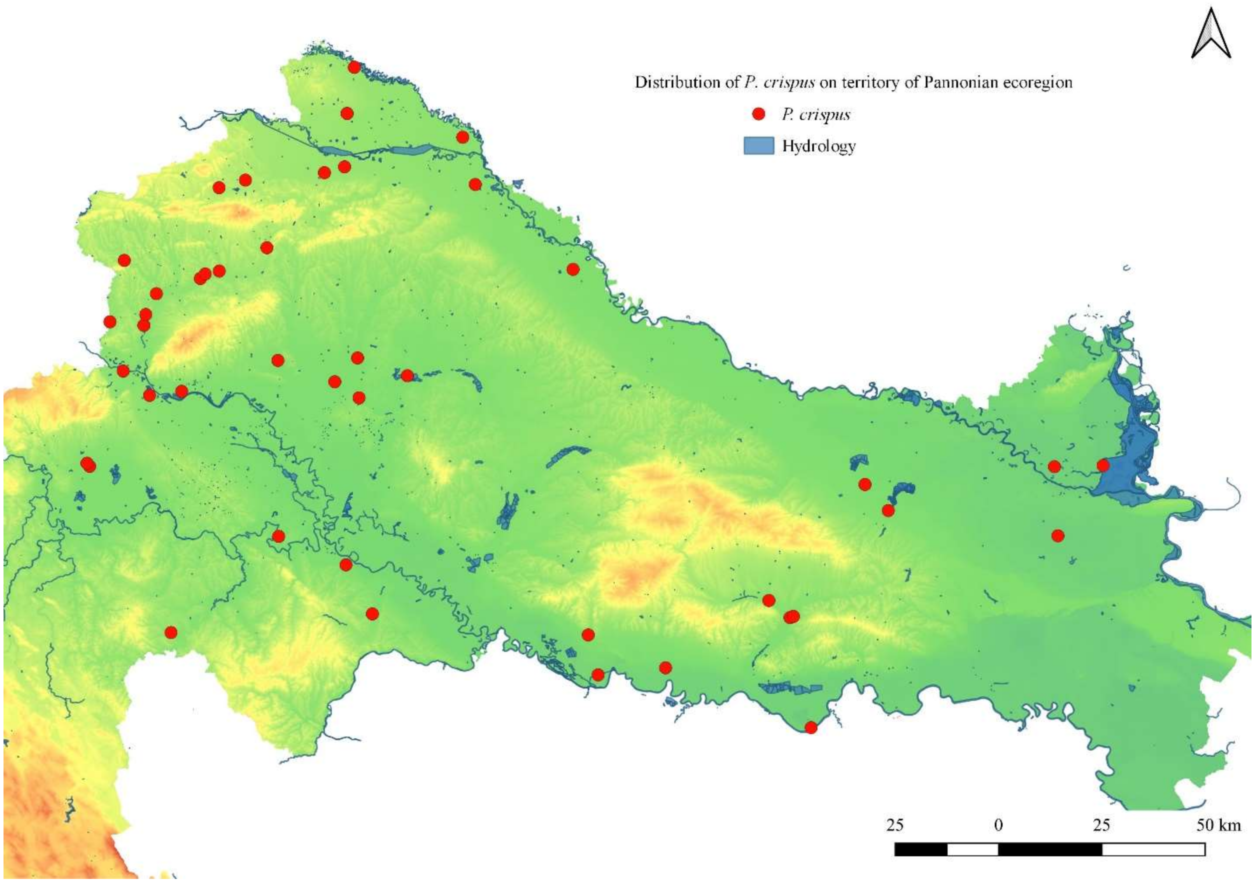

Figure 7. Distribution of *P. crispus* found in Pannonian ecoregion of Croatia.

Potamogeton crispus was very frequent throughout the Pannonian ecoregion of Croatia. It covered all the abiotic types of surface water bodies except small alluvial watercourses with gravel substrate (HR-R_3A) and very large lowland watercourses with silicate and carbonate geology – the lower reach of Mura and middle reach of Drava and Sava (HR-R_5B) but was almost entirely found in small lowland watercourses on a clayey-sandy substrate (HR-R_2A), medium and large lowland watercourses (HR-R_4) and small lowland watercourses on gravel substrate (HR-R_2B).

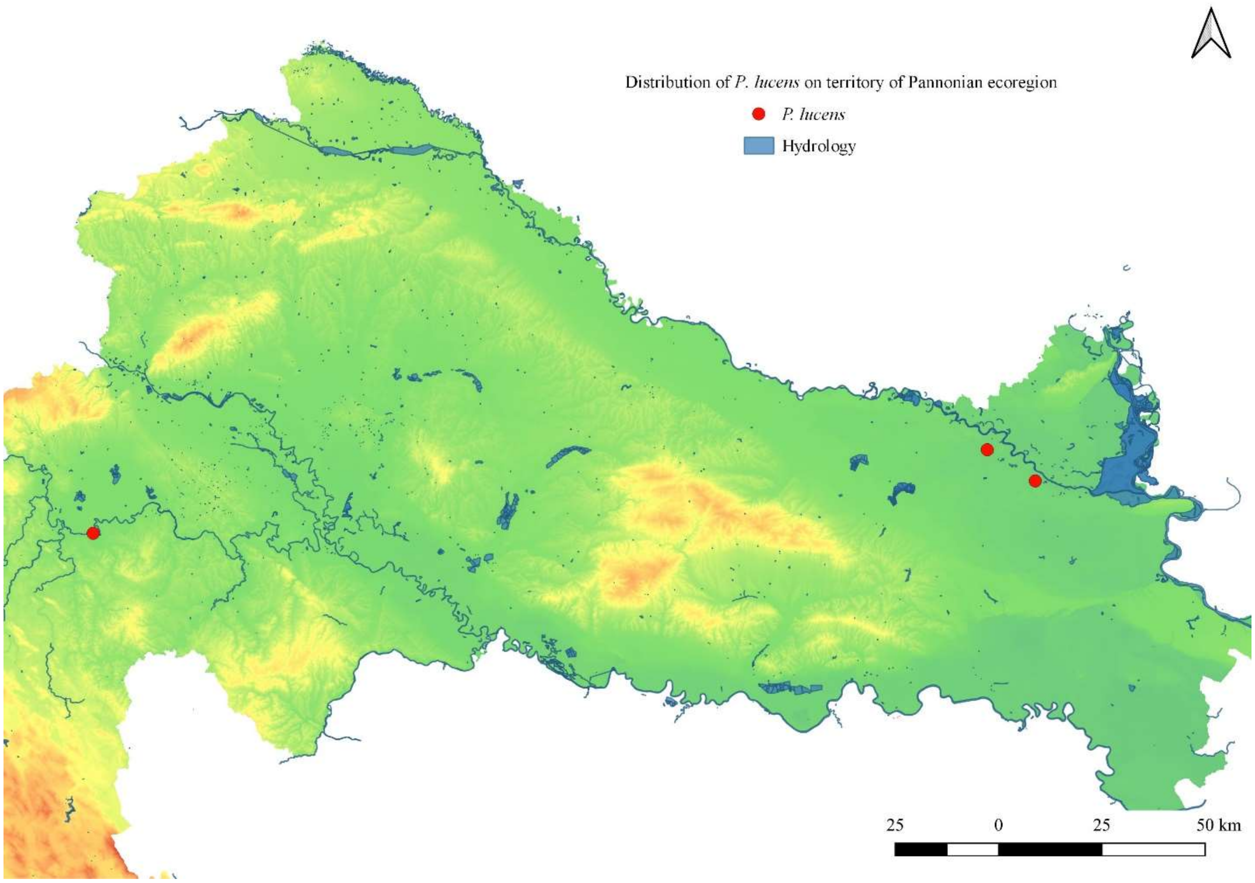

Figure 8. Distribution of *P. lucens* found in Pannonian ecoregion of Croatia.

Potamogeton lucens was found only in three locations: one in the middle stream of the Kupa River, and two in the lower stream of Drava. It had the lowest number of occurrences along with *P. trichoides* among all the species in this study.

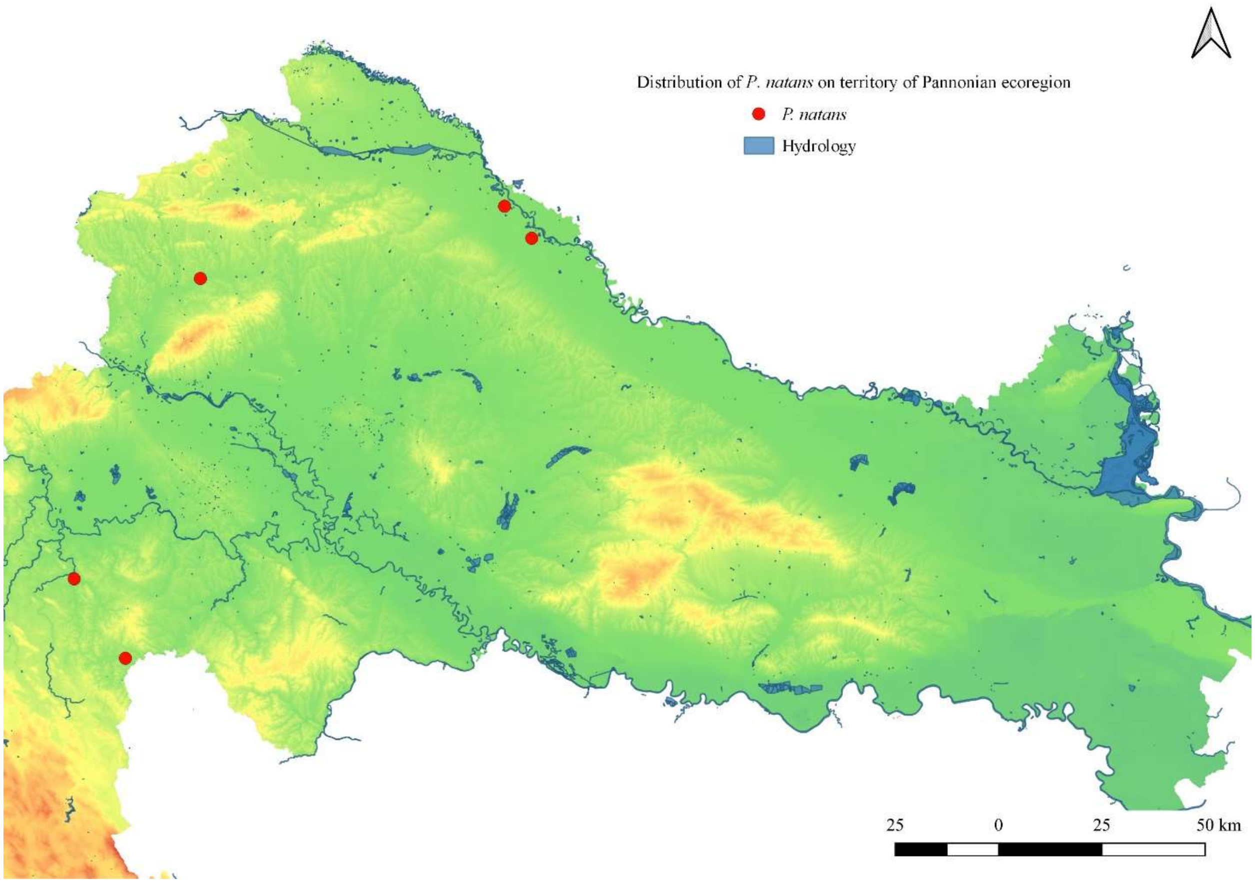

Figure 9. Distribution of *P. natans* found in Pannonian ecoregion of Croatia.

Potamogeton natans was found mostly on small rivers and streams, tributaries of bigger rivers. The species was found in two localities close to the Drava River in a small channel of the Gliboki Stream and one in the Bistra Koprivnička. Furthermore, one locality was recorded on the following rivers: Krapina, a small river in Croatian north-western micro-region of Zagorje, in the Radonja River, which is a tributary of the Kupa River and in the Ruševica River near the upper stream of the Korana River.

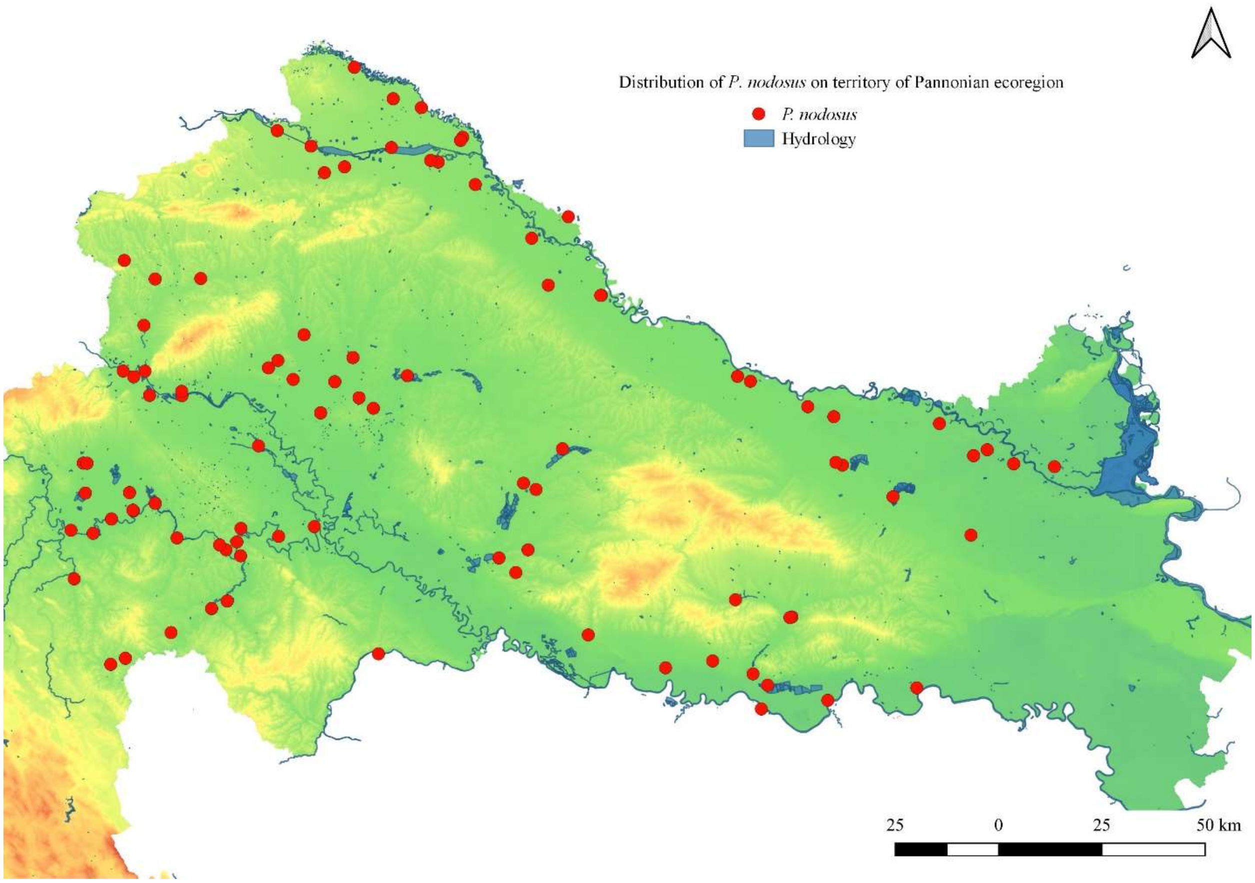

Figure 10. Distribution of *P. nodosus* found in Pannonian ecoregion of Croatia

Potamogeton nodosus was found with the highest frequency of all *Potamogeton* species and in great abundance. It was found in all types of surface water bodies and throughout the Pannonian ecoregion, with the majority of localities concentrated in the western part of the Pannonian ecoregion.

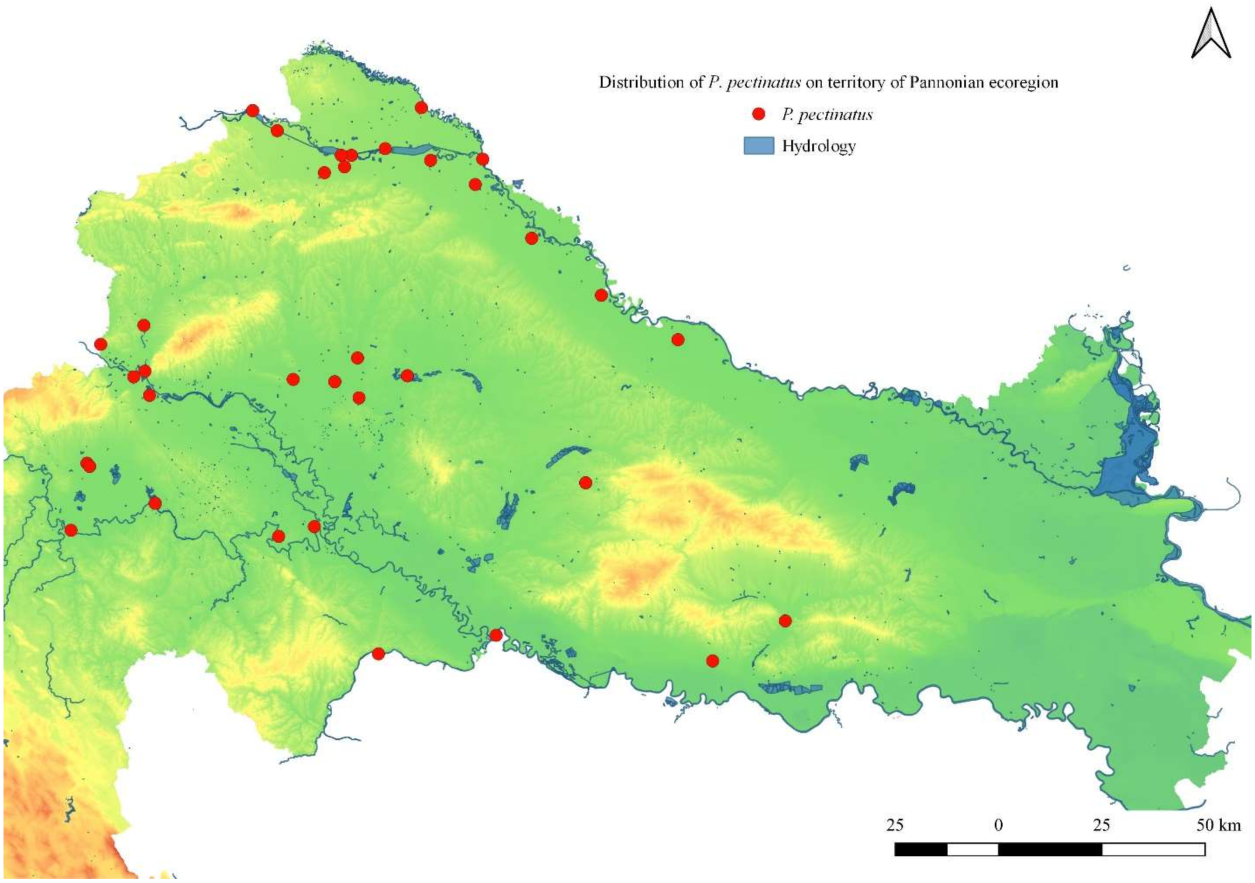

Figure 11. Distribution of *P. pectinatus* found in Pannonian ecoregion of Croatia.

Potamogeton pectinatus was found with higher frequency mostly in the upper streams of Drava, Sava and Kupa rivers as well as in rivers Mura and Una. It was found in all types of surface water bodies except in small mountain and sub-mountain watercourses (HR-R_1).

