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Environmental factors shaping water-peat vegetation and its neighbouring surface waters in Lower Silesian Forests (Western Poland)

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Abstract. Phytosociological and physicochemical studies of endangered habitats of swamp and peat-bog areas were carried out in the Lower Silesian Forest complex (Western Poland), in the vicinity of Węgliniec village. The total of 63 phytosociological relevés were made and three syntaxonomic units were distinguished as associations (*Cicuto-Caricetum pseudocyperi*, *Typhetum latifoliae*, *Phragmitetum australis*) and two as communities (with *Sphagnum girgensohnii* and with *Juncus effusus*). Using the phytoindication method, it was found that among four analysed habitat parameters (L – light availability, F – humidity, R – soil pH, N – soil nitrogen), only nitrogen content did not play a significant role in shaping the composition of these phytocoenoses. Physicochemical studies of surface waters using high performance liquid chromatography (HPLC) method indicated, among others, a higher level of nitrogen compounds in some samples. Concentrations of mineral substances dissolved in water usually exceeded limit values for class II waters. Species composition of phytocoenoses and values of parameters recorded in neighbouring surface waters indicated that mutual interactions of these habitat components clearly existed there.

Key words: wetlands, swamps, peatbog, *Phragmitetea* class, Western Poland

1. Introduction

Currently, water and peat vegetation belong to the most endangered phytocoenoses in Europe (Chytrý 2011). This is related to long-term and intensive exploitation of peat deposits, high sensitivity to changes in humidity conditions in the habitat and, in general, low number of such habitats. Not so long ago, peat was used as fuel and now, it is widely employed in horticulture and medicine. Unfortunately, regeneration of peat habitats disturbed by gradual exploitation, takes place at a very slow pace (Herbich 2004; Kucharzyk & Szary 2012; Makles *et al*. 2014). For example, wetland vegetation in Lower Silesia, belongs to most threatened with extinction due to adverse habitat changes (Dajdok & Proćków 2003; Kącki *et al*. 2005).

The Lower Silesian Forest Area is the least known in Lower Silesia in terms of flora and vegetation. Studies by W. Bena (2001, 2006) contain a description of the flora of the vicinity of Węgliniec, but they lack floristic knowledge of this area. Thanks to pollen spectra of brown coal seams, it was possible to read vegetation history from the area of Węgliniec and the surrounding regions (Sadowska 2005). In terms of water-rush vegetation, selected fish ponds around Zgorzelec – including Węgliniec, were studied (Tomaszewska *et al*. 2007). From areas neighbouring Węgliniec, many species connected with marsh habitats were reported. Among them were taxa, both endangered, dying, critically endangered, and considered extinct in this region (Schube 1903; Decker 1937; Herbichowa & Jackowiak 2001; Kącki 2003). In many cases, there are still no updates or additions to these publications. At present, all new studies in this region are particularly valuable due to protection of this type of biotopes.

Vegetation is the result of interrelationships and relationships between components of natural environment, mainly climate, soils and water relations. Our knowledge of structure – quantitative and qualitative participation of species and their range of ecological tolerance, allows to determine current state of the environment (Roo-Zielińska 2004). Parameters most often taken into account when characterising habitat include, among others: soil moisture and its pH reaction, nitrogen content, or light availability as well as ambient temperature (Ellenberg *et al*. 1992; Zarzycki *et al*. 2002). In the case of hydrogenic phytocoenoses, chemistry of waters occurring in their immediate surroundings also constitutes an important factor (Macioszczyk & Dobrzyński 2007).

The research conducted here aimed to find answers to the following questions: (*i*) what environmental factors (from those most often taken into account) shape species composition of water-peat phytocoenoses of the analysed area? (*ii*) do physicochemical properties of neighbouring surface waters have a relationship with the composition of plant communities occurring here? (*iii*) are these properties of waters subject to significant seasonal changes? In order to be able to provide answers to the above questions, thorough phytosociological analyses of the water-peat vegetation occurring in marsh strips of this area were carried out. In addition, surface water purity classes were also determined according to current standards.

2. Study area

The study area is located north of Węgliniec (51°17′18″N, 15°13′32″E) towards Stary Węgliniec. It is situated in the area of Stawiska Forestry – Krucze Gniazdo, near "Peatbog under Węgliniec" Nature Reserve (Fig. 1). According to the geobotanical division, it is located in the belt of the Silesian Basin and belongs to the District of the Silesian-Lusatian Lowlands. This lowland includes two sub-districts: Lower Silesian Forests and the Szprotawska Plain. Węgliniec and its surroundings are located almost in the centre of the Lower Silesian Forests sub-district (Kondracki 2011).

Soils made of glacial, alluvial and aeolian sands dominate in the vicinity of Węgliniec. In the depressions of the terrain and vast valleys, there are river gley fluvisols and marsh soils, peaty, mucky and silt soils. Large, compact surfaces of brown soil were found here in mosaics with brown forest podzolic soils. A part of the brown forest podzolic soils periodically accumulates

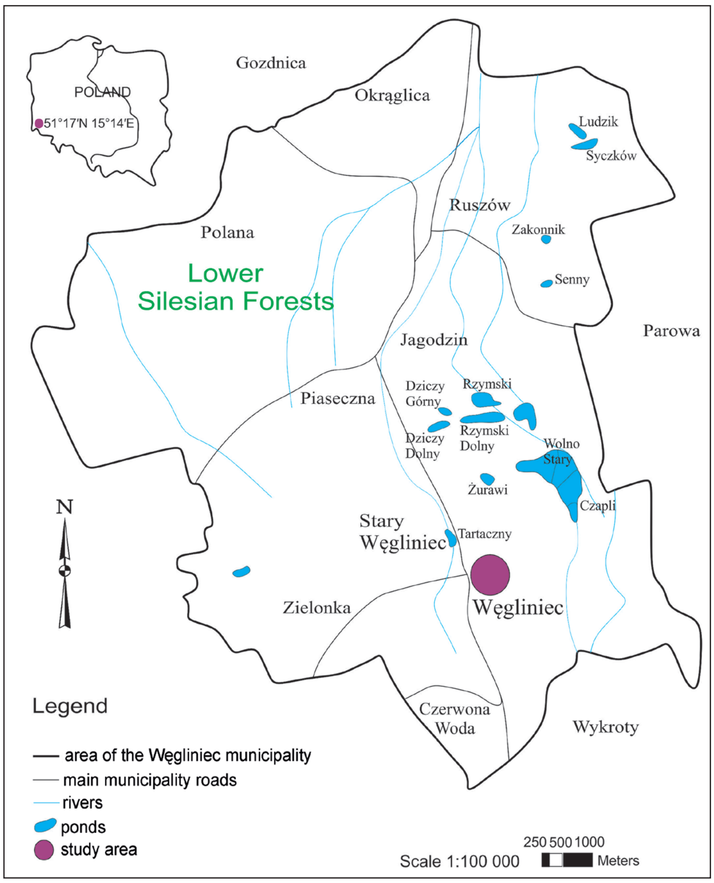

Fig. 1. Localisation of the study area

excessively water, which results in covering the surface layers of soil gley (Bogda *et al*. 2005).

Węgliniec and the surrounding area belong to the Sudetes region, which is characterised by dominance of fissure waters, occurring mainly within crystalline formations of the Paleozoic-Precambrian (Paczyński 1993, 1995). Two streams – Czerna Wielka and Czerna Mała flowing into it (in the Nysa Łużycka River basin), have the greatest impact on water relations of the Węgliniec part of the Lower Silesian Forest. Most ponds fed mainly by waters of Ziębina stream (left-bank tributary of Czerna Wielka) can be found between them. Majority of bogs and swamps are also located here (Bena 2001).

The study area is located within the Atlantic climate zone, with minor continental influences (Głowicki *et al*. 2005; Bena 2008). The highest average annual temperature for Lower Silesia of 8°C is recorded here. On average, there are 260 warm days here. Winter lasts less than 60 days, which is why the growing season includes more than 225 days (Sobik 2005).

3. Material and methods

3.1. Phytosociological studies

In the belt of marsh-peat areas, 63 phytosociological relevés were taken, based on Braun-Blanquet's methodology. The surface size of relevés depended on the habitat type – in the case of independent small ponds, the relevé had the shape and size of the reservoir (one type of phytocoenosis), and in the case of big ponds, they were squares or rectangles ranging in size from 6-8 (moss areas) to 20 m^2 (water and rush vegetation). All phytosociological relevés were entered into the Turboveg database and then subjected to numerical classification (Gauch 1986; Jongman *et al*. 1995), using the MULVA program (Wildi & Orloci 1996). The classification was carried out in two ways: on the basis of species quantity scale according to the Braun-Blanquet (the value of 0.5 was assumed as +) and on the basis of species composition (binary scale 0, 1). Similarities between relevés were calculated using the van der Maarel coefficient (Westhoff & van der Maarel 1978), according to the formula:

$$r(x,y) = \frac{\Sigma xy}{\Sigma x^2 + \Sigma y^2 - \Sigma xy}$$

where r means similarity and x, y – vectors of quantity/quality values of relevés.