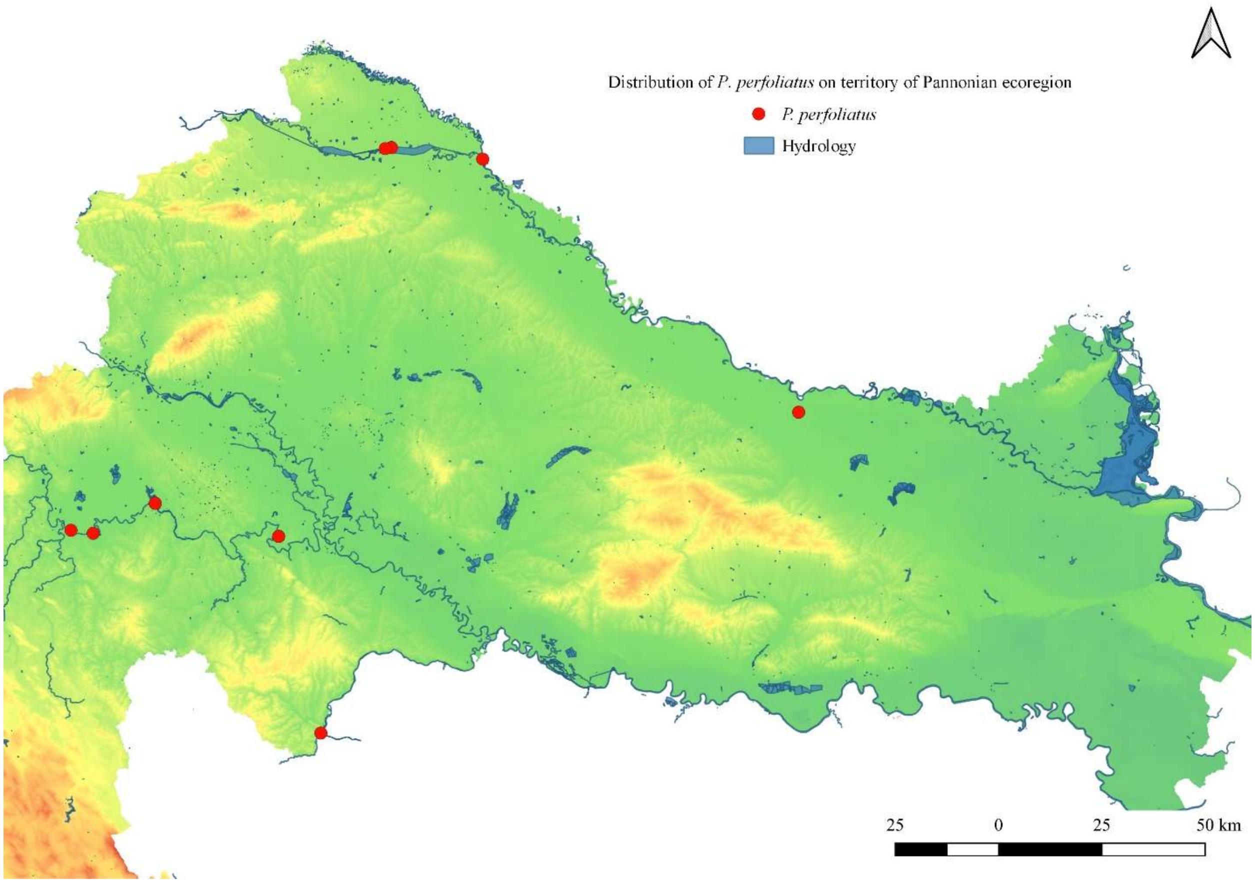

Figure 12. Distribution of *P. perfoliatus* found in Pannonian ecoregion of Croatia.

Potamogeton perfoliatus was found with a low frequency in upper streams of the Una and the Kupa rivers but also in the upper stream of the Drava River in accumulation lake as well in a small pond near the lower stream of Drava.

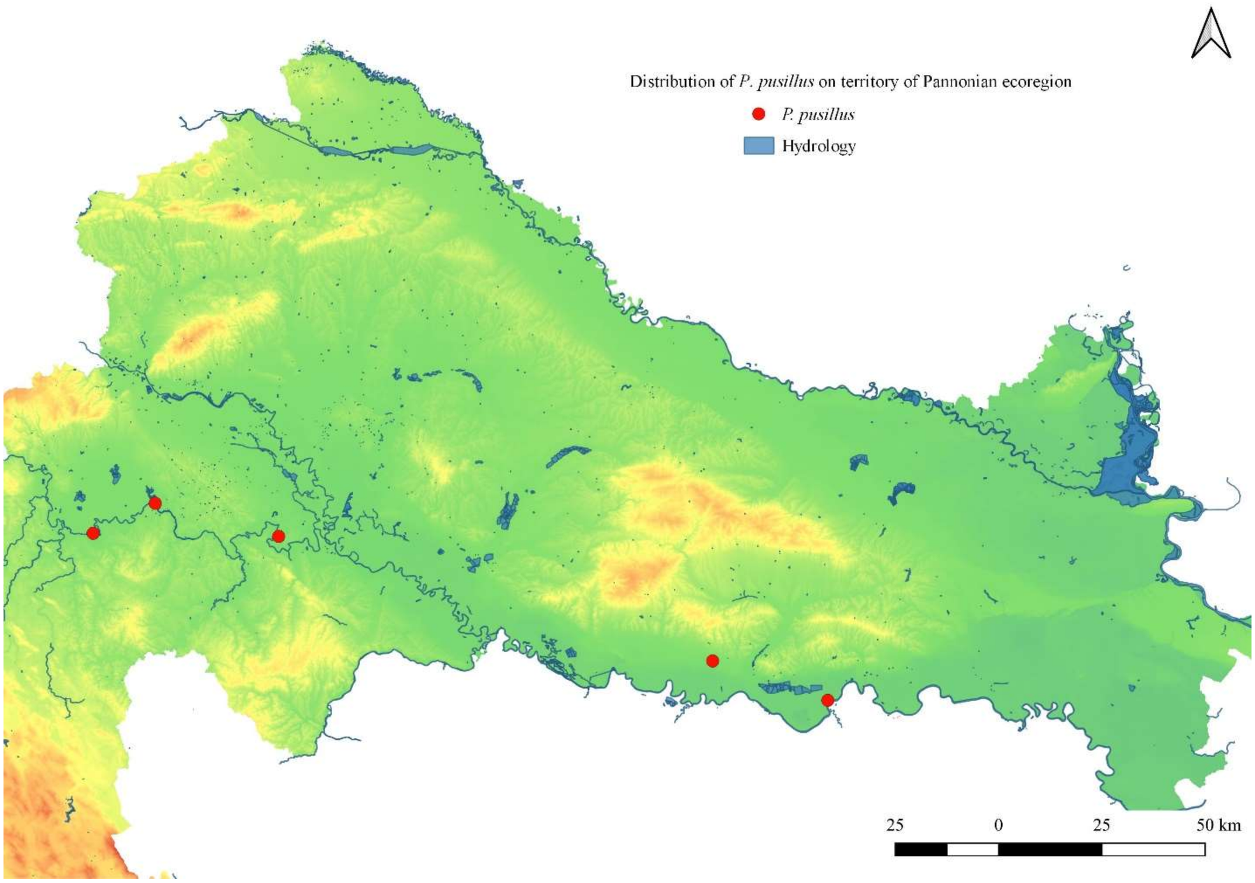

Figure 13. Distribution of *P. pusillus* found in Pannonian ecoregion of Croatia.

Potamogeton pusillus was recorded with a low frequency on three localities on the Kupa River, as well as on one on the Sava River and one on its tributary, the Orljava River.

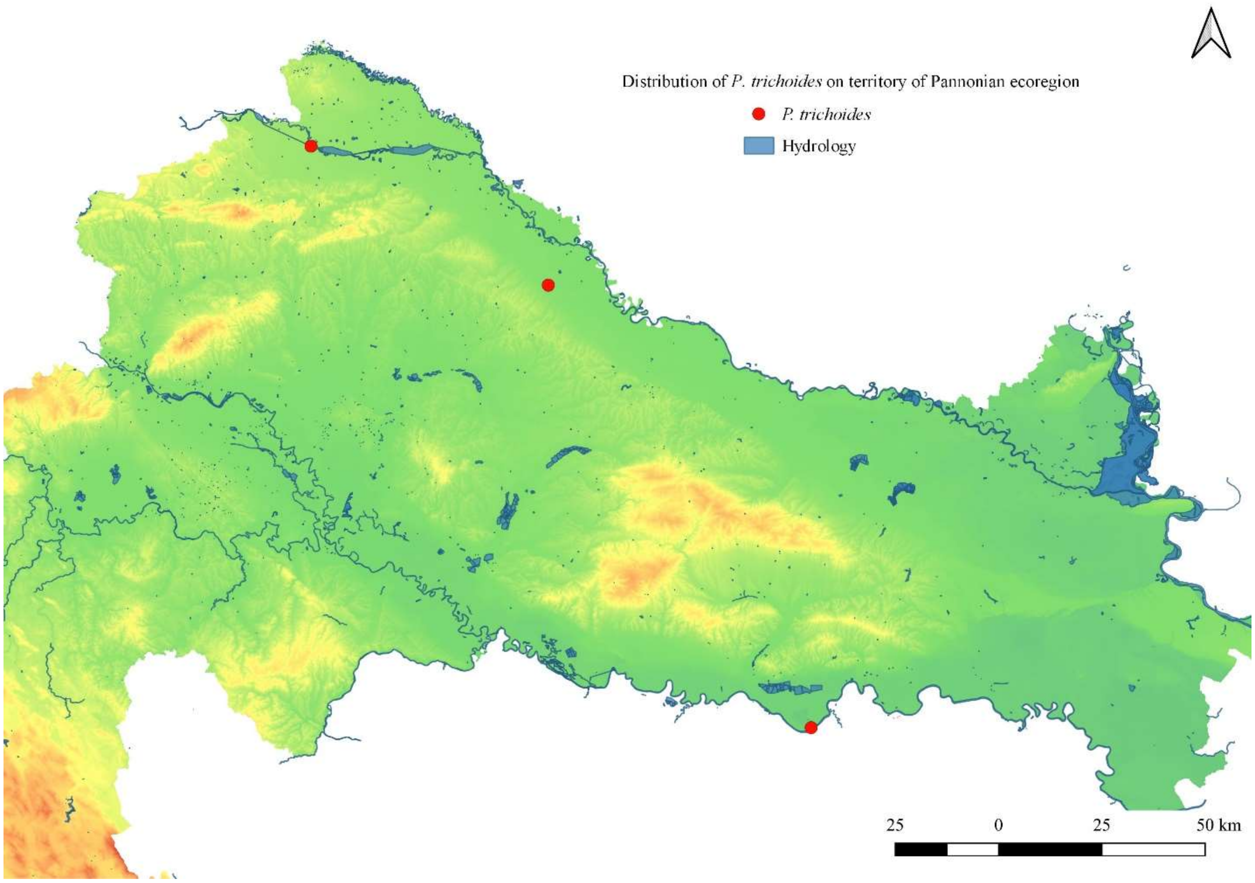

Figure 14. Distribution of *P. trichoides* found in Pannonian ecoregion of Croatia.

Potamogeton trichoides was found with a low frequency on three localities: one on the Sava, one on the canal of the accumulation lake of the Drava and one in the canal Đurđevac near the Drava River.

5.3. Physicochemical parameters of water

A summary of measured physicochemical parameters is given in Table 4. Separate box plots were made for each parameter (Figures 15-19). The values show that all *Potamogeton* species were found in mostly eutrophic waters. Average electrical conductivity is high and dissolved oxygen is low, while nitrates, ammonium, total nitrogen and total phosphorous concentrations are in the acceptable ranges according to Croatian legislative – Regulation on water quality standards (NN 96/2019).

Table 4. Annual mean values of physicochemical parameters for each *Potamogeton* species.

Species	Temperature (°C)	Electrical conductivity (µS/cm)	Alkalinity ($mgCaCO_3/l$)	Ammonium ($mgNH_4/l$)	pH	Dissolved oxygen (mgO_2/l)	Total nitrogen (mgN/l)	Nitrates ($mgNO_3/l$)	Orthophosphates (mgP/l)	Total phosphorus (mgP/l)
P. berchtoldii	13.67	504.03	230.75	0.20	7.92	9.96	1.68	1.08	0.03	0.07
P. crispus	14.45	562.45	259.49	0.49	7.83	8.43	2.62	1.29	0.13	0.26
P. lucens	13.36	379.74	230.50	0.18	7.79	8.27	1.44	0.93	0.07	0.17
P. natans	13.04	535.59	240.22	0.13	7.89	8.92	1.30	0.85	0.07	0.13
P. nodosus	13.94	487.62	231.32	0.70	7.84	9.11	2.50	1.48	0.10	0.20
P. pectinatus	14.56	502.58	229.27	0.56	7.85	8.54	2.70	1.43	0.15	0.29
P. perfoliatus	14.50	405.39	192.28	0.61	8.01	9.34	1.70	0.65	0.12	0.22
P. pusillus	13.29	426.88	205.14	0.18	7.84	9.22	1.49	0.87	0.04	0.21
P. trichoides	12.90	391.68	210.19	0.53	7.71	8.47	1.83	0.60	0.07	0.14

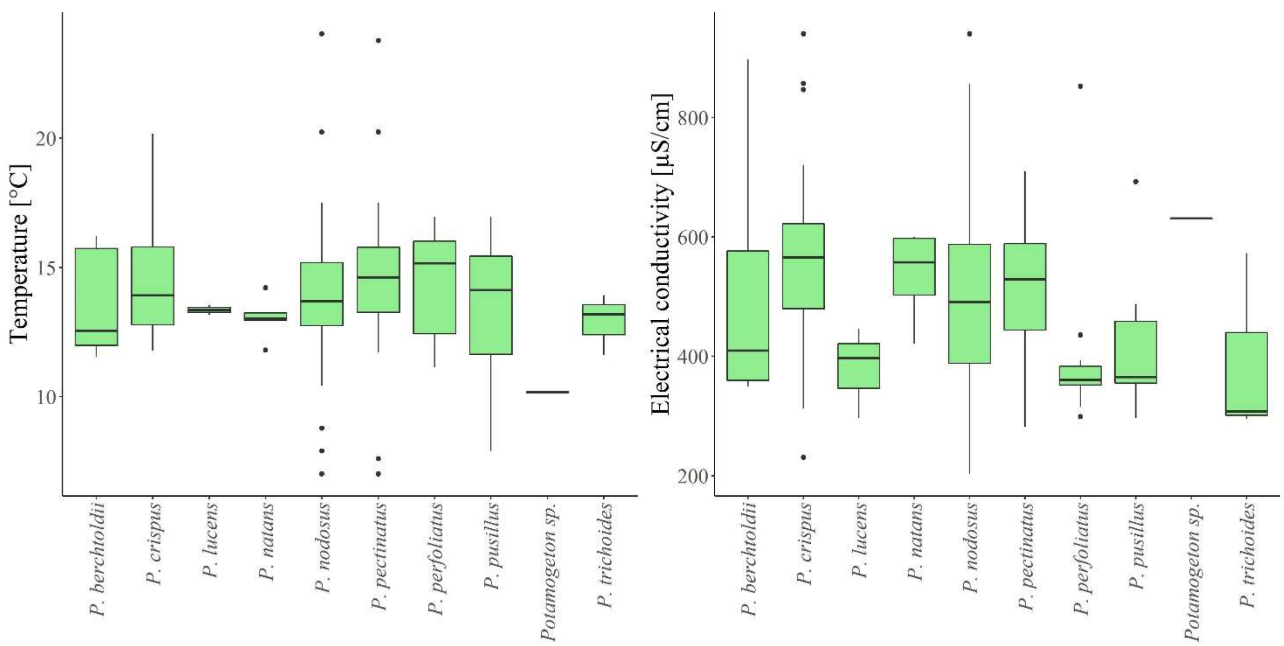

Figure 15. Boxplots of water temperature and electrical conductivity for *Potamogeton* species.

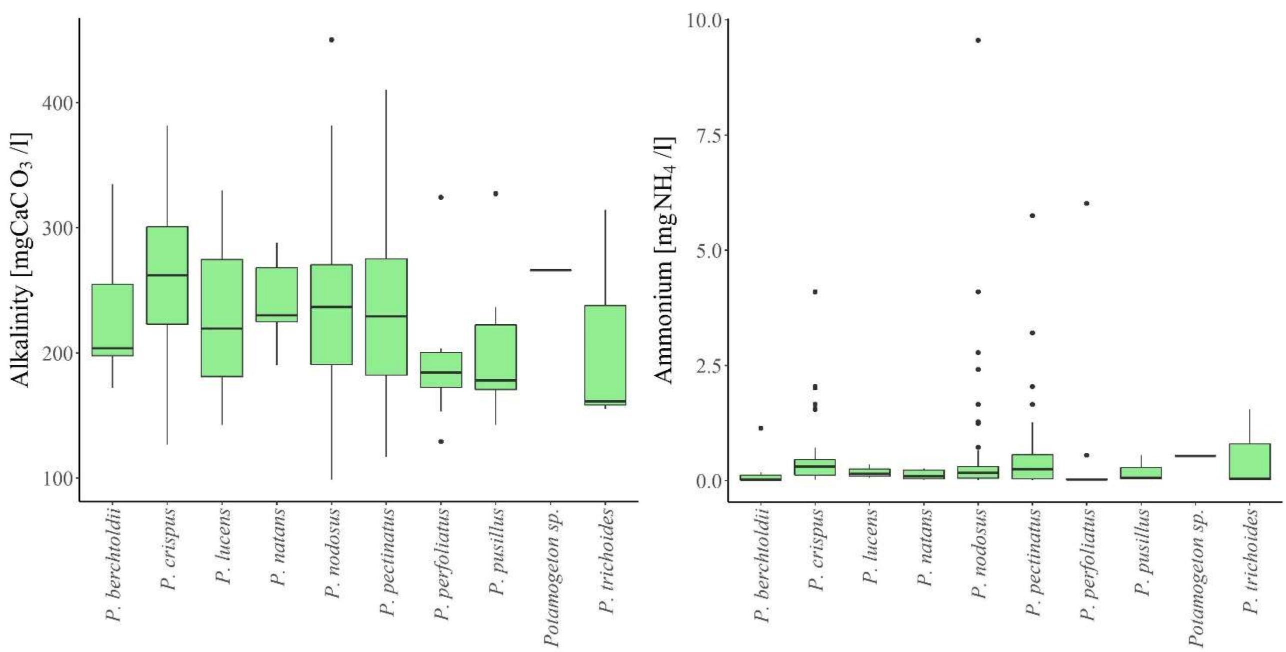

Figure 16. Boxplots of alkalinity and ammonium concentration for *Potamogeton* species.

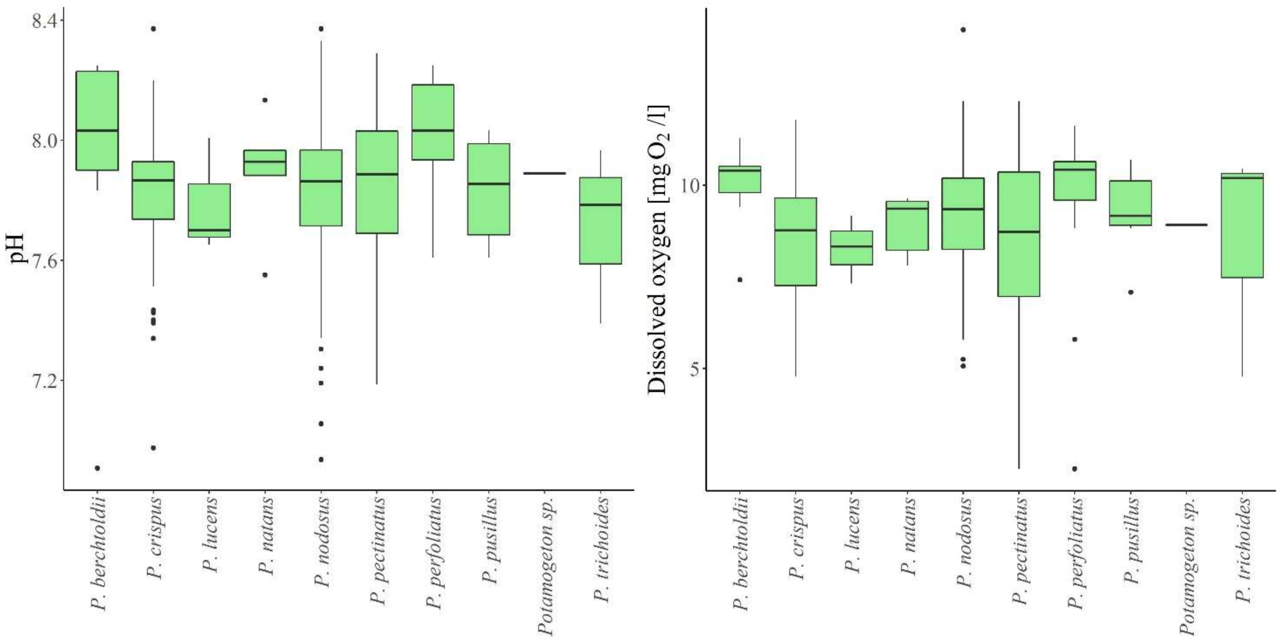

Figure 17. Boxplots of pH and dissolved oxygen for *Potamogeton* species.