The Ward's method – Minimum Variance Clustering, was used for grouping. Dendrograms obtained in the classification were compared with the assistance of the dispersion diagram and on this basis only those relevés were included in the phytosociological tables, which formed relatively homogeneous groups in terms of composition and quantity of species (Dzwonko 2007).

Habitat characteristics were performed using the phytoindication method with indicator values according to Ellenberg (Ellenberg *et al*. 1992). Weighted average values of indicators were calculated for all relevés: light – L, soil moisture – F, soil acidity – R and nitrogen – N, taking into account the quantity of species, and then arithmetic means of the indicators for groups of relevés showing the distinguished communities. To examine which habitat gradients exerted the strongest effect on the analysed communities, relevés (plots) were numerically ordered using the Detrended Correspondence Analysis DCA (Hill & Gauch 1980). The analysis was carried out in two ways: based on the presence of species and based on the quantitative share of species. Correlations between DCA axis values and selected variables (herbaceous plants cover, bryophytes, trees and shrubs cover, maximum tree height, number of species in the relevés and Ellenberg indicators as supplementary data) were calculated using the Pearson coefficient (r).

The nomenclature of vascular plants and ferns was according to Mirek *et al*. (2002), lichens – to Fałtynowicz (2003), and bryophytes – to Ochyra (2003). The syntaxonomic affiliation of the distinguished communities was determined on the basis of Matuszkiewicz's guide (2007).

3.2. Hydrochemical studies

For a more complete description of habitat of mud and peat phytocoenoses in the summer of 2009 (July/August) and spring 2010 (April/May), physicochemical analyses of surface waters flooding this area were carried out. Fourteen water samples were collected twice (in summer and spring) from I-XIV stands at different distances – water reservoirs or flooded plots where phytosociological relevés were taken or in their immediate neighbourhood (Table 1). Water was collected using a boom scoop. According to recommendations, samples were collected about 25 cm below the surface of the water surface from the part of the reservoir where it had the greatest depth. Laboratory analysis of the samples consisted of measuring selected water parameters to determine its quality. Measurements of water pH (N5170E FVat multimeter, TELEKO, Poland), electrical conductivity (CC-551 conductivity meter, ELMETRON, Poland), total water hardness (TH), calcium ion concentration (Ca^{2+}), bicarbonate ion content (HCO_{3-}), were made according to the methodology recommended by Krawczyk (1999). Determination of free carbon dioxide (CO_2) was carried out according to the instructions contained in Hermanowicz's publication (1999), and oxygen (O_2) dissolved in water together with temperature measurement – using the Winkler method (Dojlido & Zerbe 1997). To determine the content of

Table 1. List of sites (I-XIV) of water sampling for hydrochemical analyses and their habitat characteristics

Study site No.	Habitats	Name of association/community	Relev No.
I	backwaters, willow thickets	*Cicuto-Caricetum pseudocyperi*	near 10, 11, 12
II	ditch-marsh	*Cicuto-Caricetum pseudocyperi*	near 1, 2, 3
III	pond	*Cicuto-Caricetum pseudocyperi*	near 5, 6, 7, 8
IV	reed zone	*Phragmitetum australis* dry form	near 16, 17
V	cattail zone	*Typhetum latifoliae*	near 19, 20
VI	cattail zone	*Typhetum latifoliae*, community *Juncus effusus* – plots with cattail	near 22, 23, 54, 62
VII	cattail zone	*Typhetum latifoliae*	near 25, 26
VIII	cattail zone	*Typhetum latifoliae*	in 28
IX	backwaters – cattail zone	community *Juncus effusus* – plots with cattail	in 56
X	pond	transitional plot (outlier)	in 29
XI	reed-willow thickets	*Phragmitetum australis* normal form	near 33, 34
XII	reed-willow thickets	*Phragmitetum australis* normal form	near 36, 37
XIII	peaty, reed zone	*Phragmitetum australis* peaty form	in 41
XIV	swamp forest	*Phragmitetum australis* peaty form	near 46, 47

chloride ions (Cl^-), nitrites (NO_2^-), nitrates (NO_3^-) and sulfates (SO_4^{2-}), HPLC – High Performance Liquid Chromatography (HPLC-FLEXAR, Perkin Elmer, USA) was performed. This method is currently widely used in qualitative and quantitative analysis (Szczepaniak 2002; Witkiewicz 2005).

The obtained results are mean values of three independent measurement repetitions (n = 3) with standard

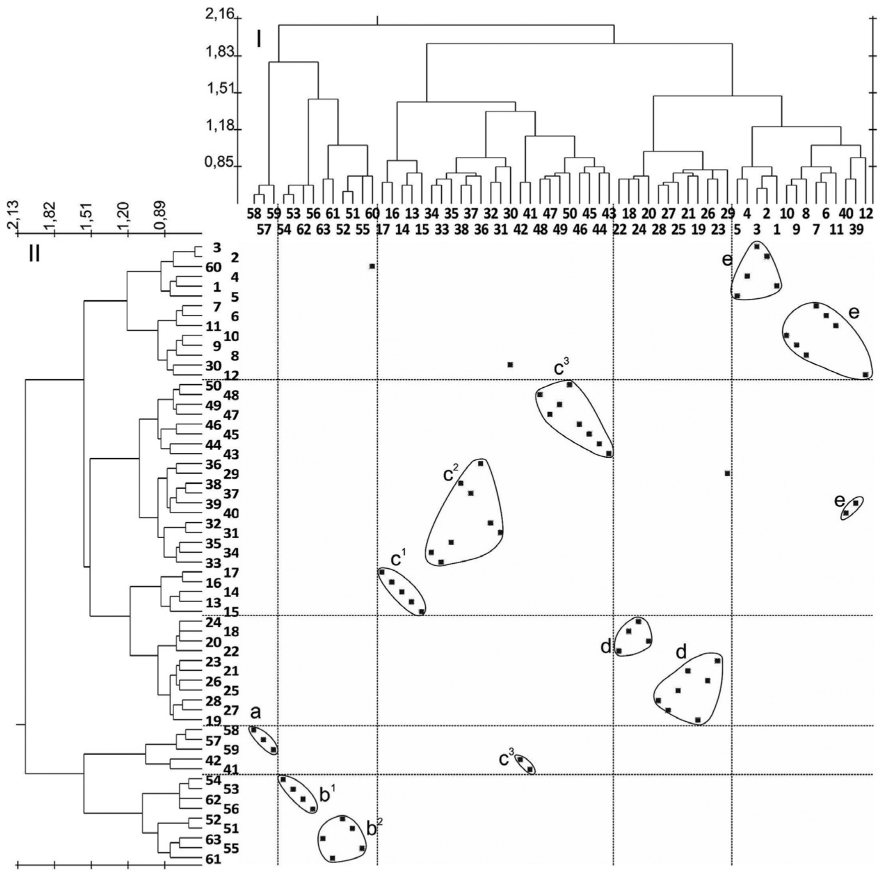

Fig. 2. Diagram of dispersion for 63 phytosociological relevés made in swamps and peatbogs in the vicinity of Węgliniec; I – classification dendrogram based on species quantity scale; II – classification dendrogram based on species composition; groups: community with *Sphagnum girgensohnii* – a, community with *Juncus effusus* – b[1], b[2], *Phragmitetum australis* – c[1] (dry form), c[2] (normal form), c[3] (peaty form), *Typhetum latifoliae* – d, *Cicuto-Caricetum pseudocyperi* – e, relevés not described – 'outliers'

deviation (± SD). Statistical analysis was performed using Duncan's test for $p < 0.05$. Statistica 10.0 for Windows was used in the calculations.

4. Results

4.1. Results of phytosociological analyses

Numerical classification of phytosociological relevés made it possible to distinguish two communities: with *Sphagnum girgensohnii* (a) and *Juncus effusus* (b^1, b^2) and three units in the rank of association: *Phragmitetum australis* (in three forms – c^1, c^2, c^3), *Typhetum latifoliae* (d), *Cicuto-Caricetum pseudocyperi* (e) – Fig. 2.