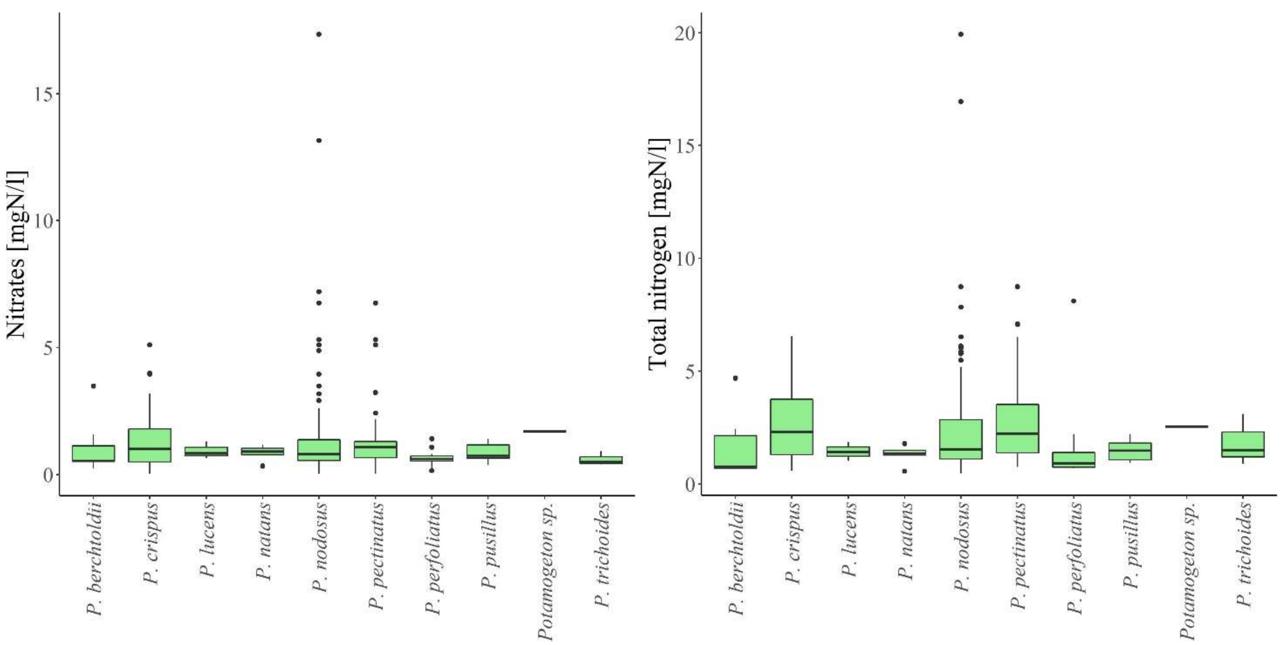

Figure 18. Boxplots of nitrates and total nitrogen conentration for *Potamogeton* species.

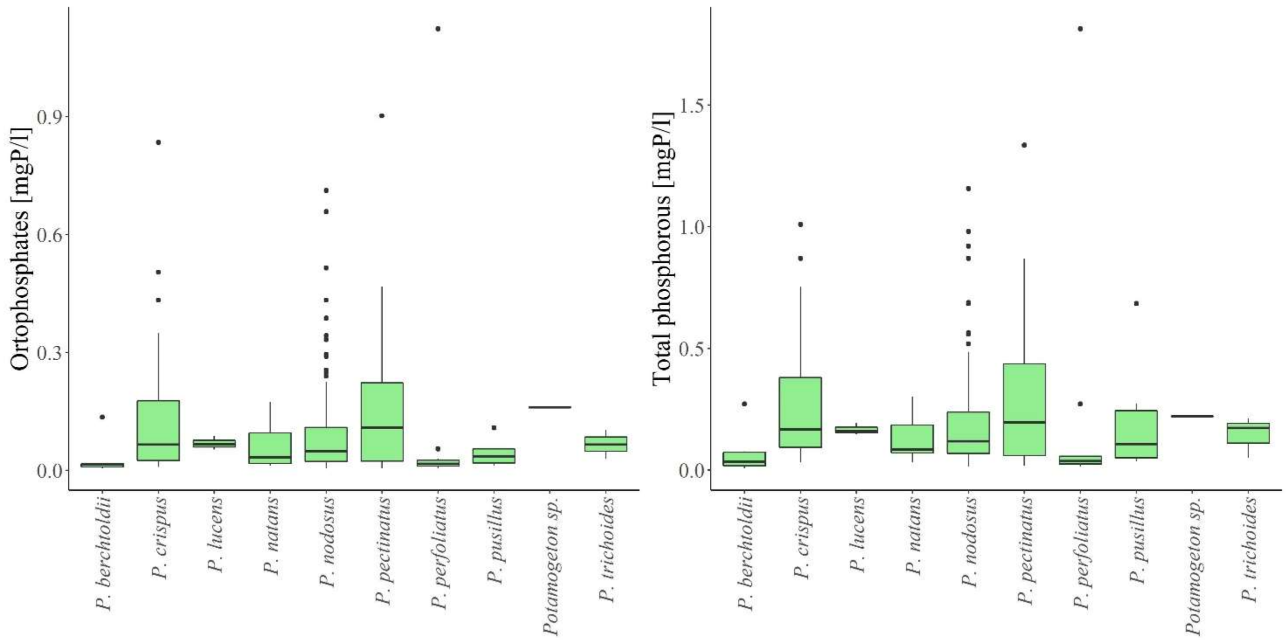

Figure 19. Boxplots of orthophosphates and total phosphorus for *Potamogeton* species.

5.4. Species response curves GAM

Species response curves give us more information about the characteristics of *Potamogeton* species. *P. pectinatus, P. crispus* and *P. pusillus* responded greatly to biological oxygen demand (BOD), while *P. nodosus* abundance was relatively high along most of the BOD gradient. On the other hand, *P. perfoliatus, P. natans, P. berchtoldii, P. lucens* and *P. trichoides* had a negative response to BOD.

Concerning dissolved oxygen, *P. pectinatus* and *P. crispus* had a negative response to higher concentrations, *P. nodosus* had a strong positive response in the middle of the gradient and *P. perfoliatus* and *P. berchtoldii* had positive responses to the higher concentrations of dissolved oxygen. Other species showed a weak response to dissolved oxygen; *P. trichoides* to the lower concentrations of dissolved oxygen and *P. lucens, P. natans* and *P. pusillus* to those in the middle of the gradient (Figure 20).

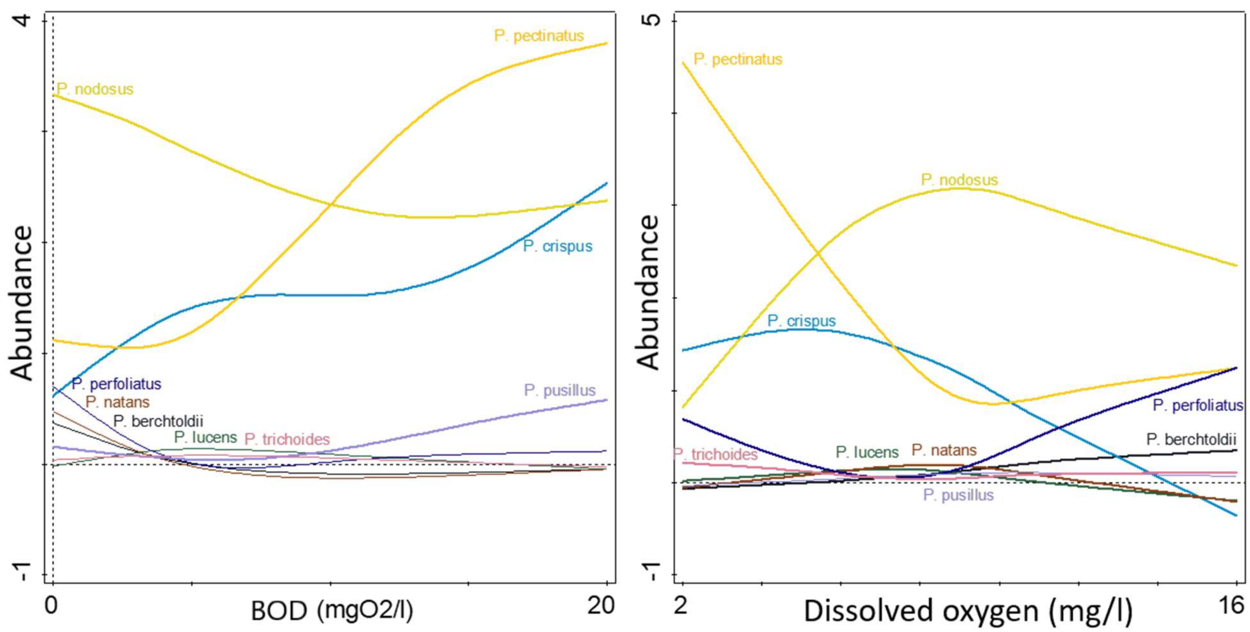

Figure 20. Response curves of *Potamogeton* species abundances to BOD and dissolved oxygen concentration.

Potamogeton nodosus showed a clear negative response to COD-Mn, while that of *P. perfoliatus, P. berchtoldii, P. natans* and *P. pusillus* was less pronounced. *Potamogeton crispus* and *P. pectinatus* gave a high positive response, while *P. lucens* and *P. trichoides* gave only a low positive response. *Potamogeton nodosus* showed a high positive response to the concentration of nitrates, as well as *P. pectinatus*, *P. crispus* and *P. berchtoldii* whose responses were also quite clear. Positive response to the lower concentration of nitrates was noticed for P. *lucens, P. natans, P. pusillus* and *P. trichoides* (Figure 21).

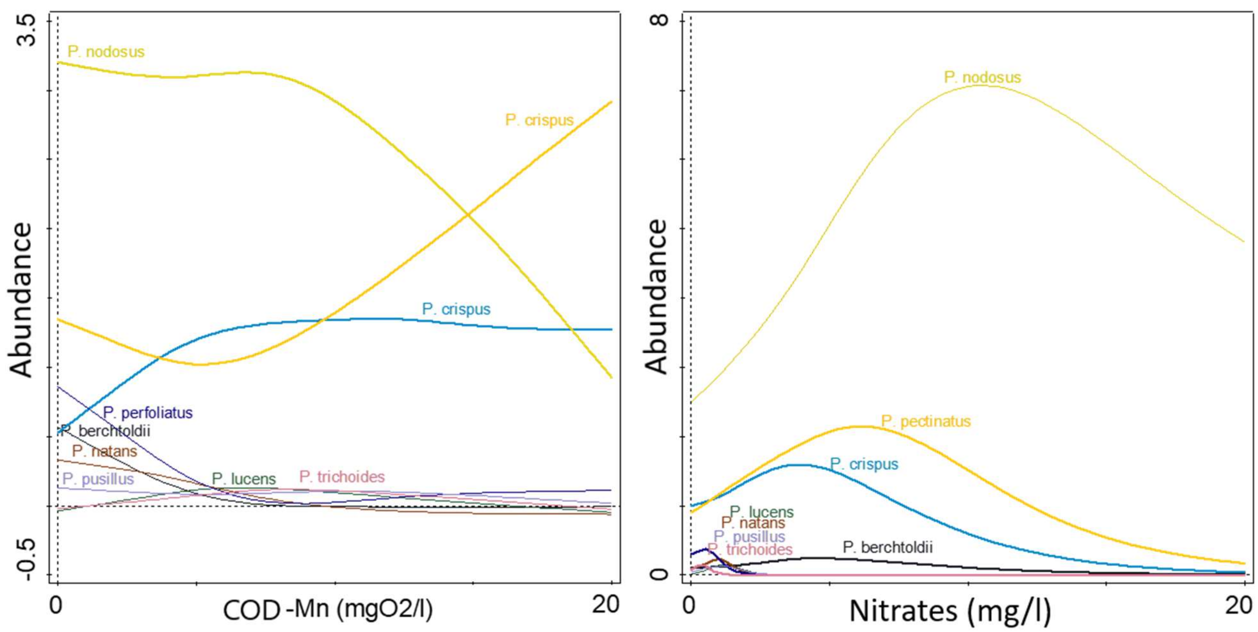

Figure 21: Response curves of species abundances to COD-Mn and nitrate concentration.

Concerning the concentration of nitrites, *P. pectinatus* and *P. crispus* gave clear and high responses to higher concentrations. *Potamogeton nodosus* had a rather negative response, and other species had a clear negative response to higher concentrations of nitrites. *Potamogeton nodosus* showed the highest response to high total nitrogen concentration, while *P. pectinatus* and *P. crispus* had a lower affinity towards high concentrations of total nitrogen. *Potamogeton perfoliatus*, *P. natans* and *P. berchtoldii* had a better response to lower concentrations of total nitrogen, while *P. pusillus*, *P. lucens* and *P. trichoides* had a weak response to moderate concentrations of total nitrogen (Figure 22).

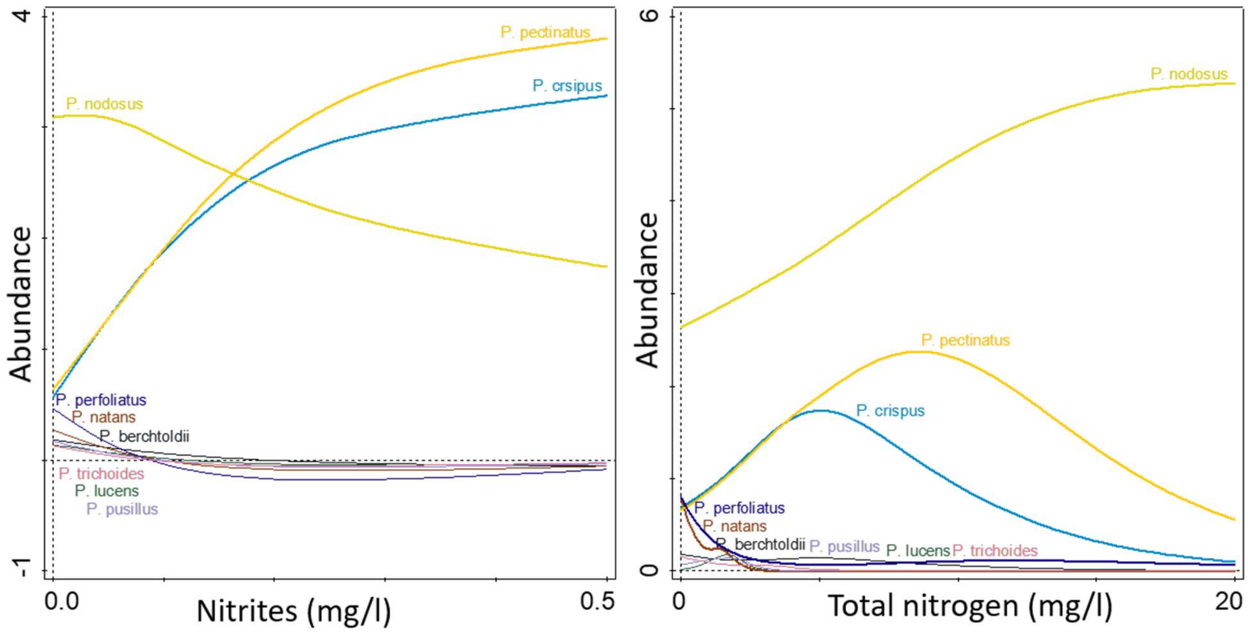

Figure 22: Response curves of species abundances to the concentration of nitrites and total nitrogen.

P. pectinatus and *P. crispus* had the highest affinity for high concentrations of total phosphorous, while *P. nodosus* had a linear and clearly negative response to rising concentrations of total phosphorous. *P. berchtoldii, P. perfoliatus, P. natans, P. pusillus, P. lucens* and *P. trichoides* had a weak response to lower concentrations of total phosphorous. *P. nodosus* was the only species with a strong positive response to high concentrations of total suspended solids. *P. crispus* and *P. trichoides* responded strongly to moderate concentrations of total suspended solids, while *P. pectinatus* responded strongly to lower concentrations. The response of *P. perfoliatus, P. natans, P. berchtoldii, P. lucens* and *P. pusillus* was rather weak to this measured water parameter.

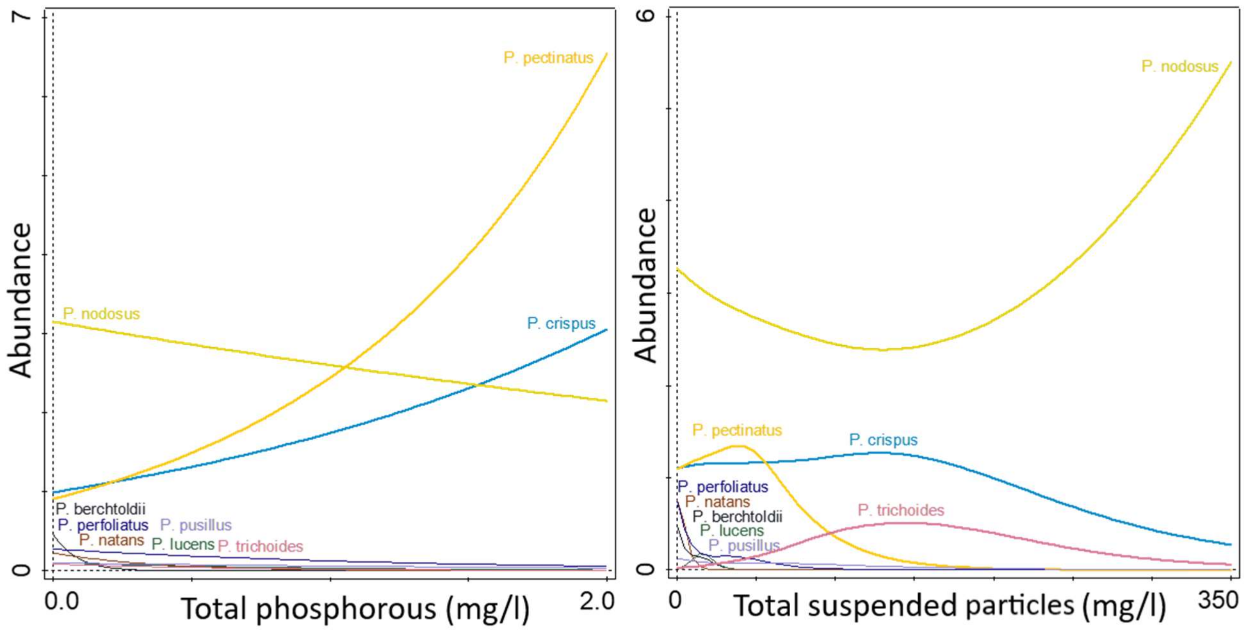

Figure 23: Response curves of species abundances to the total phosphorus concentration and total suspended particles.

5.5. Ordination analyses

Figure 24 shows the DCA ordination plot in which variables with longer eigenvectors have more significance as parameters that influence the occurrence of species. Orthophosphates, nitrites, electrical conductivity, alkalinity, suspended solids, oxygen saturation and pH value are recognized as the most important variables explaining the species occurrence. *P. pectinatus* and *P. natans* are placed in the directions of orthophosphates, total phosphorous and total nitrogen eigenvectors. *P. crispus* is placed in the direction of electrical conductivity, alkalinity and total suspended solids eigenvectors. *P. trichoides* is placed in the direction of total suspended solids eigenvector. The rest of the species are placed in a cluster in a direction of dissolved oxygen concentration, oxygen saturation and pH eigenvectors, but on the opposite side of nitrates and electrical conductivity eigenvectors. These species are *P. lucens, P. nodosus, P. berchtoldii, P. pusillus* and *P. perfoliatus* and they are placed opposite to *P. crispus*.

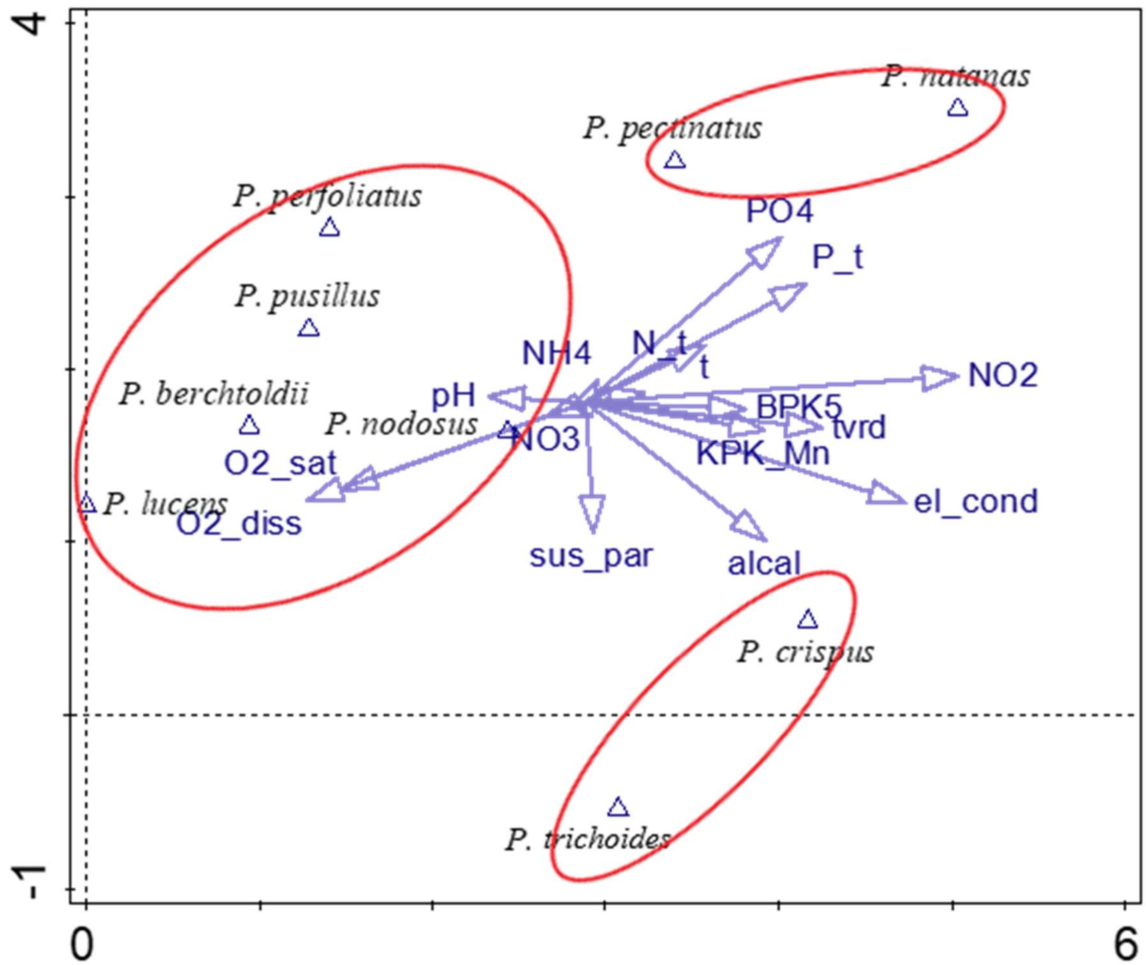

Figure 24. DCA based with passively projected environmental vectors – Explained variation: 1st axis 16.25%, 2nd axis 9.45%. Gradient length: 1st axis 5.04, 2nd axis 3.51.