Phytocoenoses of peat-bog with *Sphagnum girgensohnii* were very poor in terms of floristics (Appendix 1) and weakly represented in the study area. Except for the dominant, only taxa from the *Phragmitetea* class were here, therefore these were included only in this class (Table 2). On the other hand, plots of the *Cicuto-Caricetum pseudocyperi* association were built by species from the *Magnocaricion* alliance and *Phragmitetea* class (Appendix 2; Table 2). However, they were not homogeneous in floristic terms, as indicated in the dispersion diagram (Fig. 2). A large group here included species from wet meadows of the *Molinio-Arrhentheretea* class, which occurred mostly at edges of plots. *Phragmitetum australis* belonged to the most common wetland phytocoenoses in the analysed area. It occurred here in three forms, differing in species composition (Fig. 2; Appendix 3). In the composition of the dry form, there were no other species from the *Phragmitetea* class apart from reeds dominating here and *Galium palustre* and *Cicuta virosa* recorded singly. *Calamagrostis epigejos* was a permanent element of those plots. Normal form was characterised by share of species from the *Magnocaricion* order, as well as by the occurrence of high constancy *Lemna minor* and *Hottonia palustris* (Table 2). Species from *Molinio-Arrenatheretea* class were also present here, but with low frequency. The peaty form of this phytocoenosis was characterised by a constant share and large quantity of mosses, such as: *Sphagnum fimbriatum*, *S. girgensohnii*. Forest acidophilic species were present here, e.g. *Picea abies* (a), *Pinus sylvestris* (a and c), *Vaccinium vitis-idaea*, *Dicranum scoparium* (d) – *Vaccinio-Piceetea* class. In *Typhetum latifoliae* plots, the broadleaf cattail that gives physiognomy of the community, only sporadically reached the 5th degree of quantification (Appendix 4; Table 2). *T. latifolia* was accompanied by: *Rumex hydrolapathum*, *Alisma plantago-aquatica* and others, separately with brown mosses: *Brachythecium rutabulum* (d), *B. salebrosum* (d), and less often *Plagiomnium affine* (d). In terms of composition and quantity of species, its plots also dit not present a very homogeneous group (Fig. 2). *Calamagrostis epigejos* and meadow species were present but on edges of plots. The community of *Juncus effusus* was a group of transition plots, some of which were dominated by *Typha latifolia* (b^1) and some by *Phragmites australis* (b^2) (Appendix 5; Fig. 2). It was a phytocoenosis with rushes physiognomy, in which *J. effusus* was a common element, although it occurreds abundantly at edges of plots with constant coverage (Table 2). Constant elements were also species from the *Phragmitetea* class.

Phytocoenoses with *Sphagnum girgensohnii* included most of the half-shadow species among all communities found here (Table 3). They were also characterised by the lowest soil pH (very and mostly acid) and the lowest soil nitrogen content (intermediate soils). In the dry form of the *Phragmitetum australis*, the lowest moisture index value was observed (moist soils which did not dry out) and the highest soil pH (mostly and weakly acid). On the other hand, the peaty form of this association, after the community of *Sphagnum girgensohnii*, was distinguished by very acid soil pH. Plots with *Juncus effusus* community were characterised by the wettest substrate (wet often not well-aerated soils) and the highest light availability (half-light plants).

Numerical ordination of relevés on the basis of their species composition allowed grouping plots along the Ist DCA axis from: shady, moderately moist with a layer of bryophytes and shrubs, floristically poor – community with *Sphagnum girgensohnii* and *Phragmitetum australis* peaty form (upper left side of the graph) to moist, with a high proportion of photophilous species, floristically rich, with a poorly developed moss and shrub layer - community with *Juncus effusus* (right side of the graph) (Fig. 3). In the case of the IInd DCA axis, the highest negative correlations related to photophilous and acid-tolerant species. The same ordination of relevés based on the quantity of species showed that the highest values of negative correlations with the Ist axis related to light, soil pH and humidity, and positive to participation of bryophytes. The IInd DCA axis in this case did not represent any significant direction of variation. Among four analysed habitat parameters, only soil nitrogen (N) content did not show any significant correlations with DCA axes, while the highest correlation values related to light (L) and humidity (F) (Table 4).

4.2. Results of hydrochemical analysis

Regardless of the season, the pH reaction of the studied surface waters ranged from acidic at XIV stand (neighbouring plots of *Phragmitetum australis* peaty form) to slightly acidic at III stand (neighbouring plots of *Cicuto-Caricetum pseudocyperi*). The highest values of conductance were recorded in spring at XI stand (neighbouring plots of the *Phragmitetum australis* normal form) and in summer – at XIII stand

Table 2. Comparison of the degrees of constancy (S) or number of occurrences of the characteristic and differential species for the peat-water communities near Węgliniec (Western Poland)

Type of plant community / Species by syntaxonomical membership	*Cicuto-Caricetum pseudocyperi*	*Typhetum latifoliae*	*Phragmitetum australis* – dry form	*Phragmitetum australis* – normal form	*Phragmitetum australis* – peaty form	*Phragmitetum australis* (all forms together)	Community with *Juncus effusus*	Community with *Sphagnum girgensohnii*
Number of releves in phytosociological table	14	11	5	8	10	23	9	3
Number of species in phytosociological table	102	95	53	81	102	118	50	11
Ch.Ass. *Cicuto-Caricetum pseudocyperi*								
Cicuta virosa	V^{+-1}	V^{+-1}	1^{+}	IV^{+-1}	I^{+}	II^{+-1}	IV^{1}	1^{+}
Carex pseudocyperus	IV^{+-2}	III^{+-1}	-	I^{+}	II^{+}	II^{+}	IV^{+-2}	-
Ch.Ass. *Typhetum latifoliae*								
Typha latifolia	I^{+}	V^{1-5}	-	I^{+}	-	I^{+}	III^{4-5}	-
Ch.Ass. *Phragmitetum australis*								
Phragmites australis	IV^{+-2}	II^{1-2}	5^{4-5}	V^{4-5}	V^{1-5}	V^{1-5}	IV^{1-5}	1^{+}
Ch.All. *Magnocaricion*								
Galium palustre	IV^{+-1}	II^{+-1}	1^{+}	IV^{+-1}	III^{+}	III^{+-1}	I^{+}	-
Scutelaria galericulata	-	II^{+}	-	III^{+-1}	V^{+-1}	IV^{+-1}	I^{+}	3^{1-+}
Phalaris arundinacea	II^{+-1}	-	-	I^{+}	III^{+-2}	II^{+-2}	II^{+-2}	-
Poa palustris	-	-	-	III^{+}	I^{+}	II^{+}	-	3^{+}
Ch.O. *Phragmitetalia*/Ch.Cl. *Phragmitetea*								
Rumex hydrolapathum	II^{+}	V^{+-1}	-	-	-	-	IV^{1}	-
Alisma plantago-aquatica	I^{1}	IV^{+-2}	-	-	-	-	II^{+-1}	-
Sparganium erectum	II^{+-2}	-	-	-	-	-	II^{3}	-
Glyceria fluitans	-	-	-	-	-	-	IV^{+}	-
Ch.Cl. *Lemnetea minoris*								
Lemna minor	V^{1-5}	V^{2-5}	2^{+-1}	V^{2}	II^{+-2}	III^{+-2}	IV^{2}	-
Ch.Cl. *Potametea*								
Hottonia palustris	IV^{+-3}	V^{1-2}	-	V^{+}	III^{+-1}	IV^{+-1}	-	-
Ch.Cl. *Bidentetea tripartiti*								
Polygonum hydropiper	III^{+-1}	-	-	I^{+}	I^{+-1}	I^{+-1}	I^{+}	-
Polygonum minus	I^{+-1}	IV^{+}	1^{+}	II^{+-1}	-	I^{+-1}	-	-
Bidens cernua	-	-	-	-	III^{+-1}	II^{+-1}	-	-
Ch.Cl. *Alnetea glutinosae*								
Salix cinerea (a)	IV^{+-4}	IV^{1-3}	2^{+-1}	V^{+-3}	V^{+-4}	IV^{+-4}	V^{+-3}	-
Lycopus europaeus	V^{+-1}	V^{+}	-	V^{+}	IV^{+-2}	IV^{+-2}	III^{+}	1^{+}
Solanum dulcamara	IV^{+-1}	II^{+}	-	V^{+-1}	II^{+}	III^{+-1}	I^{+}	-
Ch.O. *Molinietalia* Diff. species*								
Lysimachia vulgaris	IV^{+-1}	V^{+-1}	5^{+-1}	III^{+-1}	IV^{+-1}	IV^{+-1}	II^{+}	-
Deschampsia caespitosa	III^{+-2}	III^{+-1}	5^{1}	IV^{+}	III^{+}	IV^{+-1}	II^{+-1}	-
**Juncus effusus*	III^{+-2}	I^{+-2}	-	II^{+}	III^{+-2}	II^{+-2}	V^{1}	-
Cirsium palustre	II^{+}	IV^{+}	3^{+}	V^{+}	II^{+}	III^{+}	-	-
Molinia caerulea	III^{+-1}	-	-	II^{+}	II^{+}	II^{+}	-	-
Juncus conglomeratus	II^{+-2}	I^{1}	-	-	II^{+-1}	I^{+-1}	I^{+}	-
Lythrum salicaria	I^{+}	V^{+-1}	-	I^{+}	-	I^{+}	I^{+}	-
Ch.O. *Arrhenatheretalia*								
Achillea millefolium	I^{+}	IV^{+}	5^{+}	IV^{+}	I^{+}	III^{+}	-	-
Dactylis glomerata	II^{+-1}	V^{+-1}	3^{+-2}	III^{+}	-	II^{+2}	-	-
Trifolium repens	I^{+}	IV^{+}	2^{+}	II^{+}	-	I^{+}	-	-
Pimpinella major	-	-	-	IV^{+}	-	II^{+}	-	-
Ch.Cl. *Molinio-Arrhenatheretea*								
Carex hirta	IV^{+-2}	IV^{+-1}	2^{+}	V^{+-1}	III^{+-1}	IV^{+-1}	I^{+-1}	-
Trifolium pratense	I^{+}	V^{+-1}	5^{+}	III^{+}	I^{+}	III^{+}	-	-
Prunella vulgaris	II^{+-1}	II^{+}	-	III^{+}	II^{+}	II^{+}	-	-
Vicia cracca	I^{+}	II^{+}	2^{+}	I^{+}	-	I^{+}	-	-
Juncus tenuis	I^{+}	-	-	V^{+}	-	II^{+}	-	-
Cerastium holosteoides	-	-	-	IV^{+}	-	II^{+}	-	-
Ch.Cl. *Epilobietea angustifolii*								
Calamagrostis epigejos	IV^{1-3}	V^{+-1}	5^{1-2}	III^{+}	III^{+-1}	III^{+-1}	-	-
Ch.Cl. *Vaccinio-Piceetea* Diff. species*								
Picea abies (a)	-	-	-	I^{+}	II^{+}	II^{+}	-	-
Pinus sylvestris (a)	-	-	-	-	I^{+}	I^{+}	-	-
Picea abies (c)	-	II^{+}	-	II^{+}	I^{+}	I^{+}	I^{+}	-
Pinus sylvestris (c)	-	I^{+}	-	-	I^{+}	I^{+}	-	-
Vaccinium vitis-idaea	-	-	-	I^{+}	III^{+}	II^{+}	-	-
**Sphagnum girgensohnii* (d)	-	I^{1}	1^{1}	-	II^{1-2}	II^{1-2}	II^{2}	3^{4-5}
Dicranum scoparium (d)	I^{1}	-	-	-	II^{+}	II^{+}	-	-
Other species								
Sphagnum fimbriatum (d)	III^{1-3}	II^{+-2}	2^{2}	IV^{+}	V^{1-5}	IV^{+-5}	-	-