Figure 25 shows the most significant parameters on the CCA plot. *P. nodosus*, *P. natans* and *P. berchtoldii* show clear positive correspondence with oxygen saturation and negative correspondence with orthophosphates and BOD. On the other side, *P. crispus*, and *P. pectinatus* correspond with orthophosphates, BOD, nitrites and higher pH. *P. lucens, P. perfoliatus, P. trichoides* and *P. pusillus* correspond negative to higher pH values, electrical conductivity and concentration of nitrates, while at the same time *P. pusillus* and *P. trichoides* show higher affinity for oxygen saturation, while *P. lucens* shows high affinity for orthophosphates.

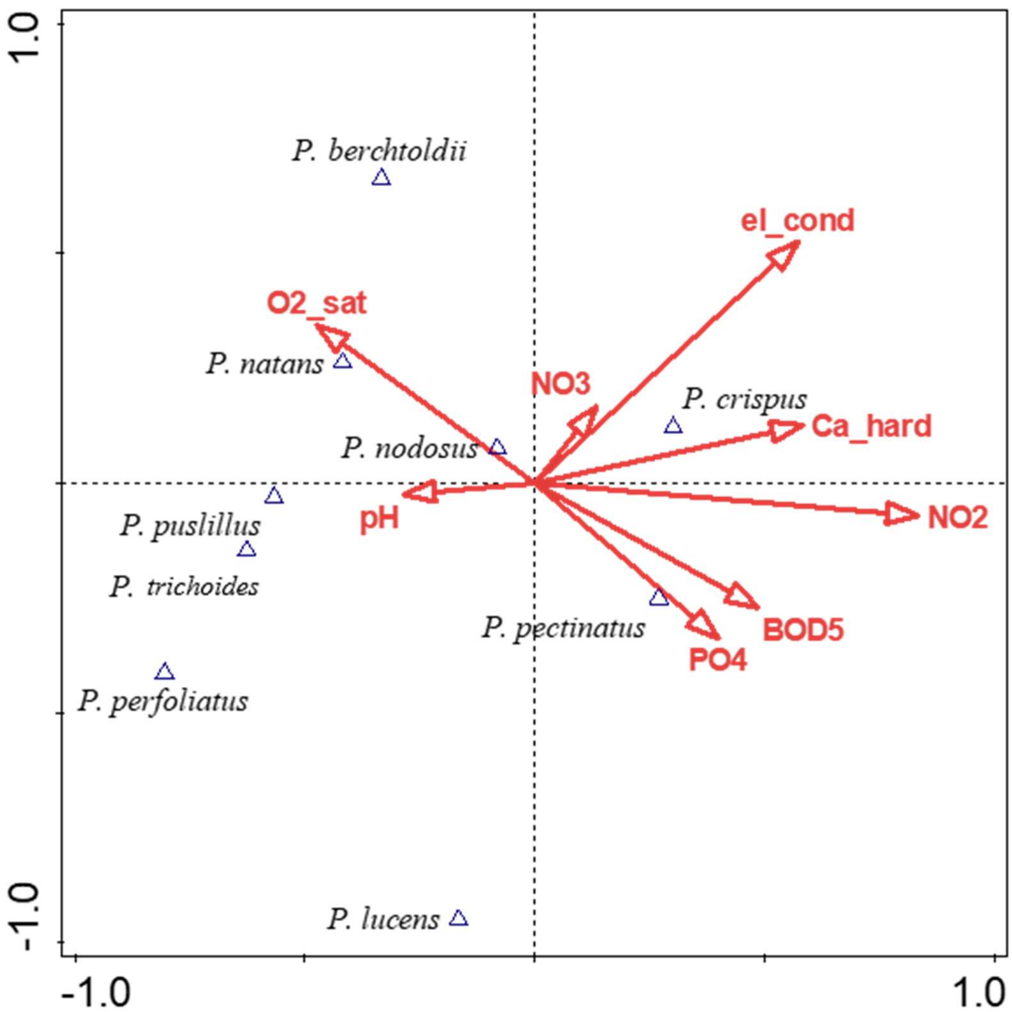

Figure 25: CCA – Explained variation: 1st axis 3.56% (41.15% fitted variation), 2nd axis 2.27% (26.21% fitted variation).

In Figure 26 we can see species responses to the components of environmental parameters on the first axis of CCA (parameters are shown in Appendix 2). The figure shows response of *Potamogeton* species to the increase of trophy from left to the right. *P. pectinatus* and *P. crispus* show correspondence with the higher levels of nutrients and indicate eutrophication. In the middle are optimums for *P. nodosus* and *P. lucens*, and the rest of the species have their optimum on the left side, which indicates negative correspondence with parameters connected to higher trophy levels of water. This is especially prominent for. *P. perfoliatus*.

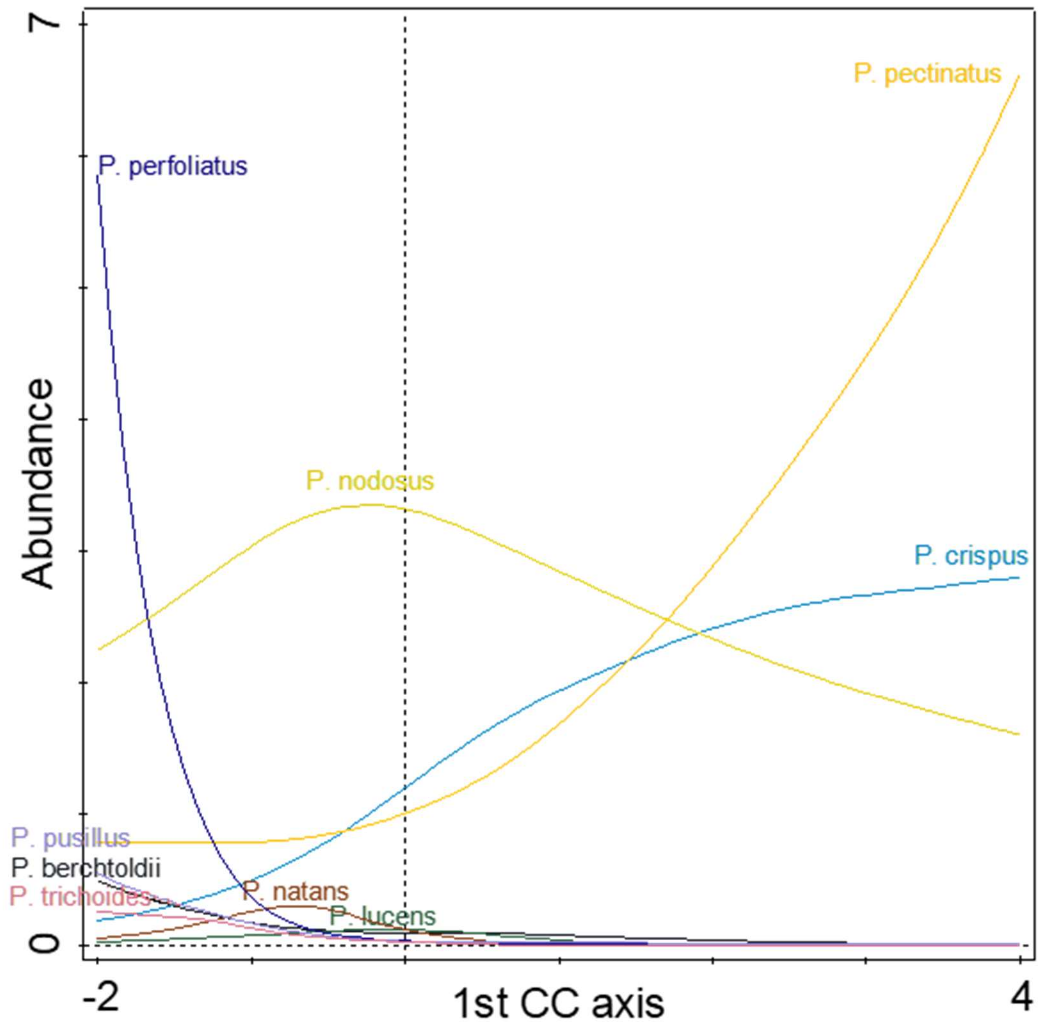

Figure 26: GAM of dependence of species abundances on components from the first CCA axis regarding environmental variables showed in Figure 25.

5.6. Vegetation analysis

The TWINSPAN analysis was performed so that the largest number of clusters into which the total set of relevés was divided was 10, but that the highest value of average Sørensen dissimilarity was for two (0.729) and three clusters (0.721). Due to similar values, three groups were retained to obtain a more detailed insight into the vegetation structure. The results are shown in Table 5.

Table 5. Synoptic table with percentage frequency and modified fidelity index.

Group No.	1		2		3	
No. of relevés	28		78		60	
Potamogeton nodosus Poir.	50	---	79	21.0	67	1.9
Sparganium erectum L.	4	---	68	31.9	65	27.7
Potamogeton crispus L.	7	---	17	---	55	46.2
Agrostis stolonifera L.	7	---	9	---	43	41.7
Lythrum salicaria L.	.	---	15	---	38	37.7
Phalaris arundinacea L.	.	---	8	---	38	45.1
Myriophyllum spicatum L.	71	36.3	29	---	37	---
Mentha aquatica L.	.	---	8	---	33	40.5
Berula erecta (Huds.) Coville	4	---	17	---	30	25.1
Alisma plantago-aquatica L.	7	---	37	23.6	25	3.2
Leersia oryzoides (L.) Sw.	.	---	22	12.1	25	18.3
Phragmites australis (Cav.) Trin. ex Ste	4	---	10	---	22	21.5
Iris pseudacorus L.	.	---	6	---	22	29.9
Lemna minor L.	.	---	58	52.6	18	---
Typha latifolia L.	4	---	8	---	17	17.9
Callitriche sp.	.	---	5	---	17	25.6
Potamogeton pectinatus L.	68	50.5	19	---	15	---
Veronica anagallis-aquatica L.	4	---	.	---	15	25.8
Sparganium emersum Rehmann	4	---	13	8.4	12	5.6
Alisma lanceolatum With.	4	---	4	---	12	15.4
Nasturtium officinale W. T. Aiton	4	---	1	---	12	19.1
Scirpus lacustris L.	.	---	5	---	12	18.7
Leptodictyum riparium (Hedw.) Warnst.	14	13.2	3	---	10	2.6
Polygonum mite Schrank	7	---	19	15.4	10	---
Elodea canadensis Michx.	4	---	5	---	10	11.0
Juncus effusus L.	.	---	.	---	8	23.9
Spirodela polyrhiza (L.) Schleid.	4	---	62	60.9	8	---
Myosotis scorpioides L.	.	---	1	---	8	20.6
Scirpus sylvaticus L.	.	---	.	---	8	23.9
Glyceria maxima (Hartm.) Holmb.	.	---	14	17.8	8	2.3
Rorippa sylvestris (L.) Besser	4	---	4	---	7	6.6
Rumex hydrolapathum Huds.	.	---	1	---	7	17.7
Juncus articulatus L.	.	---	.	---	7	21.3
Veronica beccabunga L.	.	---	4	1.3	7	12.2
Solanum dulcamara L.	.	---	1	---	7	17.7
Nuphar lutea (L.) Sm.	29	1.6	47	31.5	7	---
Potamogeton natans L.	.	---	3	---	5	11.2
Juncus inflexus L.	.	---	.	---	5	18.4
Persicaria hydropiper (L.) Delarbre	.	---	4	3.8	5	8.6
Ceratophyllum demersum L.	21	---	71	57.8	5	---
Echinochloa crus-galli (L.) P. Beauv.	.	---	4	6.7	3	4.3
Pellia endiviifolia (Dicks.) Dumort.	.	---	.	---	3	15.0
Lycopus europaeus L.	.	---	.	---	3	15.0
Fontinalis antipyretica Hedw.	18	29.8	.	---	3	---
Lemna trisulca L.	4	---	10	13.8	3	---
Leersia oryzoides cf.	.	---	.	---	3	15.0
Glyceria fluitans (L.) R. Br.	.	---	.	---	3	15.0
Mentha longifolia (L.) Huds.	.	---	.	---	3	15.0
Potamogeton berchtoldii Fieber	7	7.9	4	---	3	---
Rorippa amphibia (L.) Besser	.	---	6	12.6	3	---
Pohlia melanodon (Brid.) A. J. Shaw	.	---	.	---	3	15.0
Baldellia ranunculoides (L.) Parl.	4	9.9	.	---	2	---
Sagittaria sagittifolia L.	11	---	33	35.6	2	---
Nitella opaca (C.Agardh ex Bruzelius) C.	7	17.6	.	---	2	---
Ranunculus trichophyllus Chaix	4	9.9	.	---	2	---
Physcomitrella patens (Hedw.) Bruch et S	.	---	1	2.1	2	4.9
Butomus umbellatus L.	11	---	29	31.7	2	---
Najas marina L.	11	1.4	18	18.4	2	---
Marsilea quadrifolia L.	.	---	1	2.1	2	4.9
Marchantia polymorpha L.	.	---	.	---	2	10.6
Typha angustifolia L.	.	---	1	2.1	2	4.9
Salvinia natans (L.) All.	.	---	12	24.6	2	---
Drepanocladus aduncus (Hedw.) Warnst.	.	---	1	2.1	2	4.9
Persicaria maculosa Gray	.	---	1	2.1	2	4.9
Brachythecium mildeanum (Schimp.) Schimp	.	---	1	2.1	2	4.9
Equisetum arvense L.	.	---	.	---	2	10.6
Pellia neesiana (Gottsche) Limpr.	.	---	.	---	2	10.6
Cyperus glomeratus L.	.	---	4	10.6	2	---
Myriophyllum verticillatum L.	.	---	4	10.6	2	---
Urtica dioica L.	.	---	.	---	2	10.6
Brachythecium rivulare Schimp.	.	---	.	---	2	10.6
Myosoton aquaticum (L.) Moench	.	---	.	---	2	10.6
Nitella gracilis (J.E.Smith) C.Agardh	.	---	.	---	2	10.6
Barbarea vulgaris W. T. Aiton	.	---	.	---	2	10.6

Ranunculus repens L.	.	---	.	---	2	10.6
Hydrocharis morsus-ranae L.	.	---	8	18.6	2	---
Cratoneuron filicinum (Hedw.) Spruce	.	---	.	---	2	10.6
Oxyrrhynchium hians (Hedw.) Loeske	.	---	.	---	2	10.6
Pulicaria dysenterica (L.) Bernh.	.	---	.	---	2	10.6
Eleocharis palustris (L.) R. Br.	.	---	3	6.9	2	1.5
Brachythecium rutabulum (Hedw.) Schimp.	.	---	.	---	2	10.6
Potentilla reptans L.	.	---	.	---	2	10.6
Epilobium hirsutum L.	.	---	.	---	2	10.6
Callitriche cophocarpa Sendtn.	.	---	.	---	2	10.6
Rumex palustris Sm.	.	---	.	---	2	10.6
Ranunculus circinatus Sibth.	4	15.5	.	---	.	---
Cinclidotus riparius (Host ex Brid.) Arn	14	31.6	.	---	.	---
Rhynchostegium riparioides (Hedw.) Cardo	7	22.1	.	---	.	---
Fissidens fontanus (Bach.Pyl.) Steud.	7	22.1	.	---	.	---
Lindernia dubia (L.) Pennell	.	---	.	---	.	---
Chiloscyphus pallescens (Ehrh. ex Hoffm.	4	15.5	.	---	.	---
Fissidens crassipes Wilson ex Bruch & Sc	4	15.5	.	---	.	---
Palustriella falcata (Brid.) Hedenäs	4	15.5	.	---	.	---
Lysimachia nummularia L.	4	15.5	.	---	.	---
Cinclidotus fontinaloides (Hedw.) P. Bea	7	22.1	.	---	.	---
Fontinalis hypnoides Hartm. var. duriaei	4	15.5	.	---	.	---
Potamogeton trichoides Cham. & Schltdl.	4	7.6	3	2.6	.	---
Scirpus maritimus L.	.	---	3	13.1	.	---
Persicaria lapathifolia (L.) Delarbre	.	---	4	16.1	.	---
Riccia fluitans L.	.	---	3	13.1	.	---
Nitellopsis obtusa (N.A.Desvaux) J.Grove	7	15.6	3	---	.	---
Lysimachia vulgaris L.	.	---	3	13.1	.	---
Ricciocarpos natans (L.) Corda	.	---	3	13.1	.	---
Nymphoides peltata (S. G. Gmel.) Kuntze	.	---	3	13.1	.	---
Polygonum amphibium L.	.	---	3	13.1	.	---
Ludwigia palustris (L.) Elliott	.	---	4	16.1	.	---
Lemna minuta Kunth	.	---	8	22.9	.	---
Potamogeton perfoliatus L.	21	29.6	6	---	.	---
Trapa natans L.	.	---	18	35.7	.	---
Najas minor All.	11	11.9	9	6.9	.	---
Potamogeton pusillus L.	4	1.0	6	12.2	.	---
Potamogeton lucens L.	.	---	4	16.1	.	---
Utricularia vulgaris L.	.	---	4	16.1	.	---
Lemna gibba L.	4	2.8	5	9.4	.	---
Vallisneria spiralis L.	14	22.5	5	---	.	---
Elodea nuttallii (Planch.) H. St. John	4	7.6	3	2.6	.	---
Polygonum hydropiper	.	---	1	9.3	.	---
Chara contraria A.Braun ex Kützing	.	---	1	9.3	.	---
Oenanthe aquatica (L.) Poir.	.	---	1	9.3	.	---
Azolla filiculoides Lam.	.	---	1	9.3	.	---
Stratiotes aloides L.	.	---	1	9.3	.	---
Ranunculus fluitans Lam.	7	18.6	1	---	.	---
Ludwigia peploides (Kunth) P. H. Raven	.	---	1	9.3	.	---
Carex elata All.	.	---	1	9.3	.	---
Portulaca oleracea L.	.	---	1	9.3	.	---
Bryum klinggraeffii Schimp.	.	---	1	9.3	.	---
Cyperus fuscus L.	.	---	1	9.3	.	---
Zannichellia palustris L.	.	---	1	9.3	.	---
Riccia cavernosa Hoffm.	.	---	3	13.1	.	---
Calystegia sepium (L.) R. Br.	.	---	1	9.3	.	---
Veronica anagalloides Guss.	.	---	1	9.3	.	---
Callitriche stagnalis Scop.	4	10.9	1	---	.	---
Bryum argenteum Hedw.	.	---	1	9.3	.	---
Leptobryum pyriforme (Hedw.) Wilson	.	---	1	9.3	.	---
Riccia rhenana Lorb. ex Müll. Frib.	.	---	1	9.3	.	---

In Table 5, the first group consists of relevés with relatively low species diversity and is also the smallest group with only 28 relevés. The second group is made of relevés in which many floating species have been recorded (*Lemna minor, Spirodella polyrhiza, Nuphar lutea*) as well as the species of highly eutrophic waters (*Ceratophyllum demersum*). The third group consists of relevés with marshland vegetation (*Agrostis stolonifera, Phragmites australis, Iris pseudacorus*).

Potamogeton species that fall into the first group are *P. pectinatus, P. berchtoldii, P. perfoliatus* and *P. trichoides*, while *P. nodosus, P. pusillus* and *P. lucens* fall into the second group.

Furthermore, *P. crispus, P. natans* and *P. lucens* fall into the third group in which *P. nodosus* was highly frequent as well. The TWINSPAN dendrogram shows that groups 1 and 2 are more similar to each other compared to group 3 (Figure 27).