Explanation: the differential and characteristic species are marked in grey

Table 3. Averages and ranges of Ellenberg's indicator values for the communities occurring in the study area; *Phragmitetum australis* forms: A – dry, B – normal, C – peaty, ABC – all forms together

Type of community		Average Ellenberg's indicator values			
		Light L	Soil moisture F	Soil pH R	Soil nitrogen N
Community with *Sphagnum girgensohnii*		5.0	7.6	2.7	5.3
		4.6-5.3	7.4-7.7	2.4-3.1	4.8-5.7
Community with *Juncus effusus*		7.0	8.9	5.5	6.1
		6.5-7.5	8.0-9.6	5.0-6.0	5.2-6.8
Phragmitetum australis	A	6.7	7.2	6.0	5.9
		6.2-7.0	6.1-7.9	5.0-6.8	5.6-6.1
	B	6.4	7.4	5.5	5.8
		6.2-6.5	7.2-7.7	5.4-5.8	5.5-6.3
	C	6.2	7.4	4.5	5.4
		5.5-6.4	6.7-8.1	3.2-5.5	4.5-6.0
	ABC	6.3	7.3	5.2	5.6
		5.5-7.0	6.1-8.1	3.2-6.8	4.5-6.3
Typhetum latifoliae		6.8	7.8	5.5	5.8
		6.5-7.0	7.2-8.4	5.2-5.7	5.4-6.3
Cicuto-Caricetum pseudocyperi		6.6	8.1	5.3	5.5
		6.1-7.0	6.8-8.7	4.1-6.5	4.5-6.4

Explanation: the highest and the lowest values of the index are marked with grey colour

(in plots of the *P. a.* peaty form), and the lowest – at XIV stand, regardless of the season. At the same stand, the CO_2 content was highest in summer and the lowest (almost 6 times) – at II stand in spring (neighbouring plots of the *Cicuto-Caricetum pseudocyperi*). Oxygen concentration ranged – from 1.22 mg/dm^3 at stand XIII (in *Phragmitetum australis* peaty form plot) in the summer to 7.96 mg/dm^3 at stand X (in the transition plot) in the spring. TH values, regardless of the season, were the highest at stand XIII (in plot of the *P. a.* peaty form), and the lowest – at stand I (neighbouring plots of the *Cicuto-Caricetum pseudocyperi*) in spring and stand VIII (in plots of *Typhetum latifoliae*) in summer. The highest concentration of Ca^{2+}, both in spring and summer, was characteristic to water from stand XIII (in plots of the *Phragmitetum australis* peaty form). Stand XIV (the same type of phytocoenosis) in spring and stand I (neighbouring plots of the *Cicuto-Caricetum*

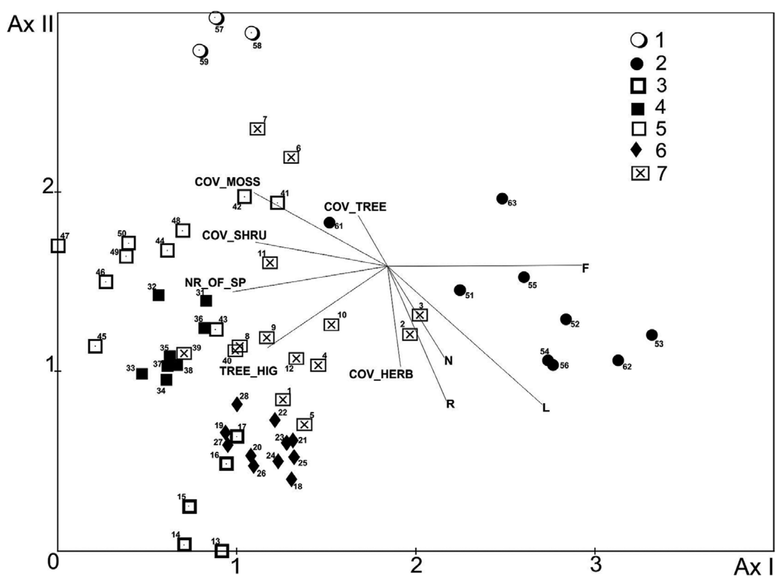

Fig. 3. Ordination of phytosociological relevs made in the peat-water areas near Węgliniec according to I and II DCA axes based on species quality

Explanations: 1 – Community with *Sphagnum girgensohnii*, 2 – Community with *Juncus effusus*, 3 – *Phragmitetum australis* – dry form, 4 – *P. a.* – normal form, 5 – *P. a.* – peaty form, 6 – *Typhetum latifoliae, 7 – Cicuto-Caricetum pseudocyperi*; describe of characteristics is in table 4

Table 4. Correlations of environmental variables and DCA axes calculated based on phytosociological relevs from peat bog areas near Węgliniec

Characteristics	Quantity		Quality	
	Axis I	Axis II	Axis I	Axis II
Tree cover	-0.14	0.12	-0.11	0.21
Shrub cover	0.20	-0.24	**-0.52**	0.09
Herbaceous plant cover	-0.48	-0.48	0.05	-0.42
Bryophyta cover	**0.49**	0.24	**-0.53**	0.30
Height of trees (maximum)	-0.11	0.07	-0.48	-0.35
Number of species in relevé	-0.05	-0.14	**-0.61**	0.12
Ellenberg's indicator values:				
Light L	**-0.82**	-0.06	**0.61**	**-0.57**
Soil moisture F	**-0.50**	0.20	**0.77**	0.02
Soil pH R	**-0.55**	-0.47	0.23	**-0.56**
Soil nitrogen N	-0.33	-0.37	0.22	-0.38

Explanation: high correlation values are marked in grey colour

pseudocyperi) in summer had the lowest content of these ions (Table 1; Appendix 6).

In summer, a higher concentration of Mg^{2+} ions was observed – except at stand XII (neighbouring plots of the *Phragmitetum australis* normal form), where the opposite was true. There were no statistically significant seasonal changes in this parameter at seven stands. In the case of HCO_3^- ions, the largest amounts were found at stand XIII, and the smallest at stand XIV, in plots of the *P. a.* peaty forms or their neighbourhood. Accumulation measurements of Cl^- ions showed the smallest amounts in spring at stand XIV (neighbouring plots of the *P. a.* peaty form), and in the summer at stand IV (neighbouring plots of the *P. a.* dry form). At ten stands their concentration was higher in summer than spring (with exception of stands IV, VII, VIII). The content of SO_4^{2-} decreased in summer (except for stands I, II – neighbouring plots of the *Cicuto-Caricetum pseudocyperi*, XIII – in plot of the *Phragmitetum australis* peaty form). In the case of nitrates (NO_3^-) and nitrites (NO_2^-), they were found to occur in the largest amounts during summer measurements also in the neighbourhood of the *P. a.* peaty form plots (stand XIV). In most of the examined stands, their content was equal to 0 (Table 1; Appendix 7).