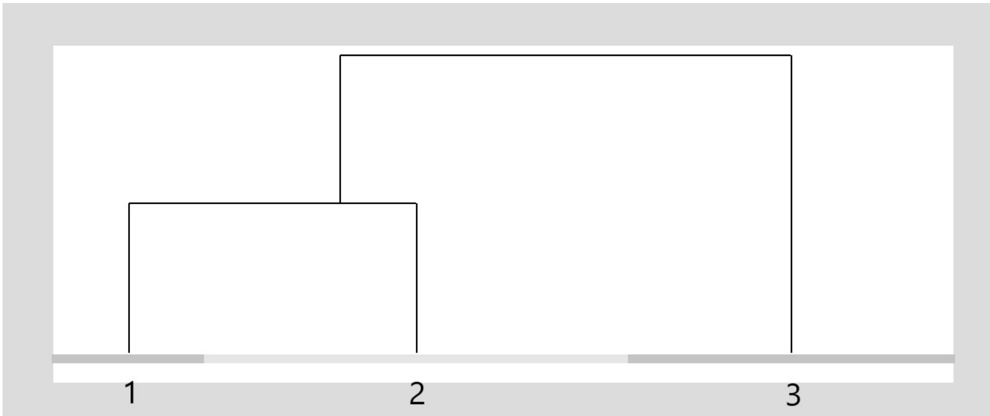

Figure 27. Dendrogram derived from TWINSPAN analysis of vegetation groups showing divisive clustering and their relationship.

DCA plot made from DCA axes also shows the relationship between the relevés that form 3 groups (Figure 28). It shows quite a clear grouping of 3 types of relevés with only slightly mixing.

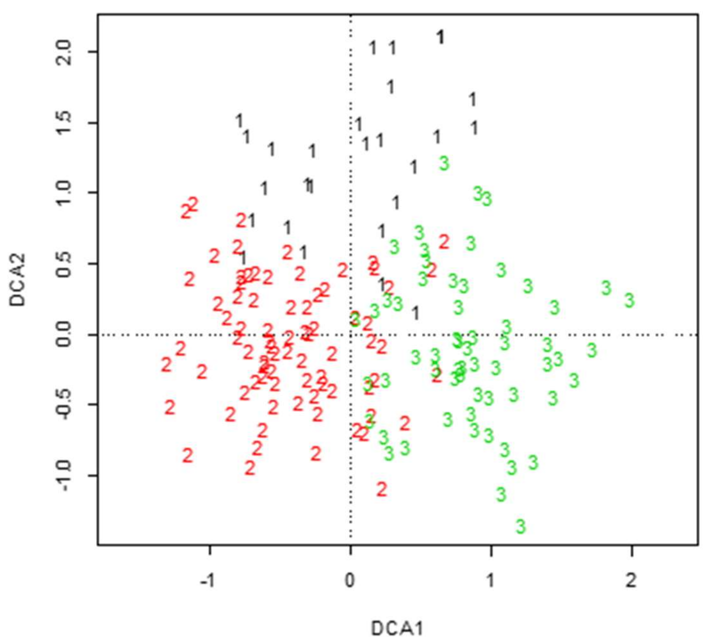

Figure 28: DCA of the interrelationship of vegetation groups. Eigenvalues - 1st axis 0.3809 and 2nd axis 0.3135.

Different surface water types represented in each group derived from TWINSPAN analysis are shown in Table 6.

Table 6: Surface water types represented in groups derived from TWINSPAN analysis.

Group	HR-R_1	HR-R_2B	HR-R_3A	HR-R_4	HR-R_5A	HR-R_5B	HR-R_2A	HR-R_3B
1	1	3	1	12	4	6		
2		3		41	3	2	21	8
3	2	15	2	14		1	24	1

In the first TWINSPAN group, the most common abiotic types were medium and large lowland watercourses (HR-R_4) and very large lowland watercourses with silicate and carbonate geology – the lower reach of Mura and middle reach of Drava and Sava (HR-R_5B).

In the second group, which was the richest in species as well as in relevés, the most common types were medium and large lowland watercourses (HR-R_4) and small lowland watercourses on a clayey-sandy substrate (HR-R_2A).

In the third group, the most common types were small lowland watercourses on a clayey-sandy substrate (HR-R_2A), small lowland watercourses on gravel substrate (HR-R_2B) and medium and large lowland watercourses (HR-R_4).

6. Discussion

6.1. Frequency

The most frequent species in the Pannonian ecoregion is *P. nodosus*, followed by *P. crispus* and *P. pectinatus*. This could mean that these species are most adapted to the abiotic parameters of the habitats of the Pannonian ecoregion of Croatia. These three species are mutually very different when comparing their leaf morphology. On the other hand, in other works (Preston, 1995) they were found in a great variety of habitats and ecological conditions. They also share tolerance to eutrophication and pollution. The species represented with low frequency in the Pannonian ecoregion are *P. lucens*, *P. natans* and *P. trichoides*, which share tolerance to a wide range of habitats along with tolerance to deep waters. Overall, these results could imply on eutrophic character of waters of Pannonian ecoregion.

6.2. Distribution

Distribution data showed that all the *Potamogeton* species are mostly found in the upper or middle reaches of rivers of the western part of the Pannonian ecoregion or central Croatia, which are characterized by hilly terrain and slow and small to middle-sized rivers. This supports the result of counting the body types. They were mostly found in water bodies which are classified as small lowland watercourses on gravel substrate (HR-R_2B), small lowland watercourses on a clayey-sandy substrate (HR-R_2A) and medium and large lowland watercourses (HR-R_4). These types of surface water present a favourable habitat for *Potamogeton* species which need slow but moving waters and rather shallow but wide rivers in which suitable conditions regarding the light, temperature and nutrient content are present.

6.3. Responses to environmental parameters

Potamogeton species live in mesotrophic to eutrophic waters, and some of them do not tolerate over-polluted habitats. The average values of water chemistry have shown that the habitat conditions in this study were rated as good and very good according to Croatian Regulation on water quality standards (NN 96/2019). Comparing the nutrient levels present in *Potamogeton* localities in other studies, the nutrients were often far higher in this study.

6.3.1. *Potamogeton berchtoldii*

In this study, the results for *P. berchtoldii* have shown the highest value of average dissolved oxygen and the lowest values of total phosphorus and orthophosphates, but with average values of total nitrogen and nitrates compared to other species. Nevertheless, GAMs for the abundance of *P. berchtoldii* dependent of total nitrogen and nitrates suggest that the species prefers higher levels of these nutrients.

However, response curves of the species abundance to other nutrients, along with the lowest average concentration of phosphorous suggest that the species prefers the least eutrophic habitats compared to other *Potamogeton* species. The majority of the rivers in the Pannonian ecoregion has higher trophy levels, and this might support the fact that *P. berchtoldii* was found on only seven sampling sites in total, although the species was so far reported to show a wide tolerance (Preston, 1995).

6.3.2. *Potamogeton crispus*

Ranges of water physicochemical parameters previously reported for *P. crispus* in other similar studies (Bolduan *et al.*, 1994) were: pH in range from 8.3 to 9.0, electrical conductivity in range of 358 to 423 ms, alkalinity in range from 118 to 171 ppm, ammonium from 123.5 to 491 ppb, total nitrogen from 1395 to 1760 ppb, nitrates from 52.5 to 495 ppb and total phosphorus from 52.5 to 102.25 ppb. The results of this study differ for alkalinity, total nitrogen and total phosphorus, which are higher. By contrast, the values of the average temperature, electrical conductivity, ammonium and pH value are within the ranges previously known for *P. crispus*. Average electrical conductivity in *P. crispus* localities is the highest when compared to that in localities of all other *Potamogeton* species in this study. The average temperature in *P. crispus* localities in this study was among the highest, being 14.45 °C, while in other available studies it varied from 1 to 18°C. The species was reported to grow mostly on sandy to loamy mud substrates and in lentic or lotic waters with low velocity. This corresponds to the results of this study, i.e., habitats such as small lowland watercourses on a clayey-sandy substrate (HR-R_2A), medium and large lowland watercourses (HR-R_4) and small lowland watercourses on gravel substrate (HR-R_2B) abiotic water types. In vegetation analysis *P. crispus* was grouped into marshland vegetation group. It also has floating leaves which can help it survive anoxic conditions in which it lives. Response curves and CCA have shown that *P. crispus* is associated with higher nutrient levels and has the highest response to BOD. Therefore, *P. crispus* can be used as an indicator of eutrophication.

6.3.3. *Potamogeton lucens*

P. lucens is not tolerable to eutrophication and has a negative response to ammonium. The locations where *P. lucens* was found have the lowest electrical conductivity and the lowest total nitrogen of all the species. This all fits well with the reports that *P. lucens* does not tolerate high concentrations of ammonium (Litav and Lehrer, 1978). Also, only 1.81% of total findings of *P. lucens* could lead to the conclusion that there are a lot of surface waters with high ammonium concentrations or high trophy levels in general. On the other hand, small number of findings could mean that there are not a lot of deep waters which *P. lucens* prefers as reported (Preston, 1995). Still, *P. lucens* has potential to be indicator of waters with lower concentrations of ammonium.

6.3.4. *Potamogeton natans*

P. natans locations have the lowest values of total phosphorus among all the *Potamogeton* species in this study as well as low average total nitrogen. On the other hand, it has the highest electrical conductivity. It has a clearly negative response to phosphorous and nitrites and positive to oxygen saturation in CCA. Nitrites in the water generally represent presence of fertilizers from the farmlands nearby and response curve between abundance and nitrites describes that *P. natans* does not tolerate high content of fertilizers. *P. natans* was situated into group of swampy vegetation according to TWINSPAN. It was found almost entirely in the medium and large lowland watercourses (HR-R_4) abiotic type which fits with the report that loam and clay mud are his favourite rooting media (Ságová-Marecková and Kvet, 1995).

6.3.5. *Potamogeton nodosus*

Abundance of *P. nodosus* is dependent on total nitrogen, nitrates and total suspended particles in water as shown on response curves. Electrical conductivity usually implies a lot of dissolved matter, which can mean higher level of trophy. Higher trophy level goes along with higher concentration of nitrogen compounds in water. Nitrogen, especially in a form of nitrates is essential for protein synthesis and plant growth. This supports the dependency of abundance of *P. nodosus* on nitrogen, electrical conductivity, and higher trophy level in general.

P. nodosus has the highest average values of ammonium and nitrates. It also had a very clear positive response to other nutrients that represent eutrophication in response curves and CCA. Its response curves are also jumping out the most among the other *Potamogeton* species. The ammonium value is far too high when comparing with 0.255±0.107 from other reports, while orthophosphates fitted in a decent interval of 0.191±0.116. These reports characterised *P. nodosus* even as hypertrophic specie (Haury *et al.*, 2006). Still, response of *P. nodosus* is moderately negative on total phosphorous and BOD and clearly negative on nitrites and COD. Therefore, there is a clear distinction between *P. nodosus* as mesotrophic species and *P. crispus* and *P. pectinatus* as eutrophic species on the other side.

In vegetation analysis it was put in the group of floating plants but also, it had high frequency in the swampy group. The floating leaves allow it to survive in these conditions and to fit in the floating group. It was found in all abiotic types of water bodies, but majority of findings was in medium and large lowland watercourses (HR-R_4) and small lowland watercourses on a clayey-sandy substrate (HR-R_2A). All in all, *P. nodosus* can be indicator of high concentrations of total nitrogen in waters.

6.3.6. *Potamogeton pectinatus*

Abundance of *P. pectinatus* is negatively dependent on dissolved oxygen and pH value. Dissolved oxygen is in negative correlation with trophy level since waters with higher trophy level have higher rate of oxygen consumption. This can support previously mentioned tolerance to eutrophication of *P. pectinatus* because its abundance is falling with rise of dissolved oxygen. Abundance of *P. pectinatus* is also in negative correlation with pH value, which can also be a consequence of the eutrophication.

The average temperature of *P. pectinatus* in this study is the highest as well as the total nitrogen, orthophosphates, and total phosphorus. It was found in medium and large lowland watercourses (HR-R_4), small lowland watercourses on a clayey-sandy substrate (HR-R_2A), small lowland watercourses on gravel substrate (HR-R_2B) and very large lowland watercourses with silicate and carbonate geology – the lower reach of Mura and middle reach of Drava and Sava (HR-R_5B) water types which can support this high values. This fits with the reports that he has high affinity to phosphorus in water which might be contributed by periphyton on his on leaves (Howard-Williams and Allanson, 1981).

6.3.7. *Potamogeton perfoliatus*

P. perfoliatus locations show the lowest alkalinity and it responds negatively on increase of nutrient concentrations in water. In CCA it is on opposite side to the vectors indicating main nutrients. It was reported to tolerate brackish waters and to be sensitive on higher eutrophication and phytotoxins in organic rich sediments of water (Caffrey and Kemp, 1991; Neundorfer and Kemp, 1993). This could support the findings in very large lowland watercourses with the source in Dinaric ecoregion (HR-R_5A).

6.3.8. *Potamogeton pusillus*

P. pusillus locations show the lowest average value of orthophosphates and high value of dissolved oxygen. It was reported that the species prefers mesotrophic habitats and has a good effect on water quality (Takeda *et al.*, 2014), which could explain its low incidence in the data set. Its response to nutrients was low in CCA. Since eutrophic species in this study have higher incidence and *P. pusillus* does not, it could be indicator of better water quality.

6.3.9. *P. trichoides*

One of the two species with lowest incidence in the studied area is *P. trichoides*. Its locations show the lowest values for temperature, electrical conductivity and pH value. In CCA it is on opposite side to the vectors indicating main nutrients. It was reported to be a species connected to eutrophication but did not show that character in this work (Mesters, 1995). His more northern areal in Europe could be the cause of his low incidence in Croatia, which could be supported by low average temperature of its sites in comparison to the other species.

7. Conclusion

After discussing the results, we can conclude the following:

- *Potamogeton* species are distributed mostly in the western and central parts of Pannonian ecoregion of Croatia where predominate shallow and comparatively faster running surface waters. The most common species are *P. nodosus*, *P. crispus* and *P. pectinatus*.
- Macrophyte vegetation where *Potamogeton* species occur can be divided in three groups. In the first group, poor in species diversity, the highest incidence have *P. pectinatus, P. berchtoldii, P. perfoliatus* and *P. trichoides*. In the second group, the richest in species, with the highest incidence are present *P. nodosus, P. pusillus* and *P. lucens*. In the third group, characterised by higher occurrence of marshland species, the highest incidences have *P. crispus* and *P. natans*.
- Ranges of the average annual physicochemical parameters of water in the habitats of *Potamogeton* species are the following: temperature from 12.9° C (*P. trichoides*) to 14.56° C (*P. crispus*), electrical conductivity from 379.74 (*P. lucens*) to 562.45 μScm^{-1} (*P. crispus*), alkalinity from 192.28 (*P. perfoliatus*) to 259.49 $mgCaCO_3l^{-1}$ (P. *crispus*), ammonium from 0.13 (*P. natans*) to 0.70 mgl^{-1} (*P. nodosus*), pH from 7.72 (*P. trichoides*) to 8.01 (*P. perfoliatus*), dissolved oxygen from 8.27 (*P. lucens*) to 9.96 mgl^{-1} (*P. berchtoldii*), total nitrogen from 1.30 (*P. natans*) to 2.70 mgl^{-1} (*P. pectinatus*), nitrates from 0.60 (*P. trichoides*) to 1.48 mgl^{-1} (*P. nodosus*), orthophosphates from 0.03 (*P. berchtoldii*) to 0.15 mgl^{-1} (*P. pectinatus*), and total phosphorous from 0.07 (*P. berchtoldii*) to 0.29 mgl^{-1} (*P. pectinatus*).
- The species with the highest positive response to the increase of nutrient concentrations were *P. pectinatus* and *P. crispus*. *P. nodosus* has moderate response to nutrient concentrations, and *P. berchtoldii, P. lucens, P. natans, P. perfolliatus* and *P. pusillus* have low or negative response to the increase of nutrient concentrations.
- *P. perfoliatus* and *P. lucens* have their optima on sites with low levels of nutrients and could serve as indicators of good ecological status of waters, as well as *P. natans* and *P. pusillus*. *P. trichoides* and *P. berchtoldii* show similar optima, even though they have been reported as eutrophic species. Species which have the highest abundances in waters with high amounts of nutrients are *P. pectinatus* and *P. crispus*, while *P. nodosus* has broad

amplitude. However, small number of finding sites of certain species (*P. pusillus*, *P. trichoides* and *P. berchtoldii*) makes them less reliable as bioindicators.

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9. Curriculum Vitae

Nikola Geršak, born on 23. November 1996 in Zagreb has been living in Čakovec since childhood. There he has finished elementary school and high school for mathematics. He continued his studies on Faculty of forestry of University of Zagreb. After obtaining bachelor's in forestry, he signed up for master's in Environmental sciences on Faculty of science of University of Zagreb.

In first few years of studies, he was focused on volunteering in his leisure time, such as volunteering on music festivals or in the Electrical engineering student's club. In this club he had a chance to obtain a valuable organising, management, and workflow skills by organising student parties and concerts as well as to learn artistic DJ skill.

Still, on the masters he has put more effort to learn programmatic skills and work experience. During the pandemics he had a time to focus on programming in python and in 3rd semester he signed up for "Introduction to R programming language" subject on Faculty of electrical engineering and computing where he gained this valuable skill. This was a great basis for Erasmus internship in Madrid in his last semester in National institute for Agronomy research and technology (INIA) where he was working entirely in R to analyse the data concerning forest inventories.

Since the end of the 2nd semester of masters, he is working as a student intern in a company in the field of sustainable development and environmental protection – Dvokut-ecro ltd.

Author in:

- del Río, Miren; Geršak, Nikola; Adea, Jorge; Bravo-Oviedo, Andrés; Bravo, Felipe; Rodríguez, Javier; Ruiz-Peinado, Ricardo; 2021, Thinning for adaptation and mitigation in Mediterranean pine-oak mixed stands, Forstwissenschaftliche Tagung 2021, Freising

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Appendix 1 - The input data

No.	Station	Code - Croatian Waters	Stream	Year	x	y	Alkalinity (mgCaCO3/l)	Electrical conductivity (µS/cm)	pH	Total suspended materia (mg/l)	Temperature	Water hardness (mgCaCO3/l)	DOC (mgC/l)
1	Rogstrug, Podravske Sesvete	21077	Rogstrug	2016	557853	5095768	277.17	557.67	7.96	5.08	12.94	286.33	
2	Bistrec-Rakovnica II, most na putu polj.dobra D.Dubrava-Kotoriba	21050	Bistrec	2016	523783	5133214	299.42	717.33	8.03	14.91	12.34	361.25	
3	Blatnica, Blatnica	16109	Blatnica	2016	439268	5041705	140.67	291.31	7.55	14.58	14.16	145.17	
4	Brebernica, Donja Kupčina	16111	Brebernica	2016	443640	5048082	109.08	224.14	7.45	53.42	13.79	146.17	
5	Brodec, Peklenica, uz cestu kod osnovne škole	21054	Brodec	2016	498078	5150848	206.42	482.17	7.92	5.00	11.79	198.58	
6	Drava, Ormož	29160	Drava	2016	473461	5140405	116.75	284.36	8.01	13.08	23.79	138.94	
7	Glogovnica, prije utoka u Česmu	15371	Glogovnica	2016	499190	5070988	154.17	586.56	7.82	36.44	15.59	267.28	
8	Gostiraj, Ježdovec	51125	Gostiraj	2016	448484	5071592	261.92	669.08	8.09	25.75	14.08	296.83	
9	Kotoripski kanal, most Donja Dubrava – utok kanala Senečnjak	21046	Kotoripski kanal	2016	524294	5133954	305.67	692.33	7.72	7.73	12.65	334.75	
10	Krapina, Bedekovčina	17004	Krapina	2016	460787	5099822	288.00	597.25	8.13	14.88	11.80	315.03	
11	Krapina, Kupljenovo	17008	Krapina	2016	447116	5088518	279.00	628.17	8.09	15.15	12.74	310.11	
12	Lonja, Lipovec Lonjski	15480	Lonja	2016	489903	5067350	210.83	534.67	7.89	84.33	12.65	309.25	
13	Martinec, Bedekovčina	17703	Martinec	2016	461968	5100918	369.17	663.08	7.82	17.08	12.53	405.33	
14	Kašina	51157	Kašina	2016	477268	5078212	253.17	634.17	7.84	4.08	10.43	354.58	
15	Radonja, Tušilović	16342	Radonja	2016	430246	5027233	190.00	502.21	7.88	4.75	13.01	199.50	
16	Rečica, prije utoka u Kupu	16103	Rečica	2016	434829	5038250	142.33	296.61	7.65	9.67	13.16	147.08	
17	Reka, Domagović	16228	Reka	2016	433352	5055177	243.08	476.00	8.06	32.83	13.56	315.67	
18	Ruševica, kod mjesta Ribići	16803	Ruševica	2016	439083	5006577	209.83	407.23	7.64	4.67	12.22	228.92	
19	Spojni kanal Zelina-Lonja-Glogovnica-Česma, crp. st. Poljanski Lug	15592	Spojni kanal Zelina-Lonja-Glogovnica-Česma	2016	493331	5074872	233.58	553.08	7.81	18.75	12.13	311.92	
20	Spojni kanal (vt749), Jastrebarsko-Domagović	16241	Spojni kanal (vt749), Jastrebarsko-Domagović	2016	433993	5054431	224.33	561.07	7.64	27.17	13.91	284.67	
21	Stari Črnec, Vrbovec	15357	Stari Črnec	2016	497735	5080713	251.83	544.08	7.88	23.67	11.83	333.33	
22	Toplica, nizvodno od Daruvara	15231	Toplica	2016	554068	5050445	137.93	476.67	7.70	21.33	13.81	263.03	
23	Volavčica, Domagović	16227	Volavčica	2016	432456	5055217	248.25	483.15	8.11	37.92	13.43	309.75	
24	Zelina, Laktec	15590	Zelina	2016	479560	5080019	266.17	631.08	7.89	6.08	10.18	354.75	
25	Boščak II, most na cesti Domašinec - Kvitrovec	21052	Boščak	2016	507472	5143266	98.67	386.83	7.64	7.58	11.87	178.25	
26	Kupa, Donje Mekušje	16010	Kupa	2016	429470	5038981	176.90	349.75	8.05	4.22	15.28	192.13	
27	Kupa, Jamnička Kiselica	16004	Kupa	2016	449858	5045490	179.58	357.93	8.03	4.51	15.06	196.18	
28	Kupa, Mala Gorica	16202	Kupa	2016	479748	5037509	176.30	354.00	8.01	6.82	16.97	193.38	
29	Kupčina, Donja Kupčina	16225	Kupčina	2016	444466	5043830	138.50	298.79	7.68	23.92	14.21	211.08	
30	Glina, nizvodno od Brusovače	16219	Glina	2016	442654	5008051	222.09	451.15	7.94	3.56	13.21	245.62	
31	Glina, Glina	16221	Glina	2016	467296	5021876	194.83	408.93	8.05	8.70	13.34	214.52	
32	Glina, Skela	16229	Glina	2016	463509	5020062	241.75	390.88	8.03	5.00	14.99	237.25	
33	Bistra Koprivnička, most kod Molvi	21079	Bistra Koprivnička	2016	541012	5109555	269.17	589.67	7.68	6.19	13.38	273.42	
34	Česma, Siščani	15354	Česma	2016	510900	5076317	137.60	501.11	7.77	47.56	15.10	238.19	
35	Horvatska, Veliko Trgovišće	17103	Horvatska	2016	450139	5096157	315.42	582.00	7.92	18.08	13.72	338.00	
36	Ždalica, Ždala	21107	Ždalica	2016	549861	5114742	310.50	714.75	7.65	12.60	8.78	382.88	
37	Ilova, most na cesti Tomašica - Sokolovac	15223	Ilova	2017	539014	5050368	242.33	490.00	7.87	69.53	13.61	247.42	
38	Sloboština, Okučani	15488	Sloboština	2017	554683	5013690	152.26	313.00	7.89	8.17	13.24	132.51	
39	Utinja, Vratečko (prije utoka u Kupu)	16746	Utinja	2017	469631	5036160	257.00	506.60	7.97	6.60	15.75	237.06	
40	Velika, uzvodno od Poznanovca	17305	Velika	2017	465372	5101622	305.80	573.00	7.90	7.02	17.62	327.44	
41	Vučica, Petrijevci	21007	Vučica	2017	657695	5055049	254.44	542.11	7.72	25.89	15.49	276.00	
42	Vučica, Marjančaci	21020	Vučica	2017	647962	5057010	220.83	486.00	7.80	78.75	13.16	237.85	
43	Slatinska Čađavica, Čađavica	21033	Slatinska Čađavica	2017	605619	5067497	324.40	852.40	7.62	24.70	15.16	363.20	
44	Bistra, jugozapadno od Darde	21038	Bistra	2017	667545	5054356	381.67	857.00	7.52	11.11	15.99	427.11	
45	Voća, Ribić Breg	21120	Voća	2017	471698	5123605	263.33	443.33	7.43	16.33	20.17	265.33	
46	Žarovnica, Žarovnica	21121	Žarovnica	2017	465324	5121772	258.75	459.00	7.43	14.75	19.30	262.00	
47	Segovina, Đelekovec	21126	Segovina	2017	527341	5122546	263.00	535.50	7.73	5.60	17.15	285.50	
48	Iskrica, Šaptinovci	21205	Iskrica	2017	621678	5050046	213.89	477.22	7.79	19.78	15.45	248.00	
49	Našička rijeka, Jelisavac	21209	Našička rijeka	2017	627322	5043746	237.22	670.33	7.87	25.11	15.32	270.22	
50	Vučica, most na cesti Staro Petrovo Polje - Zokov Gaj	21314	Vučica	2017	616216	5054732	146.67	294.00	7.86	19.89	15.23	164.44	
51	potok Rakovica, Strmec	51132	Rakovnica	2017	444662	5076059	269.50	551.80	7.30	10.35	20.24	301.25	
52	potok Vrapčak, nakon utoka Črnomerca	51140	Vrapčak	2017	456344	5071502	189.00	422.40	7.85	30.08	24.04	221.00	
53	Lateralni kanal Adžamovka - Orljava, na cesti od Vrbove prema autocesti	13009	Lateralni kanal Adžamovka - Orljava	2017	584802	5007398	327.16	692.73	7.93	57.12	15.55	241.53	
54	Orljava, ušće	13012	Orljava	2017	596587	4995795							
55	Una, most na utoku	14001	Una	2017	532402	5013598	213.33	443.33	8.13	7.47	7.60	237.57	
56	Una, Hrvatska Kostajnica	14002	Una	2017	503908	5009126	214.00	446.50	8.25	8.40	7.00	244.75	
57	Svinica, Svinica otvoreno	16234	Svinica	2017	502428	5018769	248.80	443.00	7.87	12.44	17.83	148.96	
58	Subocka, Novi Grabovac	15496	Subocka	2017	537153	5028767	255.00	491.00	8.02	16.00	15.13	247.50	
59	Una, granica Bosanski Novi	14005	Una	2017	489964	4989986	200.14	435.57	8.23	3.50	15.65	228.36	
60	Sutla, Harmica	18001	Sutla	2018	436684	5083915	242.29	534.43	8.14	34.36	13.66	285.53	2.39
61	Odra II, Čička Poljana	51133	Odra	2018	474858	5059371	277.14	609.86	7.84	5.89	15.67	341.74	2.03
62	Sutlišće III	51159	Sutlišće	2018	438909	5089362	256.25	507.92	7.78	21.73	14.65	260.92	
63	Rešetarica, Vrbje	10502	Rešetarica	2018	573410	5005739	296.25	632.08	7.91	12.68	13.20	170.12	2.50
64	Zapadni lateralni kanal Biđ polja, Poljanci prije utoka u Savu	12304	Zapadni lateralni kanal Biđ polja	2018	634218	5000885	213.04	464.42	7.91	13.25	16.03	149.87	
65	Lateralni kanal Adžamovka, Orljava - Lužani	13008	Lateralni kanal Adžamovka	2018	594571	5004269	237.75	501.75	7.89	32.79	13.63	148.77	
66	Londža, most u Pleternici	13200	Londža	2018	604003	5018043	172.17	405.50	7.80	301.67	11.30	205.25	4.18
67	Karašica, Črnkovci	21012		2018	639705	5064765	190.71	405.43	7.69	19.10	14.01	198.79	3.63
68	Stara Drava - prema jezeru Sakadaš, ustava Kopačevo	21018	Stara Drava	2018	679310	5054635	296.67	570.33	8.01	11.58	16.46	344.67	
69	Karašica, cesta Crnac - Krčenik	21019	Karašica	2018	614126	5066430	181.25	344.83	7.88	26.67	14.43	195.00	4.46
70	Karašica, nizvodno od Valpova	21021	Karašica	2018	651266	5058431	219.58	446.17	7.70	19.92	13.55	235.67	4.71
71	Županijski kanal, Vaška	21026		2018	590839	5076171	343.75	672.17	7.68	13.00	13.68	376.00	
72	Spojni kanal Profesor Bella (Vojlovica-Voćinka -Drava), Čađavica	21035	Spojni kanal Profesor Bella	2018	607826	5068848	219.17	427.89	7.75	34.92	14.54	251.67	
73	Lateralni kanal, most na cesti Čakovec - Mihovljan	21042	Lateralni kanal, most na cesti Čakovec - Mihovljan	2018	496304	5139701							
74	Gliboki II, most kod Sigeteca	21082	Gliboki	2018	534432	5117292	268.08	557.58	7.93	5.08	14.22	283.50	3.95
75	Donji obodni kanal HE Čakovec, Štefanec	21113	Donji obodni kanal HE Čakovec	2018	497381	5129590	173.33	385.00	7.41	12.33	13.40	196.67	2.54
76	Bistra, Krajnica	21125	Bistra	2018	551015	5102032	294.17	578.58	7.87	5.57	13.92	308.08	
77	Poganovečko - Kravički kanal, Josipovac	21214	Poganovečko - Kravički kanal	2018	662896	5050910	329.58	396.45	8.01	13.08	13.36	351.67	
78	Obuhvatni kanal Đurđevac, Đurđevac	21216	Obuhvatni Đurđevac	2018	545017	5098221	161.25	307.25	7.79	21.85	13.93	166.75	
79	Županijski kanal, Budrovac Lukački	21223	Županijski kanal	2018	576406	5085038	410.42	611.65	7.51	11.92	13.11	421.67	
80	Drava, Legrad	29141	Drava	2018	529130	5128672	129.00	315.00	8.03	9.50	12.59	156.66	1.29
81	Nova Rijeka, most na cesti Staro Obradovci - Zokov Gaj	21314	Nova Rijeka	2018	614617.69	5055389.2	132.07	220.19	7.89	66.97	16.79	137.93	3.10
82	Kanal Lonja - Strug, cesta Okučani-St. Gradiška	15488	Kanal Lonja - Strug	2018	557076.76	5004032.34	206.38	447.30	7.87	126.50	14.75	237.83	7.84
83	Županijski kanal, Kapinci, 21015	21026	Županijski kanal	2018	593942	5074988	331.63	625.43	7.89	37.60	17.49	340.22	5.54
84	Bobotski kanal, Ernestinovo	21031	Bobotski kanal	2018	668375	5037638	354.11	846.43	8.20	39.09	15.50	385.83	7.46
85	Odvodni kanal HE Varaždin, Varaždin		Drava	2018	487564	5131817	155.10	294.97	7.97	34.17	11.60	164.17	1.81
86	Lijevi drenažni kanal akumulacije HE Dubrava	29141	Lijevi drenažni kanal akumulacije HE Dubrava	2018	507041	5131473	184.34	393.57	7.86	7.07	12.29	199.47	1.08
87	Odvodni kanal HE Čakovec, Otok		Drava	2018	505541	5131207	153.20	299.20	8.08	35.33	12.12	144.13	1.22
88	Desni obodni kanal HE Čakovec, Bartolovec	21113	Desni obodni kanal HE Čakovec	2018	494905	5129594			7.41			196.67	
89	Dovodni kanal HE Varaždin, Petrijanec		Drava	2018	479405	5135550.97	156.62	294.60	8.05	38.00	11.70	151.30	1.79
90	Obodni kanal HE Dubrava, Dubovac	29141	Obodni kanal HE Dubrava	2018	514585.11	5130005.96	172.10	359.00	7.97	5.17	12.55	180.63	0.92
91	Glogovnica, prije utoka u Česmu, D. Lipovčani	15371	Spojni kanal Zelina-Lonja-Glogovnica-Česma	2018	502666.96	5068462.19	287.60	657.33	8.03	36.20	16.58	309.17	5.50
92	Ilova, Veliki Zdenci	15226	Ilova	2018	548445.12	5058687.34	325.10	603.88	7.64	24.25	14.59	313.00	2.75
93	Oteretni kanal Kupa-Kupa, cesta D. Kupčina-Šišljavić	16225	Oteretni kanal Kupa-Kupa	2018	444599.38	5043654.52	217.48	432.50	7.98	21.83	15.35	248.10	5.26
94	Dovodni kanal akumulacije Pakra, Jamarica	15109	Dovodni kanal akumulacije Pakra	2018	533075.7	5032291.11	213.15	390.50	7.88	45.13	15.29	215.50	4.93
95	Pakra, Janja Lipa	15109	Pakra, Janja Lipa	2018	540106.16	5034249.73	237.45	484.38	7.97	73.55	14.79	235.00	3.60
96	Spojni kanal Kupčina	16224	Spojni kanal Kupčina	2018	432952.47	5047983.58	282.82	539.83	8.13	10.73	13.85	282.63	2.34
97	Gradna, Savrščak	51155	Gradna	2018	442118.54	5077460.62	262.21	565.86	8.37	14.51	12.84	293.17	1.37
98	Črnomerec, Srednjaci	51140	Črnomerec	2018	456269.65	5072559.34	204.76	940.00	8.10	20.60	12.28	272.46	3.11
99	Blinja, Komarevo	10052	Blinja	2019	496043	5030630	249.83	517.50	7.87	20.27	15.30	248.83	
100	Vrbova, Pleternica	12211	Vrbova	2019	603526	5017882	270.23	616.45	8.14	11.39	13.67	240.47	
101	Vrbova, Pleternica	12211	Vrbova	2019	603526	5017882	270.23	616.45	8.14	11.39	13.67	240.47	
102	Orljava, most u Pleternici	13002	Orljava	2019	602381	5017081	207.00	448.20	7.85	20.65	15.68	217.06	2.39
103	Orljava, uzvodno od Požege	13004	Orljava	2019	590317	5022183	185.60	370.90	8.03	24.64	15.79	189.70	1.70
104	Orljava, Kuzmica	13007	Orljava	2019	598415	5022007	206.70	448.50	7.88	17.71	15.59	218.87	2.24
105	Kanal Miroševa, Dubocac III	13010	Kanal Miroševa	2019	608639	4991287	314.23	572.82	7.39	80.79	13.18	225.38	
106	Kanal Bistra, uzvodno od Migalovaca	13234	Kanal Bistra	2019	612667	4997886	236.70	487.20	7.78	2.99	7.90	175.76	
107	Skočinovac, Resnik - prije utoka u Londzu	13240	Skočinovac	2019	604349	5018167	303.64	671.91	7.92	51.81	14.14	135.09	
108	Mrsunja, na cesti Oriovac - Slavonski Kobaš	13300	Mrsunja	2019	598101	5001527	269.77	533.55	7.71	10.96	14.02	174.27	
109	Odra, Sisak	16220	Odra	2019	488376	5039867	276.50	526.00	7.89	7.37	17.51	276.90	
110	Trnava III, most na cesti Čakovec-GP Goričan	21041	Trnava III	2019	514288	5141115	190.50	543.10	7.44	7.23	16.42	223.17	2.15
111	Vuka, na cesti Krndija - Poganovci	21061	Vuka	2019	647340	5037802	242.50	494.42	7.96	16.83	14.99	286.67	
112	Bednja, Mali Bukovec	21085	Bednja	2019	518363	5127947	258.60	526.60	7.92	22.72	16.11	269.99	3.04
113	Plitvica, most kod Kućana Gornjeg	21092	Plitvica	2019	490826	5125398	244.50	573.00	7.84	5.62	16.33	292.81	2.75
114	Plitvica, Veliki Bukovec	21093	Plitvica	2019	516530	5128372	270.80	654.60	7.94	6.02	16.16	327.97	1.73
115	Glogovnica, prije utoka u Česmu	15371	Glogovnica	2019	499190	5070988	251.50	531.19	7.40	35.16	16.05	249.50	
116	Glogovnica, Koritna	15374	Glogovnica	2019	498842	5080622	223.56	502.89	7.74	49.06	16.20	230.59	5.56
117	Lonja, Lipovec Lonjski	15480	Lonja	2019	489903	5067350	259.83	608.75	7.58	9.42	13.49	314.58	2.47
118	Plitvica, prije utoka Zbela	21069	Plitvica	2019	495694	5126813	222.20	520.60	7.34	44.90	17.16	210.50	
119	Toplica, nizvodno od Daruvara	15231	Toplica	2020	554068	5050445	247.00	454.36	8.29	17.31	15.09	265.36	2.30
120	Toplica, Sokolovac	15232	Toplica	2020	542041	5048833	271.82	489.55	7.71	16.47	14.72	291.27	
121	Česma, Siščani	15354	Česma	2020	510900	5076318	248.70	519.50	7.82	38.15	15.55	253.40	6.73

No.	Station	Code - Croatian Waters	Stream	Year	x	y	Alkalinity (mgCaCO3/l)	Electrical conductivity (µS/cm)	pH	Total suspended materia (mg/l)	Temperature	Water hardness (mgCaCO3/l)	DOC (mgC/l)
122	Stari Črnec, Vrbovec	15357	Stari Črnec	2020	497735	5080713	320.25	581.92	7.19	26.42	13.57	291.75	
123	Zelina, Laktec	15590	Zelina	2020	479560	5080019	321.18	720.45	7.94	8.52	13.51	350.36	
124	Zelina, Božjakovina	15591	Zelina	2020	483260	5075436	282.30	637.20	7.93	13.83	14.65	309.30	4.46
125	Spojni kanal Zelina-Lonja-Glogovnica-Česma, crp.st. Poljanski Lu	15592	Spojni kanal Zelina-Lonja-Glogovnica-Česma	2020	493331	5074872	281.11	597.00	7.79	32.78	14.59	296.89	4.89
126	Salnik, na cesti Rakovec - Samoborec	15597	Salink	2020	485889	5086229	214.17	361.50	6.94	24.50	11.64	214.42	
127	Kupa, Šišinec	16003	Kupa	2020	466999	5034260	204.90	353.50	8.33	2.00	15.77	208.00	1.41
128	Kupa, Jamnička Kiselica	16004	Kupa	2020	449858	5045489	203.60	360.10	8.25	2.12	15.81	211.80	1.37
129	Kupa, Donje Mekušje	16010	Kupa	2020	429470	5038981	195.10	350.10	8.23	2.00	16.22	205.20	1.18
130	Rečica, prije utoka u Kupu	16103	Rečica	2020	434829	5038250	168.75	372.83	7.61	29.92	11.13	177.42	
131	Skopljak, Gradec Pokupski	16106	Skopljak	2020	450566	5045385	334.67	896.78	6.91	19.17	11.63	185.83	
132	Veliki Potok, Bukovci	16107	Veliki Potok	2020	465450	5035442	204.83	345.50	7.86	7.68	12.33	225.75	
133	Blatnica, Blatnica	16109	Blatnica	2020	439268	5041705	178.08	354.67	7.53	31.67	11.02	187.42	
134	Trepča, Trepča (vodotok)	16110	Trepča	2020	455138	5037126	104.64	205.45	7.81	8.80	12.73	115.60	3.76
135	Brebernica, Donja Kupčina	16111	Brebernica	2020	443640	5048082	114.00	202.83	7.24	16.33	12.34	116.42	
136	Kupa, Mala Gorica	16202	Kupa	2020	479748	5037509	200.67	368.58	8.14	2.78	16.51	211.67	1.47
137	Glina, nizvodno od Brusovače	16219	Glina	2020	442654	5008051	230.08	420.75	7.97	3.31	12.94	250.08	2.06
138	Glina, Glina	16221	Glina	2020	467296	5021876	211.67	393.83	7.97	6.17	14.19	223.75	1.92
139	Glina, Slana	16223	Glina	2020	470517	5032798	203.00	374.08	8.05	9.77	13.36	239.00	
140	Kupčina, Donja Kupčina	16225	Kupčina	2020	444466	5043830	171.58	306.33	7.06	40.17	12.38	174.50	
141	Volavčica, Domagović	16227	Volavčica	2020	432456	5055217	312.83	545.67	7.47	6.00	13.81	339.58	
142	Reka, Domagović	16228	Reka	2020	433352	5055177	324.25	532.42	7.51	7.00	14.08	330.50	
143	Glina, Skela	16229	Glina	2020	463509	5020062	219.45	418.00	7.90	4.71	14.05	251.00	
144	Perna, most nizvodno od vodocrpilišta	16233	Perna	2020	453693	5014262	126.32	230.55	7.82	4.85	11.95	158.30	
145	Hotnjica, Stari Farkašić	16240	Hotnjica	2020	470611	5039434	156.88	295.63	7.80	14.89	14.64	167.88	
146	Spojni kanal (vt749), Jastrebarsko-Domagović	16241	Spojni kanal vt749	2020	433993	5054431	366.92	702.08	7.19	16.50	14.12	339.50	5.61
147	Radonja, Tušilović	16342	Radonja	2020	430246	5027233	206.25	381.58	8.06	6.07	14.63	223.42	1.55
148	Ruševica, kod mjesta Ribići	16803	Ruševica	2020	439083	5006577	210.25	409.33	7.83	17.33	11.53	219.00	
149	Krapina, Zaprešić	17001	Krapina	2020	447392	5077436	291.91	598.73	7.93	18.25	13.35	321.45	3.08
150	Krapina, Bedekovčina	17004	Krapina	2020	460878	5099822	307.60	596.10	7.96	15.49	11.27	327.10	3.52
151	Krapina, Krapina selo - most	17005	Krapina	2020	476898	5107262	298.20	585.70	8.00	15.13	12.36	318.20	
152	Krapina, Kupljenovo	17008	Krapina	2020	447116	5088518	292.83	604.42	7.92	17.90	12.74	326.00	3.14
153	Luka, Luka	17012	Luka	2020	447572	5091128	367.50	631.58	6.97	22.50	11.86	355.50	
154	Horvatska, Tuhelj	17102	Horvatska	2020	442386	5104207	331.67	589.33	7.83	34.17	12.36	353.83	
155	Kosteljina, Jalšje	17113	Kosteljina	2020	449845	5099703	305.42	592.92	7.73	60.58	14.39	335.00	2.93
156	Vučica, Petrijevci	21007	Vučica	2020	657695	5055049	237.50	522.67	7.75	10.83	12.38	259.67	
157	Vučica, Marjančaci	21020	Vučica	2020	647962	5057010	252.17	508.33	7.80	11.19	14.78	266.67	4.27
158	Našička rijeka, Ribnjak - uzvodno od ustave	21036	Našička rijeka	2020	628455	5047079	184.17	499.00	8.32	22.42	13.58	207.08	
159	Lateralni kanal, most na cesti Čakovec - Mihovljan	21042	Lateralni kanal	2020	496304	5139701	139.17	418.08	7.85	14.59	12.90	159.83	9.18
160	Bistrec-Rakovnica II, most na putu polj.dobra D. Dubrava-Kotoriba	21050	Bistrec-Rakovnica II	2020	523783	5133214	450.17	719.75	7.86	5.63	13.20	300.58	1.00
161	Boščak II, most na cesti Domašinec - Kvitrovec	21052		2020	507472	5143266	99.83	391.00	7.45	5.00	13.15	160.67	
162	Brodec, Peklenica, uz cestu kod osn. škole	21054	Brodec	2020	498078	5150848	181.92	463.50	7.72	5.00	12.80	187.58	
163	Rogstrug, Podravske Sesvete	21077	Rogstrug	2020	557689	5095742	253.08	556.83	8.28	5.00	12.93	276.17	
164	Bistra Koprivnička, most kod Molvi	21079	Bistra Koprivnička	2020	541012	5109555	224.92	600.17	7.55	6.22	13.23	253.33	
165	Drava, Ormož	29160	Drava	2020	473461	5140405	130.00	282.08	7.95	18.95	12.33	148.33	1.23
166	Gostiraj, Ježdovec	51125	Gostiraj	2020	448484	5071592	292.90	709.50	7.99	25.83	14.66	270.70	