Table. 5. The classification of water quality from the studied area based on the samples taken in spring (Sp) and summer (Sm)

Study sites No.	Water quality indicator – class																	
	pH		O_2		NO_3^-		NO_2^-		General alkalinity		SO_4^{2-}		Cl^-		Ca^{2+}		Mg^{2+}	
	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm
I	>II	>II	>II	>II	I	I	>II	>II	I	I	I	I	>II	>II	II	II	I	I
II	>II	>II	>II	>II	I	I	>II	>II	I	I	II	II	>II	>II	II	II	I (bd)	I
III	>II	>II	>II	>II	I	I	>II	I (bd)	I	I	II	I	>II	>II	II	II	I	II
IV	>II	>II	>II	>II	I	I	>II	I (bd)	I	I	>II	II	>II	I	II	II	I	I
V	>II	>II	>II	>II	I	I	I (bd)	I (bd)	I	I	>II	>II	>II	>II	II	II	I (bd)	II
VI	>II	>II	>II	>II	I	I	I (bd)	I (bd)	I	I	>II	>II	>II	>II	II	II	II	II
VII	>II	>II	>II	>II	I	I	I (bd)	I (bd)	I	I	>II	I	>II	II	>II	II	I	II
VIII	>II	>II	>II	>II	I	I	I (bd)	I (bd)	I	I	>II	I	>II	I	II	II	I	II
IX	>II	>II	>II	>II	I	I	I (bd)	I (bd)	I	I	>II	>II	>II	>II	>II	II	I	II
X	>II	>II	>II	>II	I	I	I (bd)	I (bd)	I	I	II	II	>II	>II	II	>II	I	I
XI	>II	>II	>II	>II	I	I	I (bd)	I (bd)	I	I	>II	>II	>II	>II	II	II	II	II
XII	>II	>II	>II	>II	I	I	I (bd)	I (bd)	I	I	II	II	>II	>II	II	>II	I(bd)	I (bd)
XIII	>II	>II	>II	>II	I	I	>II	>II	II	II	II	>II	>II	>II	>II	>II	I	I
XIV	>II	>II	>II	>II	I	>II	I	>II	I	II	II	I	I	>II	>II	II	II	II

Explanations: sites I-XVI, according to Table 1; bd – below detection level; classes: I – very good, II – good, >II – includes classes: III (satisfactory), IV (unsatisfactory), V (bad), without limit values; classification follows Regulation of the Minister of the Environment of 21 July 2016 (Journal of Laws 2016, item 1187)

Based on the measurements of acidification and salinity indicators, it was found that waters around Węgliniec qualified below the II[nd] (good) quality class, both in spring and summer (Appendices 6-7; Table 5). Their pH reactions, oxygenation, sulfate, calcium and magnesium ion concentrations characterised contents higher than quality class II. In terms of nitrates, only in the summer at stand XIV (neighbouring plots of the *Phragmitetum australis* peaty form), their level reached values below this class. In contrast, nitrites occurred at a level higher than class II only in spring in the *Cicuto-Caricetum pseudocyperi* plots or in their neighbourhood (stands I-IV).

In summer, in most of the studied stands, regardless of the type of adjacent phytocoenosis, decreases of pH reaction, conductance, dissolved oxygen content and SO_4^{2-} ions in surface waters were observed, while the contents of CO_2, Mg^{2+}, HCO_3^-, Cl^-, NO_2^- and NO_3^- ions were increased. In the case of TH and content of Ca^{2+} ions, it was difficult to observe clear seasonal regularity. Water samples taken from stand XIV differed most (neighbouring plots of the *Phragmitetum australis* peaty form). They were clearly acidic, had the lowest conductivity, the highest dissolved CO_2 content, both in spring and summer. In addition, they exhibited the lowest content of Ca^{2+} and Mg^{2+} ions in summer, the lowest concentration of HCO_3^- ions in spring and summer, and the lowest content of Cl^- in spring. In summer, the highest values of nitrate and nitrite contents were noted here (Appendices 6-7).

5. Discussion

The status and ecological potential of waters are determined by three groups of quality elements: biological, physicochemical and hydromorphological. These parameters are influenced by morphological conditions of the ground, including substrate type, flow velocity, degree of site shading and anthropogenic impacts (Macioszczyk & Dobrzyński 2007; Suska-Malawska *et al*. 2014). The results of the water sample analysis obtained from each of the examined stands showed that one of them differed from the others in terms of mineral resources – stand XIV near plots of the *Phragmitetum australis* peaty form (Appendices 6-7). These differences were especially visible in summer. The increased nitrate and nitrite values observed may be related to the way in which adjacent areas are used (Jachimowski 2017). High concentrations of these substances, exceeding the class values, often result from surface and subsurface runoff from agricultural areas, outside the growing season (Fleisher & Stibe 1991). In nature, nitrites are an indirect form of biochemical transformation of mineral nitrogen, therefore their concentrations in waters are usually low. The differences in the content of individual nitrogen compounds within the catchment can be up to 18% in forest areas (Freeze 1972).

Oxidation and reduction processes, which are carried out on a large scale by local microflora and fauna, have a significant impact on the formation of hydrochemical conditions in the studied area. Organic matter deposited in the swamps takes part in these processes (Sullivan & Drever 2001; Clark *et al*. 2004). It is biodegradable or completely mineralised by microorganisms, mainly bacteria, thus providing mineral substances, including SO_4^{2-} ions, nitrates or CO_2. Naturally, an important element is also the current plant cover in the vicinity. This was well illustrated by stand XIV, neighbouring the plots of the *P. a.* peaty form. These phytocoenoses were characterised by participation of acidophilic species of *Vaccinio-Piceetea* class (Appendix 3; Table 2). Mosses, especially *Sphagnum fimbriatum* (d), were also found here with high constancy and quantity. An additional element was the proximity of pine forests, in which falling pine needles reduced pH reaction of the ground. These factors caused that the peaty form of this phytocoenosis showed the lowest pH indicator among the forms of this association (Table 3). This was reflected in the direct measurement of water pH samples from stand XIV, which were most acidified. Undoubtedly, it was also the effect of surface and subsurface runoff. The organic matter from dead remains provided an excellent sorbent in the ion exchange process. For this matter and clay fraction occurring in the local soil, the highest intensity of adsorption from water of some ions was found, instead of others (Białkiewicz & Babiński 1981; Macioszczyk & Dobrzyński 2007).

Seasonality is a very important element shaping the chemistry of surface and groundwater. The physicochemical properties of water change significantly during the year, along with fluctuations in air temperature, vegetation progress and changing properties of the drainage catchment (Moniewski 2014; Tomalski 2016; Krasowska 2017). This also applied to the surface water of the study area (Appendices 6-7). Although water sampling was carried out here only in spring and summer, general seasonal trends were already observable. In the spring, after thaws and rainfall, when the water level rises, the pH reaction of surface water was generally slightly acidic – close to neutral, and in summer – due to evaporation and higher temperature – the pH decreased. This was accompanied by an increase in CO_2 content and a decrease in dissolved O_2 concentration. In addition, the content of Mg^{2+}, HCO_3^-, Cl^- ions may increase. In spring, conductivity was higher here than in summer, except for samples taken mainly in the vicinity of *Cicuto-Caricetum pseudocyperi* plots (stands I, II, III). This may have been due to the fact that in winter, along with increased underground outflow, domestic pollutants and inorganic compounds from remains of plant also moved. Their free migration was inhibited along with the development of bottom vegetation in watercourses and ponds (Moniewski 2014).

Seasonality has an important role in the phenology of species and, thus, shapes the aspect of phytocoenoses. In forming the composition of the whole plant cover, habitat factors, both animate and inanimate, play a very important role (Ellenberg *et al.* 1992; Roo-Zielińska 2004). Analysing species composition and types of phytocoenoses in the peat-bog areas of Węgliniec it was found that the most important role was played by: light availability (L), humidity (F) and soil pH reaction (R). Nitrogen content of soil had secondary importance in this case (Table 3-4). DCA analysis showed that these factors determined clear habitat gradients that shaped local vegetation (Fig. 3). Interesting examples of these phenomena were exhibited by phytocoenoses of *Phragmitetum australis*, which were among the most common in this area. This association is commonly found all over Europe (Chytrý 2011). Wherever there is sufficient hydrological conditions, *Phragmites australis* settles down giving characteristic appearance to phytocoenoses. However, its plots in the vicinity of Węgliniec were not homogeneous in terms of composition and quantity of species (Fig. 2). They clearly formed three groups (c^1, c^2, c^2), which, after precise analysis, were classified into three different forms of this phytocoenosis: dry, normal, peaty (Appendix 3; Table 2). In this case, the three habitat gradients mentioned above were the differentiating factors: humidity, light availability and soil pH reaction (Fig. 3; Table 4).

In wetland areas, the humidity gradient was certainly the most important environmental parameter, shaping both chemistry of surface water and the species composition of the vegetation. Even slight disturbances of this factor caused changes in species composition over season. These changes are not always a consequence of anthropogenic influences, but may result from natural succession processes (Valachovič 2001; Herbich 2004). Examples are *Cicuto-Caricetum pseudocyperi* phytocoenoses, which are a permanent element of swamp belt vegetation in many parts of Poland and Europe (Chytrý 2011; Młynkowiak & Kutyna 2011). The vegetation dynamics of this association is connected with the natural phenomenon of shallowing of the water reservoir, which runs from the periphery of the basin towards its centre. Shallow surfaces of this phytocoenosis are occupied by meadow species of the class *Molinio-Arrhenatheretea* (Appendix 2), which was also observed in the study area. A similar tendency to settle down by meadow species, associated with natural shallowing, was observed in the plots of *Typhetum latifoliae* and *Phalaridetum arundinacea* occurring here (Table 2). However, the direction of these changes in humidity may be the reverse, when drainage facilities stop working. Probably, in this way, a community of *Juncus effusus* was created, which is clearly transitional. In the species composition of the plots, groups of heliophilous and higrophilous species were present and, as a constant element, common rush (Appendix 5; Table 2). In this case, the disappearance of anthropopressure contributed to the return of plants typical for this kind of habitat.

The progressive degradation of wetlands entails rapid changes in the population size of many plant and animal species whose survival depends on the conservation of moist habitats (Herbich 2004; Kucharzyk & Szary 2012). Wetland protection is the protection of clean water resources, the most effective protection against floods, prevention of soil erosion and degradation, and protection of the microclimate. In view of the growing threat of global climate change (Kędziora 1995; Sévellec & Drijfhout 2018), nature monitoring is getting special importance in the protection of wetland and peat habitats. In swampy areas, it is possible by controlling the current state of plant cover and humidity conditions, as well as by appropriate knowledge regarding interactions and local environmental factors. Thanks to this, it will be possible to preserve these habitats not only as "closed refuges" but also in the conditions of sustainable management.

6. Conclusions

Environmental factors that had the highest impact on local vegetation were: humidity, light availability and soil pH reaction; soil nitrogen content did not play a significant role here; these factors created clear habitat gradients shaping floristic composition of communities.

Interactions occurred between vegetation cover of communities and physicochemical properties of neighbouring surface waters; humidity gradient was the most important environmental parameter, shaping both properties of surface waters and species composition of the vegetation cover.

Physicochemical properties of the examined waters were subject to significant seasonal changes; in the summer, in most of the examined stands, decreases in pH, conductance, content of dissolved O_2 and SO_4^{2-} ions were recorded, while the content of CO_2 and Mg^{2+}, HCO_3^-, Cl^-, NO_2^- and NO_3^-ions increased; the state of water purity here was typical for swamp and coniferous forest areas: poor oxygen conditions and acidification.

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Appendices

Appendix 1. Community with *Sphagnum girgensohnii*

Successive No.	1	2	3	Number of occurrences
Relev No.	58	57	59	
Group in dendrograms	a	a	a	
Date (day/month/year)	13	13	13	
	09	09	09	
	10	10	10	
Relev area [m^2]	6	6	6	
Herb layer cover [%]	20	20	20	
Moss layer cover [%]	98	98	98	
Number of species in relev	6	5	9	
Diff. species				
Sphagnum girgensohnii (d)	5	5	4	3
Ch.All. *Magnocaricion*				
Cicuta virosa	+	.	.	1
Scutellaria galericula	+	+	1	3
Poa palustris	+	+	+	3
Ch.Cl. *Phragmitetea*				
Phragmites australis	.	+	.	1
Ch.Cl. *Alnetea glutinosae*				
Lycopus europaeus	.	.	+	1
Other species				
Epilobium palustre	+	1	+	3
Athyrium filix-femina	1	.	+	2
Frangula alnus (c)	.	.	+	1
Polytrichum commune (d)	.	.	1	1
Brachythecium salebrosum (d)	.	.	+	1

Appendix 2. *Cicuto-Caricetum pseudocyperi* Boer et Siss. in Boer 1942

Successive No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Constancy (S)
Relev No.	5	4	3	2	1	10	9	8	7	6	11	40	39	12	
Group in dendrograms	e	e	e	e	e	e	e	e	e	e	e	e	e	e	
Date (day/month/year)	10	10	10	06	06	10	10	10	10	10	11	18	18	11	
	08	08	08	08	08	08	08	08	08	08	08	08	08	08	
	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
Releve area [m^2]	20	20	20	20	20	20	20	20	20	20	20	20	20	20	
Tree layer cover [%]	60	70	70	70	10	80	70	70	70	85	75	70	30	60	
Shrub layer cover [%]	0	0	0	0	0	0	1	0	0	0	0	1	1	0	
Herb layer cover [%]	95	90	90	90	90	90	90	90	90	70	85	90	95	90	
Moss layer cover [%]	20	20	10	30	80	30	25	75	60	25	50	65	70	50	
Tree height [m]	5	5	6	8	10	5	5	7	7	5	8	5	6	6	
Number of species in relev	20	27	20	24	31	28	27	35	33	25	36	37	40	30	
Trees and shrubs															
Salix capraea (a)	3	1	1	3	+	+	1	+	+	1	4	3	2	2	V
Carpinus betulus (a)	1	+	+	+	+	+	2	+	.	1	1	.	.	+	V
Salix cinerea (a)	1	3	3	1	+	4	3	3	3	4	.	.	.	.	IV
Betula pendula (a)	.	.	.	.	.	.	.	+	.	.	.	+	+	+	II
Quercus rubra (c)	.	+	.	.	+	+	+	+	+	.	+	.	+	+	IV
Betula pendula (c)	.	+	.	.	+	+	.	+	+	.	+	+	+	.	III
Sorbus aucuparia (c)	.	.	.	.	+	.	.	+	.	.	+	+	+	+	III
Rubus caesius (c)	+	.	.	.	+	+	.	.	.	.	.	.	.	.	II
Herbs															
Ch.Ass. *Cicuto-Caricetum pseudocuperi*															
Cicuta virosa	+	.	1	+	+	+	+	+	1	+	+	+	1	+	V
Carex pseudocyperus	+	+	1	2	.	+	1	+	.	.	+	+	.	+	IV

Ch.All. *Magnocaricion*															
Galium palustre	.	+	.	1	1	1	1	1	.	1	+	.	+	1	IV
Phalaris arundinacea	.	.	.	.	.	+	1	.	1	.	1	1	.	.	II
Ch. O. *Phragmitetalia*/Ch.Cl. *Phragmitetea*															
Phragmites australis	+	+	2	3	3	+	.	.	.	.	.	2	2	+	IV
Sparganium erectum	.	2	2	2	+	.	.	.	.	.	.	.	.	.	II
Rumex hydrolapathum	.	.	+	+	+	+	.	.	.	.	.	.	.	.	II
Ch.Cl. *Lemnetea*															
Lemna minor	5	4	4	3	4	3	3	4	4	3	3	4	5	1	V
Ch.Cl. *Potametea*															
Hottonia palustris	2	2	.	.	.	3	3	3	3	2	2	+	+	.	IV
Ch.Cl. *Alnetea glutinosae*															
Lycopus europaeus	+	.	.	+	.	+	1	+	+	1	+	+	+	+	V
Solanum dulcamara	.	.	1	+	+	+	+	.	+	.	+	+	+	.	IV
Ch.O. *Molinietalia*															
Lysimachia vulgaris	.	.	+	.	+	+	+	+	+	1	.	.	+	+	IV
Juncus effusus	.	+	1	+	+	1	.	.	.	.	+	.	+	2	III
Deschampsia caespitosa	.	.	.	.	.	+	.	1	2	+	2	2	2	+	III
Molinia caerulea	.	.	.	.	+	.	1	1	.	1	.	+	.	+	III
Equisetum palustre	.	.	.	.	+	+	+	+	.	.	.	.	+	1	III
Juncus conglomeratus	.	.	+	.	.	.	.	+	.	.	+	+	.	2	II
Cirsium palustre	+	+	+	+	.	.	.	.	.	.	.	.	+	.	II
Ch.Cl. *Molinio-Arrhenatheretea*															
Carex hirta	2	2	.	2	+	2	1	.	2	2	2	+	.	.	IV
Prunella vulgaris	.	.	.	.	+	.	+	.	.	.	1	+	.	.	II
Ranunculus acris	.	+	.	.	.	.	+	.	+	.	.	+	.	.	II
Dactylis glomerata	+	.	.	.	.	.	.	1	.	.	.	1	.	.	II
Ch.Cl. *Epilobietea angustifolii*															
Calamagrostis epigejos	.	1	.	.	2	2	2	2	2	1	2	.	.	3	IV
Other species															
Athyrium filix-femina	.	+	+	1	+	1	1	+	+	+	.	.	.	+	IV
Urtica dioica	3	1	2	2	+	.	.	.	.	.	+	+	.	.	III
Polygonum hydropiper	1	+	+	+	+	.	.	.	+	.	+	.	.	.	III
Agrostis capillaris	.	.	.	.	+	.	1	.	+	.	2	.	.	.	II
Galeopsis tetrahit	.	+	+	+	.	.	.	.	.	.	+	.	.	.	II
Pteridium aquilinum	.	.	.	.	.	.	.	.	.	.	+	1	1	.	II
Calla palustris	.	.	+	+	.	.	.	.	.	+	.	.	.	.	II
Cladonia coniocraea (d_1)	+	+	.	1	1	.	+	+	.	.	.	+	+	+	IV
Hypogymnia physodes (d_1)	.	.	.	.	.	+	.	.	+	+	+	+	1	.	III
Parmelia sulcata (d_1)	.	.	.	.	.	.	.	.	+	+	+	.	+	.	II
Lecanora pulicaris (d_1)	.	.	.	.	.	.	.	.	1	+	+	.	.	.	II
Xanthoria parietina (d_1)	.	.	.	.	.	.	.	.	1	+	+	.	.	.	II
Hypnum cupressiforme (d)	1	.	.	.	.	+	.	+	+	+	1	.	+	1	III
Brachythecium rutabulum (d)	.	+	1	2	2	.	.	.	1	+	1	.	.	.	III
Sphagnum fimbriatum (d)	.	.	.	.	.	2	1	1	.	.	2	2	3	.	III
Mnium hornum (d)	.	.	.	.	.	.	+	+	.	+	+	.	1	.	II
Plagiomnium affine (d)	.	.	.	.	.	.	.	.	.	2	+	+	2	+	II
Sanionia uncinata (d)	.	+	.	.	.	.	.	1	+	.	.	.	.	.	II
Polytrichum juniperinum (d)	.	+	.	.	.	+	.	+	.	.	.	.	.	.	II
Aulacomnium androgynum (d)	.	.	.	.	.	.	.	.	+	.	.	.	+	+	II