No.	TOC (mgC/l)	Amonium (mgN/l)	Inorganic nitrogen (mgN/l)	Non-ionized amonium (mgNH3/l)	Nitrates (mgN/l)	Nitrites (mgN/l)	Organic nitrogen (mgN/l)	Total nitrogen (mgN/l)	Ortho-phosphates (mgP/l)	Total phosphorous (mgP/l)	BOD (mgO2/l)	COD-Mn (mgO2/l)	Dissolved oxygen (mgO2/l)	Oxygen saturation (%)	*Potamogeton berchtoldii* Fieber	*Potamogeton crispus* L.	*Potamogeton lucens* L.	*Potamogeton natans* L.	*Potamogeton nodosus* Poir.	*Potamogeton pectinatus* L.
1		0.12	0.69		0.65	0.03	0.69	1.38	0.040	0.088	1.24	2.32	8.07	75.55					6	3
2		0.05	3.55		3.48	0.03	1.14	4.68	0.018	0.068	1.18	1.10	9.40	88.08	6				5	
3		0.65	1.35	0.009	0.68	0.02	0.27	1.56	0.075	0.272	2.76	9.82	8.61	79.56					3	
4		0.59			1.39	0.07		2.26	0.162	0.226	3.01	6.70	8.64	79.42					5	
5		0.28	2.96		2.60	0.08	0.82	3.78	0.046	0.069	1.53	1.90	9.16	84.46		3			3	
6		0.03	0.93	0.003	0.90	0.00	0.26	1.19	0.014	0.048	1.18	2.35	10.32	95.75						3
7		0.57		0.018	1.94	0.29		3.70	0.333	0.561	5.60	10.93	7.34	70.09					4	3
8		1.24			2.91	0.22		5.17	0.387	0.519	4.63	5.90	9.39	89.92					4	
9		4.09	4.58		0.55	0.03	0.55	5.03	0.248	0.451	4.04	3.57	6.82	63.43		6			2	
10		0.22	1.32	0.007	1.03	0.06	0.47	1.79	0.094	0.184	2.19	3.57	9.63	86.97		4		2		
11		0.32	1.64	0.010	1.23	0.09	0.44	2.07	0.065	0.167	2.15	3.93	9.39	86.44		5				
12		0.25			2.33	0.05		2.85	0.295	0.486	2.97	8.45	8.56	78.66					3	
13		0.36			0.97	0.08		2.07	0.025	0.116	4.28	7.60	9.07	82.06		4				
14		0.10			1.85	0.04		2.03	0.090	0.118	1.91	3.64	10.33	89.98					6	
15		0.09	1.01	0.004	0.92	0.00	0.28	1.29	0.017	0.070	1.08	2.13	9.36	87.42				5		
16		0.35	1.21	0.006	0.84	0.01	0.24	1.42	0.052	0.160	3.22	7.16	9.17	84.09			3		3	
17		0.18			1.15	0.04		1.49	0.123	0.192	2.89	4.60	10.56	98.46		2			2	6
18		0.10	0.79	0.003	0.69	0.00	0.29	1.08	0.011	0.040	1.45	2.68	10.08	91.30					4	
19		0.37			1.70	0.07		2.37	0.343	0.444	3.00	6.67	8.77	79.01		4			5	3
20		2.04			0.67	0.05		3.68	0.314	0.414	3.04	6.40	6.66	60.84		2				9
21		1.27			1.63	0.08		3.45	0.659	0.920	3.15	7.01	7.78	68.56					5	
22		0.82		0.012	1.28	0.11		3.07	0.224	0.356	7.13	8.72	7.39	70.02						8
23		0.08			1.03	0.02		1.24	0.077	0.148	2.66	4.63	10.69	100.00					2	
24		0.54			1.70	0.10		2.55	0.160	0.220	2.49	4.28	8.92	76.37						
25		0.06	13.25		13.15	0.05	3.70	16.94	0.020	0.064	1.32	1.34	9.90	91.45					6	
26		0.02	0.65	0.001	0.63	0.00	0.18	0.83	0.005	0.023	0.69	1.57	10.68	99.73						4
27		0.03	0.68	0.001	0.65	0.00	0.24	0.92	0.012	0.036	0.69	1.82	10.68	100.41					3	3
28		0.02	0.69	0.001	0.66	0.01	0.27	0.96	0.019	0.054	1.11	2.56	10.43	101.04						
29		0.22			0.81	0.03		1.21	0.096	0.144	2.80	7.48	7.93	72.63					5	
30		0.03	0.37	0.001	0.34	0.00	0.20	0.57	0.010	0.043	0.65	2.22	9.71	87.96					8	
31		0.02	0.88	0.001	0.85	0.01	0.25	1.13	0.022	0.069	0.86	2.48	10.42	97.89					3	
32		0.16		0.005	0.85	0.02		1.20	0.023	0.061	2.00	3.01	9.45	91.35					3	
33		0.22	0.84		0.67	0.04	0.55	1.39	0.225	0.363	1.20	2.47	6.12	57.27					7	5
34		0.51		0.010	1.97	0.25		3.80	0.208	0.397	8.03	14.12	7.93	75.10		2				2
35		0.20			1.03	0.07		1.73	0.025	0.143	3.95	5.77	8.70	81.84		4				
36		0.01	0.11	0.000	0.10	0.00	0.35	0.47	0.016	0.064	2.53	4.46	7.26	61.44					2	
37		0.09	0.93	0.001	0.83	0.02	0.45	1.39	0.061	0.301	3.58	6.60	9.86	94.61					3	
38		0.05	0.54	0.002	0.50	0.01	0.67	1.21	0.161	0.689	18.87	3.31	9.31	88.36		5			3	
39		0.26	0.64	0.010	0.34	0.01	0.39	1.03	0.022	0.060	1.57	3.65	8.42	83.81					5	
40		0.14	0.52	0.003	0.35	0.03	0.88	1.35	0.013	0.232	1.27	4.15	8.93	93.59		7				
41		0.19	0.66		0.46	0.03	0.63	1.29	0.045	0.108	4.73	6.84	7.71	76.18					3	
42		0.17	1.51	0.003	1.35	0.03	0.66	2.17	0.076	0.368	5.30	9.00	10.26	97.94					5	
43		6.01	6.02		0.15	0.04	2.08	8.10	1.124	1.814	10.20	12.78	2.25	22.53						
44		0.16	0.18		0.15	0.03	0.41	0.59	0.059	0.096	5.10	6.37	5.25	51.38		2			2	
45		0.08	0.26		0.19	0.01	0.24	1.00	0.025	0.142	1.92	3.21	4.84	53.28		4				
46		0.50	1.07		0.49	0.08	0.04	1.00	0.025	0.125	2.75	4.71	5.57	60.50		8				
47		1.65	1.93		0.19	0.10	1.87	3.80	0.250	0.390	3.30	7.71	5.06	52.69		3			2	2
48		0.11	0.76		0.64	0.03	0.33	1.09	0.091	0.153	3.60	4.29	7.72	75.73		2				
49		0.38	4.52		3.99	0.12	0.38	4.90	0.834	1.010	4.77	5.83	8.86	87.70		5				
50		0.16	0.97		0.78	0.03	0.12	1.09	0.073	0.133	2.86	3.60	9.49	92.96					1	
51		0.72	1.45		0.67	0.08	1.40	2.85	0.217	0.463	3.33	1.75	5.79	62.04					7	8
52		0.65	1.28		0.62	0.05	0.94	2.18	0.137	0.270	5.77	3.26	11.43	133.26					6	
53		0.07	1.38	0.002	1.28	0.03	0.53	1.91	0.108	0.685	15.54	4.02	7.08	69.52					4	5
54																			3	
55		0.02	0.83	0.001	0.80	0.01	0.12	0.95	0.014	0.026	1.30	1.90	11.40	95.19						3
56		0.01	0.68	0.000	0.68	0.00	0.19	0.87	0.007	0.019	0.85	1.75	12.30	100.06					3	4
57		0.21	0.55	0.008	0.30	0.01	0.38	0.93	0.030	0.074	1.50	3.92	6.15	63.28		2				
58		0.22	0.67	0.009	0.34	0.01	0.26	0.94	0.010	0.069	2.70	4.36	9.42	93.91					2	
59		0.01	0.53	0.000	0.52	0.00	0.17	0.70	0.007	0.034	1.39	2.26	10.44	103.91	2					
60	3.07	0.07	1.40	0.003	1.31	0.03	0.37	1.78	0.037	0.112	2.01	4.23	10.21	96.96						2
61	2.45	0.02	2.19	0.001	2.15	0.02	0.29	2.48	0.013	0.042	1.59	3.04	8.65	87.78					6	
62	7.91	0.51	2.52		1.89	0.13	0.25	2.77	0.349	0.577	5.20	11.74	9.53	91.84		3				
63	3.59	0.30	1.17	0.016	0.86	0.02	4.36	5.48	0.069	0.136	3.13	3.68	9.67	90.70		2			3	
64	8.49	0.18	0.72	0.004	0.54	0.02	2.60	3.32	0.149	0.197	6.58	8.69	10.53	99.77					4	
65	4.09	0.24	1.96	0.010	1.66	0.06	3.81	5.77	0.109	0.188	4.59	4.52	8.69	80.11					4	
66	5.01	0.10	1.71	0.002	1.58	0.04	0.47	2.19	0.061	0.166	9.53	15.90	11.07	99.17					5	
67	4.20	0.08	1.14	0.001	1.04	0.01	0.34	1.49	0.063	0.181	2.87	5.14	7.87	73.47					5	
68	6.81	0.12	0.39		0.32	0.01	0.68	1.08	0.008	0.068	6.65	7.76	11.39	115.03		3				
69	5.53	0.13	0.71		0.60	0.01	0.59	1.31	0.065	0.116	3.67	5.13	9.27	87.61					6	
70	5.00	0.14	0.76		0.65	0.02	0.36	1.03	0.087	0.146	3.19	5.08	7.32	65.07			5		7	
71	5.87	0.31	0.90		0.59	0.03	0.30	1.20	0.062	0.121	3.13	6.03	6.08	55.14					6	
72	5.27	0.35	0.62		0.29	0.01	0.32	0.94	0.166	0.249	4.18	5.13	9.09	86.52					3	
73																9				
74	4.16	0.04	0.81		0.79	0.01	0.54	1.35	0.033	0.084	0.91	3.61	8.22	78.30				5		
75	4.05	1.27	1.66		0.38	0.04	0.88	2.49	0.096	0.272	13.94	16.87	2.25	21.06						9
76	4.38	0.03	0.43		0.42	0.01	0.41	0.76	0.013	0.070	0.99	3.41	8.48	80.65		3				
77	6.69	0.06	1.34		1.30	0.02	0.52	1.86	0.066	0.192	4.48	5.77	8.33	73.87			6			
78	7.58	0.01	0.41		0.40	0.01	0.49	0.90	0.066	0.173	2.53	6.99	10.19	93.08					7	
79	7.38	3.20	6.55		3.23	0.14	0.51	7.07	0.468	0.535	3.62	6.58	3.88	35.09						9
80	1.69	0.01	1.09	0.000	1.07	0.01	0.24	1.33	0.013	0.058	1.20	2.29	10.60	97.79						5
81	3.59	0.03	0.48		0.47	0.01	0.48	0.96	0.022	0.075	2.12	4.44	10.12	100.73					4	
82	8.05	0.04	0.10		0.12	0.01	1.39	1.49	0.030	0.095	6.88	19.22	10.11	100.89		4				
83	5.92	0.07	0.51		0.47	0.01	0.64	1.15	0.021	0.053	2.56	6.91	8.87	93.67					5	
84	7.73	0.02	0.60		0.60	0.02	1.53	2.14	0.015	0.116	4.56	11.54	7.71	76.72		3				
85	1.89	0.04	0.93		0.92	0.01	0.57	1.51	0.030	0.048	2.05	2.80	10.45	94.42					2	
86	1.02	0.02	0.26		0.26	0.01	0.46	0.72	0.016	0.029	1.02	2.64	5.79	53.82					5	
87	1.35	0.04	0.82		0.81	0.01	0.65	1.46	0.030	0.019	1.74	2.15	10.36	94.85						2
88		86.52			0.39	0.04					13.94	16.87	2.25	260.65						6
89	1.89	0.04	0.96		0.94	0.01	0.57	1.53	0.030	0.044	1.88	3.08	10.31	93.30					2	3
90	0.97	0.02	0.25		0.24	0.01	0.41	0.65	0.015	0.007	1.20	2.29	10.60	97.79	3					
91	6.08	0.38	1.65		1.20	0.09	1.01	2.66	0.030	0.312	4.65	7.38	7.92	79.16					5	
92	3.04	0.08	0.96	0.003	0.89	0.01	0.68	1.64	0.024	0.067	2.23	6.13	9.36	90.49					4	
93	5.45	0.04	0.39		0.36	0.01	0.88	1.28	0.030	0.070	3.40	8.35	8.49	82.88					8	
94	5.80	37.00	37.32	3.947	0.32	0.01	0.58	1.16	0.049	0.094	2.38	4.98	9.87	89.48					4	
95	3.40	9.55	10.42	0.018	0.80	0.08	1.02	2.47	0.035	0.185	4.88	5.32	8.80	84.38					2	
96	2.43	0.06	0.76		0.69	0.03	0.86	1.62	0.030	0.068	2.07	3.60	10.21	97.90					6	
97	1.61	0.02	0.76	0.000	0.75	0.00	0.52	1.27	0.019	0.032	1.65	2.58	11.74	108.96		3			2	
98	3.11	0.02	2.08	0.002	2.05	0.02	1.08	3.15	0.025	0.083	1.69	5.56	9.87	88.02		7			9	
99	6.83	0.37	0.52	0.010	0.15	0.03	0.39	0.91	0.014	0.107	2.91	7.01	7.01	67.90		9				
100	3.78	0.03	4.00	0.001	3.95	0.03	1.18	5.17	0.046	0.082	2.51	4.25	10.70	102.91		2			2	
101	3.78	0.03	4.00	0.001	3.95	0.03	1.18	5.17	0.046	0.082	2.51	4.25	10.70	102.91					3	
102	2.89	0.61	1.94	0.014	1.21	0.12	0.46	2.39	0.126	0.373	3.81	4.59	7.57	75.73						2
103	2.09	0.02	0.60	0.001	0.58	0.01	0.27	0.87	0.027	0.071	1.66	3.65	10.62	105.88					3	
104	2.62	0.71	1.91	0.021	1.14	0.06	0.60	2.51	0.123	0.315	3.65	4.74	8.27	82.18		3				
105	7.36	1.55	2.00	0.009	0.49	0.00	1.24	3.10	0.103	0.213	5.60	7.80	4.77	43.20		3				
106	6.52	0.05	0.41	0.001	0.38	0.00	1.11	1.52	0.019	0.049	3.65	6.94	9.16	75.97					5	
107	3.78	0.41	2.57	0.009	2.14	0.03	2.04	4.50	0.094	0.165	4.67	4.32	9.37	88.37		3				
108	9.48	0.17	2.73	0.003	2.54	0.03	1.38	4.07	0.084	0.161	4.85	7.16	7.86	71.72					7	
109	4.18	0.25	1.19	0.008	0.91	0.02	0.26	1.44	0.014	0.090	2.61	5.76	7.78	80.35					3	3
110	2.81	0.45	7.35	0.005	6.75	0.15	1.40	8.75	0.293	0.564	2.74	3.85	6.16	60.57					9	5
111	7.27	0.08	0.78		0.82	0.04	0.59	1.37	0.174	0.238	3.93	5.68	10.11	97.28					8	
112	3.86	0.13	1.34	0.004	1.16	0.05	0.46	1.81	0.041	0.118	2.80	5.53	9.63	96.53					3	
113	3.37	0.03	5.18	0.001	5.11	0.04	0.92	6.11	0.029	0.061	1.61	4.55	9.83	100.51		5			8	5
114	2.30	0.06	5.44	0.002	5.32	0.06	1.08	6.52	0.044	0.075	1.26	2.96	9.62	97.39					9	5
115	4.87	0.66	2.40	0.019	1.55	0.18	0.58	2.97	0.290	0.558	3.84	10.22	6.55	64.93		2			2	
116	7.09	0.71	3.13	0.019	2.18	0.24	1.10	4.23	0.192	0.576	5.17	12.48	6.84	68.86		8				7
117	3.32	0.23			7.20	0.02		7.83	0.025	0.135	2.98	4.40	9.21	88.33					8	
118	4.76	0.30	2.81		2.43	0.08	0.28	3.09	0.433	0.870	2.54	8.20	6.45	66.11		2			7	6
119	2.93	0.29	0.68	0.021	0.38	0.01	0.36	1.04	0.021	0.086	2.55	3.44	10.58	103.03						8
120	5.72	0.51	1.17	0.009	0.62	0.04	0.58	1.74	0.079	0.202	4.14	7.05	8.04	78.62					1	
121	8.66	0.54	2.01	0.013	1.37	0.10	1.51	3.52	0.217	0.451	11.64	12.90	9.31	92.08					2	5