Sporadic species – trees and shrubs: *Salix alba* (a) 4, *Quercus rubra* (a) 1, *Crataegus monogyna* (a) 9, *Populus tremula* (a) 8. *Frangula alnus* (b) 40, 39, *Rubus idaeus* (b) 40, 39, *Picea abies* (b) 39. *Crataegus monogyna* (c) 4, *Quercus robur* (c) 40, *Carpinus betulus* (c) 39, *Betula pubescens* (c) 12. Herbs: Ch.Cl. *Phragmitetea*: *Alisma plantago-aquatica* 5:1, *Typha latifolia* 40. Ch.Cl. *Alnetea glutinosae*: *Calamagrostis canescens* 5, 8. Ch.O. *Molinietalia*: *Myosotis palustris* 2:1, 1:1, *Lotus uliginosus* 1, 12:1, *Lythrum salicaria* 2. Ch.Cl. *Molinio-Arrhenatheretea*: *Vicia cracca* 5, 1, *Leontodon autumnalis* 8, 11, *Juncus tenuis* 40, 39, *Achillea millefolium* 9, *Agrostis stolonifera* 40, *Ranunculus repens* 39, *Trifolium pratense* 39, *T. repens* 39. Other species: *Polygonum minus* 11:1, 39, *Chaerophyllum hirsutum* 40, 39:1, *Tussilago farfara* 1, 39, *Hieracium murorum* 9, 8, *Carex ovalis* 40, 39, *Stellaria uliginosa* 40, 39, *Epilobium palustre* 40, 12, *Agrostis canina* 12:2, *Viola palustris* 10, *Linaria vulgaris* 8, *Moehringia trinervia* 8, *Plantago major* 40, *Trifolium aureum* 40, *Carex nigra* 39, *Oxalis acetosella* 39. Lichens: *Phaeophyscia orbicularis* (d_1) 7, 6, *Physcia tenella* (d_1) 7, 6, *Lepraria* sp. (d_1) 7. Mosses and liverworts: *Polytrichastrum formosum* (d) 7, 39:1, *Polytrichum piliferum* (d) 11, 12:2, *Rhytidiadelphus squarrosus* (d) 40:2, *Lophocolea heterophylla* (d) 4:1, *Dicranum scoparium* (d) 8:1, *Brachythecium salebrosum* (d) 7:1, *Aulacomnium palustre* (d) 8, *Dicranella cerviculata* (d) 8, *Amblystegium juratzkanum* (d) 7, *Dicranoweisia cirrata* (d) 7, *Ceratodon purpuraeus* (d) 12, *Pohlia nutans* (d) 12.

Appendix 3. *Phragmitetum australis* (Gams 1927) Schmale 1939

Successive No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Relev No.	17	16	14	13	15	34	33	35	38	37	36	32	31	42	41	48	47
Group in dendrograms	c^1	c^1	c^1	c^1	c^1	c^2	c^2	c^2	c^2	c^2	c^2	c^2	c^2	c^3	c^3	c^3	c^3
Date (day/month/year)	11	11	11	11	11	17	17	17	18	18	18	17	17	18	18	25	25
	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08
	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Releve area [m^2]	20	20	20	20	20	20	20	20	20	20	20	20	20	8	8	20	20
Tree layer cover [%]	20	20	40	40	40	50	70	50	20	10	10	50	60	1	1	60	30
Shrub layer cover [%]	0	0	0	0	0	1	5	5	1	5	5	5	5	0	0	5	5
Herb layer cover [%]	95	95	98	98	90	95	95	95	95	95	95	95	95	20	30	95	95
Moss layer cover [%]	60	60	1	1	60	50	60	70	60	60	50	70	70	95	95	70	70
Tree height [m]	6	12	6	8	11	6	6	5	6	7	4	6	6	5	6	7	7
Number of species in relev	31	21	22	18	30	35	33	44	42	37	46	27	25	8	9	42	47
Forms	dry – A					normal – B								peaty – C			
Trees and shrubs																	
Salix cinerea (a)	1	+	.	.	.	2	3	2	1	+	+	.	3	+	+	3	1
Betula pendula (a)	.	.	+	+	.	.	+	.	+	+	+	+	+	.	.	+	+
Salix capraea (a)	+	+	2	2	2	.	.	.	.	.	.	3	.	.	.	.	.
Sorbus aucuparia (a)	.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	+	+
Quercus rubra (a)	.	1	.	.	1	.	.	.	.	+	.	.	.	.	.	.	.
Picea abies (a)	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.
Quercus robur (a)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
Frangula alnus (b)	.	.	.	.	.	.	+	.	+	+	.	+	.	.	.	+	+
Rubus idaeus (b)	.	.	.	.	.	.	.	+	+	.	+	.	.	.	.	.	.
Rubus caesius (b)	.	.	.	.	.	+	1	.	.	+	.	.	.	.	.	+	.
Crataegus monogyna (b)	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+
Rosa canina (b)	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	+
Sorbus aucuparia (c)	.	.	.	.	+	+	+	+	+	+	+	+	+	.	.	+	+
Betula pendula (c)	.	+	.	.	+	.	+	.	+	+	+	+	+	.	.	.	+
Quercus rubra (c)	+	.	.	+	.	+	.	.	.	+	+	+	+	.	.	.	.
Quercus robur (c)	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	+	+
Rubus caesius (c)	1	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Betula pubescens (c)	+	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.
Frangula alnus (c)	.	.	.	.	.	+	.	+	.	.	+	.	.	.	.	.	.
Carpinus betulus (c)	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	+
Picea abies (c)	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.
Herbs																	
Ch.Ass. *Phragmitetum australis*																	
Phragmites australis	4	4	5	5	4	5	5	5	5	5	5	5	4	1	1	4	4
Ch.O. *Phragmitetalia/* Ch.Cl. *Phragmitetea*																	
Scutellaria galericulata	.	.	.	.	.	.	.	1	+	+	1	.	.	1	1	1	1
Galium palustre	.	.	+	.	.	.	+	+	+	.	1	+	.	.	+	+	+
Cicuta virosa	+	.	.	.	.	+	.	+	1	+	+	.	.	.	.	+	.
Phalaris arundinacea	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	2	2
Carex pseudocyperus	.	.	.	.	.	.	.	+	+	.	+	.	.	.	.	+	.
Poa palustris	.	.	.	.	.	.	.	.	+	.	.	+	+	.	.	.	+
Ch. Cl. *Lemnetea*																	
Lemna minor	1	+	.	.	.	2	2	2	2	2	2	2	2	.	.	.	.
Ch. Cl. Potametea																	
Hottonia palustris	.	.	.	.	.	+	+	+	+	+	+	+	+	.	.	+	+
Ch. Cl. *Bidentetea tripartiti*																	
Bidens cernua	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Polygonum minus	.	.	+	.	.	.	.	.	1	.	+	.	.	.	.	.	.
Polygonum hydropiper	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Bidens tripartita	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+

18	19	20	21	22	23					
49	50	46	45	44	43					
c^3	c^3	c^3	c^3	c^3	c^3					
25	25	25	19	18	18					
08	08	08	08	08	08					
10	10	10	10	10	10					
20	20	20	20	8	20					
50	80	50	30	30	60					
10	5	5	5	0	5					
90	70	95	95	40	20					
70	90	60	60	90	90					
8	7	7	7	7	6					
42	45	41	38	25	33	Number of occurrences	Constancy (S)	Constancy (S)	Constancy (S)
peaty – C						A	B	C	ABC
2	4	3	.	2	3	2	V	V	IV
+	+	.	.	.	+	2	IV	III	III
.	.	.	2	.	.	5	I	I	II
.	+	.	.	.	.	-	III	II	II
.	.	+	+	.	.	2	I	I	II
+	+	+	.	.	.	-	I	II	II
+	+	.	.	+	.	-	-	III	II
+	+	+	+	.	.	-	III	III	III
.	+	+	+	.	.	-	III	II	II
.	.	.	.	.	+	-	III	I	II
+	+	.	+	.	.	-	I	II	II
+	.	.	.	.	.	-	II	I	I
.	+	.	+	+	+	1	V	III	IV
+	+	+	.	+	+	2	IV	III	IV
.	.	+	.	.	.	2	IV	I	II
+	+	.	.	.	.	-	II	II	II
+	.	.	.	.	.	4	-	I	II
.	.	.	+	.	+	1	I	II	II
.	.	.	.	+	.	-	III	I	I
.	.	+	.	.	.	-	II	I	I
+	+	.	.	.	.	-	II	I	I
4	1	4	5	1	4	5	V	V	V
+	+	1	1	1	1	-	III	V	IV
.	+	+	+	.	.	1	IV	III	III
+	.	.	.	.	.	1	IV	I	II
+	.	.	1	1	.	-	I	III	II
.	.	+	+	.	.	-	I	II	II
+	.	.	.	.	.	-	III	I	II
.	.	+	.	+	2	2	V	II	III
1	1	+	1	.	.	-	V	III	IV
+	+	+	+	.	.	-	-	III	II
.	.	.	.	.	.	1	II	-	I
.	+	1	.	.	.	-	I	I	I
.	.	1	+	.	.	-	-	II	I