No.	TOC (mgC/l)	Amonium (mgN/l)	Inorganic nitrogen (mgN/l)	Non-ionized amonium (mgNH3/l)	Nitrates (mgN/l)	Nitrites (mgN/l)	Organic nitrogen (mgN/l)	Total nitrogen (mgN/l)	Ortho-phosphates (mgP/l)	Total phosphorous (mgP/l)	BOD (mgO2/l)	COD-Mn (mgO2/l)	Dissolved oxygen (mgO2/l)	Oxygen saturation (%)	*Potamogeton berchtoldii* Fieber	*Potamogeton crispus* L.	*Potamogeton lucens* L.	*Potamogeton natans* L.	*Potamogeton nodosus* Poir.	*Potamogeton pectinatus* L.
122	7.96	2.41	3.39		0.91	0.07	1.28	4.67	0.712	0.981	2.67	7.85	6.04	56.50					5	
123	4.27	0.39	1.73	0.008	1.27	0.07	0.87	2.59	0.195	0.371	4.21	6.16	7.51	68.13		4			5	
124	5.18	0.14	1.29	0.002	1.13	0.02	1.37	2.66	0.129	0.199	3.31	7.09	9.87	94.49					7	6
125	6.22	0.31	1.66	0.005	1.29	0.06	1.01	2.67	0.240	0.563	6.09	9.98	8.72	82.40					6	4
126	6.40	0.09	0.86		0.75	0.02	0.36	1.23	0.077	0.207	2.44	6.06	9.84	88.86					2	
127	1.64	0.01	0.55	0.001	0.53	0.00	0.20	0.75	0.007	0.019	0.75	2.38	10.96	110.08					2	
128	1.62	0.01	0.56	0.001	0.54	0.00	0.19	0.75	0.009	0.020	1.01	2.48	11.29	114.49	3				3	4
129	1.35	0.01	0.55	0.001	0.54	0.01	0.16	0.71	0.005	0.014	0.98	2.25	10.40	104.54	2				2	
130	11.78	0.55	1.97	0.006	1.40	0.01	0.23	2.20	0.054	0.272	2.32	10.48	8.82	77.49					5	
131	27.37	1.13	1.89		0.67	0.09	0.54	2.43	0.136	0.272	3.51	9.39	7.42	65.07	3					
132	7.28	0.36	0.59	0.007	0.22	0.02	0.46	1.04	0.021	0.092	3.12	10.71	9.50	86.33					3	
133	16.83	2.77	4.51	0.051	1.68	0.05	1.55	6.03	0.515	1.157	2.92	15.03	6.99	60.15					5	
134	4.75	0.02	0.33	0.000	0.30	0.00	0.37	0.70	0.038	0.093	3.32	6.95	14.25	139.81					3	
135	5.31	0.08	0.48		0.39	0.01	0.37	0.85	0.080	0.113	2.33	4.90	10.78	99.39					2	
136	1.71	0.01	0.63	0.002	0.61	0.01	0.21	0.84	0.021	0.038	1.16	2.88	11.62	120.28		2			3	2
137	2.53	0.02	0.35	0.001	0.34	0.00	0.22	0.57	0.012	0.033	1.31	3.76	9.56	87.48				6	5	
138	2.42	0.03	0.64	0.001	0.60	0.01	0.38	1.02	0.027	0.048	1.15	3.40	10.29	98.15					7	
139	3.67	0.28	0.91	0.008	0.61	0.03	0.39	1.30	0.020	0.081	2.63	5.33	9.34	86.58					3	
140	8.35	0.21	0.75		0.52	0.02	0.44	1.18	0.077	0.127	2.79	7.55	7.88	70.99					6	
141	1.76	0.19	0.92		0.71	0.02	0.45	1.37	0.075	0.113	1.76	2.67	10.70	103.27					3	
142	2.22	0.09	0.94	0.818	0.03	0.48	1.41		0.109	0.141	1.47	2.37	11.79	115.25		3			2	3
143	2.86	0.27	0.90	0.007	0.62	0.02	0.48	1.39	0.020	0.073	2.40	3.14	9.35	88.74					6	
144	2.63	0.26	0.43	0.004	0.17	0.01	0.45	0.87	0.020	0.045	2.34	3.46	9.36	84.28		6			3	
145	9.90	0.02	0.23	0.000	0.21	0.00	0.58	0.81	0.012	0.032	6.29	14.86	7.68	73.52					4	
146	6.65	5.75	6.14		0.34	0.05	1.60	7.08	0.902	1.336	1.99	5.64	5.76	54.52						5
147	1.91	0.02	0.70	0.001	0.67	0.01	0.23	0.93	0.011	0.029	1.10	3.40	9.43	90.17					3	
148	3.55	0.18	1.78	0.004	1.59	0.01	0.07	1.84	0.016	0.076	1.58	2.68	10.19	91.89	2				5	
149	3.85	0.24	1.57	0.005	1.25	0.08	0.61	2.17	0.057	0.156	5.61	6.79	9.45	88.15					3	3
150	4.38	0.28	1.52	0.007	1.17	0.07	0.68	2.20	0.161	0.234	6.18	7.11	9.23	81.79					5	
151	3.14	0.12	1.18	0.003	1.01	0.05	0.57	1.74	0.042	0.073	4.29	5.63	9.76	89.59		6				
152	3.94	0.42	1.64	0.009	1.13	0.09	0.58	2.22	0.065	0.172	6.41	7.18	8.48	77.79		4			5	4
153	4.51	0.41	2.00		1.53	0.07	0.68	2.67	0.097	0.220	2.26	4.33	8.25	73.24		2				
154	5.24	0.34			0.96	0.04		1.80	0.025	0.170	3.28	6.59	9.73	89.02		3			2	
155	4.62	0.60			1.14	0.10		2.41	0.057	0.237	3.35	6.93	7.56	71.48					4	
156	8.20	0.19	0.47		0.48	0.02	0.56	1.03	0.045	0.094	4.45	4.97	8.50	76.86					2	
157	5.38	0.27	0.93	0.009	0.60	0.06	0.53	1.45	0.032	0.135	5.14	7.08	9.16	87.96					5	
158	11.22	0.19	0.75		0.64	0.06	0.84	1.58	0.255	0.310	6.01	6.98	9.75	90.88					1	
159	9.43	2.01	4.84		2.68	0.15	2.23	6.55	0.504	0.753	3.74	6.59	8.67	78.88		6				
160	1.00	0.03	4.94		4.88	0.03	0.92	5.86	0.016	0.056	1.13	1.11	10.77	103.38					8	
161	1.18	0.08	17.47		17.33	0.06	2.49	19.93	0.018	0.061	1.33	1.30	11.09	104.87					4	
162	2.25	0.20	3.46		3.18	0.09	0.40	3.86	0.041	0.092	1.32	2.03	8.90	83.49		6			2	
163	2.50	0.05	0.79		0.73	0.02	0.33	1.05	0.027	0.060	0.92	2.93	8.67	80.88					8	
164	3.05	0.26	1.44		1.19	0.02	0.42	1.48	0.174	0.301	1.48	4.08	7.81	72.88				6		6
165	1.71	0.02	0.89	0.001	0.85	0.02	0.21	1.10	0.012	0.037	1.46	19.27	10.37	95.40						4
166	4.30	0.58	1.95	0.010	1.20	0.17	1.00	2.95	0.115	0.344	7.69	9.49	8.72	85.99		5			5	5

No.	***Potamogeton perfoliatus* L.**	***Potamogeton pusillus* L.**	***Potamogeton trichoides* Cham. & Schltdl.**	***Potamogeton* sp.**	*Brachythecium mildeanum* Schimp.	*Brachythecium rivulare* Schimp.	*Brachythecium rutabulum* (Hedw.) Schimp.	Bryum argenteum Hedw.	*Bryum klinggraeffii Schimp.*	*Chiloscyphus pallescens (Ehrh. ex Hoffm.) Dumort.*	*Cinclidotus fontinaloides (Hedw.) P. Beauv.*	*Cinclidotus riparius (Host ex Brid.) Arn.*	*Cratoneuron filicinum (Hedw.) Spruce*	*Fissidens crassipes Wilson ex Bruch & Schimp.*	*Fissidens fontanus (Bach.Pyl.) Steud.*	*Fissidens sp.*
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No.	***Potamogeton perfoliatus* L.**	***Potamogeton pusillus* L.**	***Potamogeton trichoides* Cham. & Schltdl.**	***Potamogeton* sp.**	*Brachythecium mildeanum* Schimp.	*Brachythecium rivulare* Schimp.	*Brachythecium rutabulum* (Hedw.) Schimp.	Bryum argenteum Hedw.	*Bryum klinggraeffii Schimp.*	*Chiloscyphus pallescens (Ehrh. ex Hoffm.) Dumort.*	*Cinclidotus fontinaloides (Hedw.) P. Beauv.*	*Cinclidotus riparius (Host ex Brid.) Arn.*	*Cratoneuron filicinum (Hedw.) Spruce*	*Fissidens crassipes Wilson ex Bruch & Schimp.*	*Fissidens fontanus (Bach.Pyl.) Steud.*	*Fissidens sp.*
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No.	*Fontinalis antipyretica Hedw.*	*Fontinalis hypnoides Hartm. var. duriaei (Schimp.) Husn.*	*Leptobryum pyriforme (Hedw.) Wilson*	*Leptodictyum riparium (Hedw.) Warnst.*	*Marchantia polymorpha L.*	*Oxyrrhynchium hians (Hedw.) Loeske*	*Palustriella falcata (Brid.) Hedenäs*	*Pellia neesiana (Gottsche) Limpr.*	*Pellia endiviifolia (Dicks.) Dumort.*	*Pellia sp.*	*Physcomitrella patens (Hedw.) Bruch et Schimp.*	*Pohlia melanodon (Brid.) A. J. Shaw*	*Rhynchostegium riparioides (Hedw.) Cardot*	*Riccia cavernosa Hoffm.*	*Riccia fluitans L.*	*Riccia rhenana Lorb. ex Müll. Frib.*	*Riccia sp.*	*Ricciocarpos natans (L.) Corda*
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No.	*Fontinalis antipyretica Hedw.*	*Fontinalis hypnoides Hartm. var. duriaei (Schimp.) Husn.*	*Leptobryum pyriforme (Hedw.) Wilson*	*Leptodictyum riparium (Hedw.) Warnst.*	*Marchantia polymorpha L.*	*Oxyrrhynchium hians (Hedw.) Loeske*	*Palustriella falcata (Brid.) Hedenäs*	*Pellia neesiana (Gottsche) Limpr.*	*Pellia endiviifolia (Dicks.) Dumort.*	*Pellia sp.*	*Physcomitrella patens (Hedw.) Bruch et Schimp.*	*Pohlia melanodon (Brid.) A. J. Shaw*	*Rhynchostegium riparioides (Hedw.) Cardot*	*Riccia cavernosa Hoffm.*	*Riccia fluitans L.*	*Riccia rhenana Lorb. ex Müll. Frib.*	*Riccia sp.*	*Ricciocarpos natans (L.) Corda*
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No.	*Drepanocladus aduncus (Hedw.) Warnst.*	*Agrostis stolonifera L.*	*Alisma lanceolatum With.*	*Alisma plantago-aquatica L.*	*Baldellia ranunculoides (L.) Parl.*	*Barbarea vulgaris W. T. Aiton*	*Berula erecta (Huds.) Coville*	*Butomus umbellatus L.*	*Calystegia sepium (L.) R. Br.*	*Carex elata All.*	*Carex sp.*	*Cyperus fuscus L.*	*Cyperus glomeratus L.*	*Cyperus sp.*	*Echinochloa crus-galli (L.) P. Beauv.*	*Eleocharis palustris (L.) R. Br.*	*Epilobium hirsutum L.*	*Epilobium sp.*	*Equisetum arvense L.*
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No.	*Drepanocladus aduncus (Hedw.) Warnst.*	*Agrostis stolonifera L.*	*Alisma lanceolatum With.*	*Alisma plantago-aquatica L.*	*Baldellia ranunculoides (L.) Parl.*	*Barbarea vulgaris W. T. Aiton*	*Berula erecta (Huds.) Coville*	*Butomus umbellatus L.*	*Calystegia sepium (L.) R. Br.*	*Carex elata All.*	*Carex sp.*	*Cyperus fuscus L.*	*Cyperus glomeratus L.*	*Cyperus sp.*	*Echinochloa crus-galli (L.) P. Beauv.*	*Eleocharis palustris (L.) R. Br.*	*Epilobium hirsutum L.*	*Epilobium sp.*	*Equisetum arvense L.*
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No.	*Glyceria fluitans (L.) R. Br.*	*Glyceria maxima (Hartm.) Holmb.*	*Glyceria sp.*	*Iris pseudacorus L.*	*Juncus articulatus L.*	*Juncus effusus L.*	*Juncus inflexus L.*	*Juncus sp.*	*Leersia oryzoides (L.) Sw.*	*Leersia oryzoides cf.*	*Lindernia cf.*	*Lindernia dubia (L.) Pennell*	*Ludwigia palustris (L.) Elliott*	*Ludwigia peploides (Kunth) P. H. Raven*	*Lycopus europaeus L.*	*Lysimachia nummularia L.*	*Lysimachia vulgaris L.*	*Lythrum salicaria L.*	*Mentha aquatica L.*	*Mentha longifolia (L.) Huds.*	*Myosoton aquaticum (L.) Moench*
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No.	Glyceria fluitans (L.) R. Br.	Glyceria maxima (Hartm.) Holmb.	Glyceria sp.	Iris pseudacorus L.	Juncus articulatus L.	Juncus effusus L.	Juncus inflexus L.	Juncus sp.	Leersia oryzoides (L.) Sw.	Leersia oryzoides cf.	Lindernia cf.	Lindernia dubia (L.) Pennell	Ludwigia palustris (L.) Elliott	Ludwigia peploides (Kunth) P. H. Raven	Lycopus europaeus L.	Lysimachia nummularia L.	Lysimachia vulgaris L.	Lythrum salicaria L.	Mentha aquatica L.	Mentha longifolia (L.) Huds.	Myosoton aquaticum (L.) Moench
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No.	*Nasturtium officinale W. T. Aiton*	*Oenanthe aquatica (L.) Poir.*	*Persicaria hydropiper (L.) Delarbre*	*Persicaria maculosa Gray*	*Persicaria lapathifolia (L.) Delarbre*	*Phalaris arundinacea L.*	*Phragmites australis (Cav.) Trin. ex Steud.*	*Polygonum amphibium L.*	*Polygonum hydropiper*	*Polygonum mite Schrank*	*Polygonum cf. mite*	*Polygonum sp.*	*Portulaca oleracea L.*	*Potentilla reptans L.*	*Pulicaria dysenterica (L.) Bernh.*	*Ranunculus repens L.*	*Rorippa amphibia (L.) Besser*	*Rorippa sylvestris (L.) Besser*	*Rumex hydrolapathum Huds.*
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No.	*Nasturtium officinale W. T. Aiton*	*Oenanthe aquatica (L.) Poir.*	*Persicaria hydropiper (L.) Delarbre*	*Persicaria maculosa Gray*	*Persicaria lapathifolia (L.) Delarbre*	*Phalaris arundinacea L.*	*Phragmites australis (Cav.) Trin. ex Steud.*	*Polygonum amphibium L.*	*Polygonum hydropiper*	*Polygonum mite Schrank*	*Polygonum cf. mite*	*Polygonum sp.*	*Portulaca oleracea L.*	*Potentilla reptans L.*	*Pulicaria dysenterica (L.) Bernh.*	*Ranunculus repens L.*	*Rorippa amphibia (L.) Besser*	*Rorippa sylvestris (L.) Besser*	*Rumex hydrolapathum Huds.*
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No.	*Rumex palustris* Sm.	*Rumex* sp.	*Sagittaria sagittifolia* L.	*Scirpus lacustris* L.	*Scirpus maritimus* L.	*Scirpus sylvaticus* L.	*Solanum dulcamara* L.	*Sparganium erectum* L.	*Sparganium emersum* Rehmann	*Typha angustifolia* L.	*Typha latifolia* L.	*Urtica dioica* L.	*Veronica anagallis-aquatica* L.	*Veronica anagalloides* Guss.	*Veronica beccabunga* L.	*Myosotis scorpioides* L.	*Azolla filiculoides* Lam.	*Callitriche cophocarpa* Sendtn.	*Callitriche stagnalis* Scop.	*Callitriche* sp.	*Ceratophyllum demersum* L.
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No.	*Rumex palustris Sm.*	*Rumex sp.*	*Sagittaria sagittifolia L.*	*Scirpus lacustris L.*	*Scirpus maritimus L.*	*Scirpus sylvaticus L.*	*Solanum dulcamara L.*	*Sparganium erectum L.*	*Sparganium emersum Rehmann*	*Typha angustifolia L.*	*Typha latifolia L.*	*Urtica dioica L.*	*Veronica anagallis-aquatica L.*	*Veronica anagalloides Guss.*	*Veronica beccabunga L.*	*Myosotis scorpioides L.*	*Azolla filiculoides Lam.*	*Callitriche cophocarpa Sendtn.*	*Callitriche stagnalis Scop.*	*Callitriche sp.*	*Ceratophyllum demersum L.*
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No.	*Elodea canadensis Michx.*	*Elodea nuttallii (Planch.) H. St. John*	*Hydrocharis morsus-ranae L.*	*Lemna gibba L.*	*Lemna minor L.*	*Lemna minuta Kunth*	*Lemna trisulca L.*	*Marsilea quadrifolia L.*	*Myriophyllum spicatum L.*	*Myriophyllum verticillatum L.*	*Najas marina L.*	*Najas minor All.*	*Nuphar lutea (L.) Sm.*	*Nymphoides peltata (S. G. Gmel.) Kuntze*	*Ranunculus circinatus Sibth.*	*Ranunculus fluitans Lam.*	*Ranunculus trichophyllus Chaix*	*Salvinia natans (L.) All.*	*Spirodela polyrhiza (L.) Schleid.*	*Stratiotes aloides L.*	*Trapa natans L.*	*Utricularia vulgaris L.*
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No.	*Elodea canadensis Michx.*	*Elodea nuttallii (Planch.) H. St. John*	*Hydrocharis morsus-ranae L.*	*Lemna gibba L.*	*Lemna minor L.*	*Lemna minuta Kunth*	*Lemna trisulca L.*	*Marsilea quadrifolia L.*	*Myriophyllum spicatum L.*	*Myriophyllum verticillatum L.*	*Najas marina L.*	*Najas minor All.*	*Nuphar lutea (L.) Sm.*	*Nymphoides peltata (S. G. Gmel.) Kuntze*	*Ranunculus circinatus Sibth.*	*Ranunculus fluitans Lam.*	*Ranunculus trichophyllus Chaix*	*Salvinia natans (L.) All.*	*Spirodela polyrhiza (L.) Schleid.*	*Stratiotes aloides L.*	*Trapa natans L.*	*Utricularia vulgaris L.*
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No.	*Vallisneria spiralis L.*	*Zannichellia palustris L.*	*Chara contraria A.Braun ex Kützing*	*Chara sp.*	*Nitella gracilis (J.E.Smith) C.Agardh*	*Nitella opaca (C.Agardh ex Bruzelius) C.Agardh*	*Nitellopsis obtusa (N.A.Desvaux) J.Groves*	*Batrachospermum sp.*	*Cladophora glomerata (Linnaeus) Kützing*	*Hydrodictyon reticulatum (Linnaeus) Bory*	*Microcystis aeruginosa (Kützing) Kützing*	*Mougeotia sp.*	*Tribonema viridae*	*Tribonema utriculosum*	*Oscillatoriales*	*Rhizoclonium hieroglyphicum (C.Agardh) Kützing*	*Rhizoclonium sp.*	*Spirogyra sp.*	*Vaucheria sp.*	*Vucheria dichotoma*
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No.	*Vallisneria spiralis L.*	*Zannichellia palustris L.*	*Chara contraria A.Braun ex Kützing*	*Chara sp.*	*Nitella gracilis (J.E.Smith) C.Agardh*	*Nitella opaca (C.Agardh ex Bruzelius) C.Agardh*	*Nitellopsis obtusa (N.A .Desvaux) J.Groves*	*Batrachospermum sp.*	*Cladophora glomerata (Linnaeus) Kützing*	*Hydrodictyon reticulatum (Linnaeus) Bory*	*Microcystis aeruginosa (Kützing) Kützing*	*Mougeotia sp.*	*Tribonema viridae*	*Tribonema utriculosum*	*Oscillatoriales*	*Rhizoclonium hieroglyphicum (C.Agardh) Kützing*	*Rhizoclonium sp.*	*Spirogyra sp.*	*Vaucheria sp.*	*Vucheria dichotoma*
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Appendix 2 - Results of CCA and DCA

Analysis 'Constrained-2'

Method: CCA
Total variation is 4.37932, explanatory variables account for 8.7%
(adjusted explained variation is 3.9%)

Summary Table:

Statistic	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalues	0.1561	0.0994	0.0601	0.029
Explained variation (cumulative)	3.56	5.83	7.21	7.87
Pseudo-canonical correlation	0.5142	0.4246	0.3139	0.2176
Explained fitted variation (cumulative)	41.15	67.36	83.21	90.84

Forward Selection Results:

Name	Explains %	Contribution %	pseudo-F	P
NO2	2.6	21.6	4.3	0.006
el_vod	1.3	10.7	2.1	0.056
tvrd	1	8.1	1.6	0.134
O2_zas	0.9	7.3	1.5	0.19
pH	1	8.4	1.7	0.068
PO4	0.7	5.8	1.2	0.294
BPK5	0.6	5.3	1.1	0.312
NO3	0.5	4	0.8	0.464

Analysis 'Unconstrained-suppl-vars-2'

Method: DCA with supplementary variables
Total variation is 4.37932, supplementary variables account for 12.2%
(adjusted explained variation is 2.4%)

Summary Table:

Statistic	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalues	0.7117	0.5014	0.2896	0.2271
Explained variation (cumulative)	16.25	27.7	34.32	39.5
Gradient length	5.04	3.51	3.86	3.65
Pseudo-canonical correlation (suppl.)	0.3681	0.2718	0.4265	0.2864

Results of Dentrended correspondence analysis

Summary Table:

Statistic	DCA1	DCA2	DCA3	DCA4
Eigenvalues	0.3809	0.3135	0.251	0.2001
Decorana values	0.3815	0.3221	0.2219	0.1797
Axis length	3.286	3.4822	4.0382	3.0683