Successive No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Relev No.	17	16	14	13	15	34	33	35	38	37	36	32	31	42	41	48	47
Group in dendrograms	c^1	c^1	c^1	c^1	c^1	c^2	c^2	c^2	c^2	c^2	c^2	c^2	c^2	c^3	c^3	c^3	c^3
Date (day/month/year)	11	11	11	11	11	17	17	17	18	18	18	17	17	18	18	25	25
	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08
	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Releve area [m²]	20	20	20	20	20	20	20	20	20	20	20	20	20	8	8	20	20
Tree layer cover [%]	20	20	40	40	40	50	70	50	20	10	10	50	60	1	1	60	30
Shrub layer cover [%]	0	0	0	0	0	1	5	5	1	5	5	5	5	0	0	5	5
Herb layer cover [%]	95	95	98	98	90	95	95	95	95	95	95	95	95	20	30	95	95
Moss layer cover [%]	60	60	1	1	60	50	60	70	60	60	50	70	70	95	95	70	70
Tree height [m]	6	12	6	8	11	6	6	5	6	7	4	6	6	5	6	7	7
Number of species in relev	31	21	22	18	30	35	33	44	42	37	46	27	25	8	9	42	47
Forms	dry – A					normal – B								peaty – C			
Ch. Cl. *Alnetea glutinosae*																	
Lycopus europaeus	.	.	.	.	.	+	+	+	+	+	+	+	+	.	.	1	.
Solanum dulcamara	.	.	.	.	.	.	+	+	+	1	+	+	+	.	.	+	.
Ch. O. *Molinietalia*																	
Lysimachia vulgaris	+	+	1	+	+	1	+	.	.	.	1	.	+	.	.	+	+
Deschampsia caespitosa	1	1	1	1	1	.	+	.	+	+	+	.	+	.	.	+	+
Cirsium palustre	.	.	+	+	+	+	+	.	+	+	+	+	+	.	.	.	+
Juncus effusus	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	1	.
Molinia caerulea	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.
Equisetum palustre	.	.	1	1	+	.	.	.	.	.	.	.	.	.	.	.	.
Juncus conglomeratus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Galium uliginosum	+	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.
Ch. O. *Arrhenatheretalia*																	
Achillea millefolium	+	+	+	+	+	+	+	+	+	+	+	.	.	.	.	.	.
Dactylis glomerata	1	.	+	.	2	.	.	+	+	+	.	+	.	.	.	.	.
Pimpinella major	.	.	.	.	.	+	+	+	+	+	.	.	.	.	.	.	.
Leontodon autumnalis	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.
Trifolium repens	+	.	+	.	.	+	.	+	.	.	.	.	.	.	.	.	.
Arrhenatherum elatius	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Ch. Cl. *Molinio-Arrhenatheretea*																	
Carex hirta	+	.	.	.	+	+	.	+	+	+	+	+	1	.	+	+	+
Trifolium pratense	+	+	+	+	+	+	.	.	+	+	+	.	.	.	.	.	.
Ranunculus repens	+	+	.	.	.	.	+	+	+	+	.	.	.	.	.	+	.
Prunella vulgaris	.	.	.	.	.	+	+	+	.	+	.	.	.	.	.	.	+
Juncus tenuis	.	.	.	.	.	+	+	+	+	+	+	+	.	.	.	.	.
Cerastium holosteoides	.	.	.	.	.	+	+	+	.	+	+	.	.	.	.	.	.
Ranunculus acris	+	+	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.
Agrostis stolonifera	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Vicia cracca	.	.	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.
Ch. Cl. *Epilobietea angustifolii*																	
Calamagrostis epigejos	1	2	2	1	1	+	+	.	.	.	.	.	+	.	.	.	1
Ch. Cl. *Vaccinio-Piceetea*																	
Vaccinium vitis-idaea	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+
Sphagnum girgensohnii (d)	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2
Dicranum scoparium (d)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
Other species																	
Athyrium filix-femina	+	+	+	.	.	+	.	+	.	.	+	1	1	+	.	.	1
Trifolium campestre	+	+	.	.	+	.	.	+	+	.	.	.	.	.	.	.	+
Oxalis acetosella	.	.	.	.	.	+	+	+	+	+	+	.	.	.	.	.	.
Agrostis capillaris	.	.	.	.	.	+	+	+	.	.	+	.	.	.	.	+	.
Urtica dioica	.	+	+	+	1	.	.	.	.	.	.	.	.	.	.	.	.
Pteridium aquilinum	.	.	.	.	.	.	+	.	1	1	.	.	.	.	.	+	.
Plantago major	+	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.
Tussilago farfara	.	.	+	.	+	.	.	.	+	.	.	.	.	.	.	.	.
Galeopsis bifida	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.

18	19	20	21	22	23	Number of occurrences	Constancy (S)	Constancy (S)	Constancy (S)
49	50	46	45	44	43				
c^3	c^3	c^3	c^3	c^3	c^3				
25	25	25	19	18	18				
08	08	08	08	08	08				
10	10	10	10	10	10				
20	20	20	20	8	20				
50	80	50	30	30	60				
10	5	5	5	0	5				
90	70	95	95	40	20				
70	90	60	60	90	90				
8	7	7	7	7	6				
42	45	41	38	25	33				
peaty – C						A	B	C	ABC
+	+	2	+	+	+	-	V	IV	IV
.	+	.	+	.	+	-	V	II	III
1	1	+	+	+	+	5	III	IV	IV
+	+	.	.	+	+	5	IV	III	IV
.	+	.	.	.	+	3	V	II	III
1	2	.	.	+	+	-	II	III	II
.	+	+	+	.	.	-	II	II	II
.	.	.	.	.	.	3	-	-	I
.	1	.	.	.	+	-	-	II	I
.	.	.	.	.	.	2	I	-	I
.	.	.	+	.	+	5	IV	I	III
.	.	.	.	.	.	3	III	-	II
.	.	.	.	.	.	-	IV	-	II
.	.	+	+	.	.	-	III	I	II
.	.	.	.	.	.	2	II	-	I
.	.	.	.	.	+	2	-	I	I
.	1	.	.	.	+	2	V	III	IV
.	.	.	+	.	.	5	III	I	III
.	.	+	+	.	+	2	III	II	III
.	.	+	+	+	.	-	III	II	II
.	.	.	.	.	.	-	V	-	II
.	.	.	.	.	.	-	IV	-	II
.	.	.	.	.	.	3	I	-	I
.	.	.	.	+	.	2	-	I	I
.	.	.	.	.	.	2	I	-	I
+	.	+	+	.	1	5	III	III	III
+	+	+	+	.	+	-	I	III	II
.	1	2	.	.	.	1	-	II	II
.	.	+	.	.	.	-	-	II	I
+	.	+	.	.	1	3	IV	III	III
+	.	.	.	+	.	3	II	II	II
.	+	.	+	.	.	-	IV	I	II
.	.	+	.	.	+	-	III	II	II
.	.	+	.	.	+	4	-	I	II
.	1	.	1	.	.	-	III	II	II
+	.	.	.	.	.	3	I	I	II
+	.	.	.	.	+	2	I	I	II
+	.	.	1	+	.	-	I	II	I

Successive No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Relev No.	17	16	14	13	15	34	33	35	38	37	36	32	31	42	41	48	47
Group in dendrograms	c^1	c^1	c^1	c^1	c^1	c^2	c^2	c^2	c^2	c^2	c^2	c^2	c^2	c^3	c^3	c^3	c^3
Date (day/month/year)	11 08 10	11 08 10	11 08 10	11 08 10	11 08 10	17 08 10	17 08 10	17 08 10	18 08 10	18 08 10	18 08 10	17 08 10	17 08 10	18 08 10	18 08 10	25 08 10	25 08 10
Releve area [m²]	20	20	20	20	20	20	20	20	20	20	20	20	20	8	8	20	20
Tree layer cover [%]	20	20	40	40	40	50	70	50	20	10	10	50	60	1	1	60	30
Shrub layer cover [%]	0	0	0	0	0	1	5	5	1	5	5	5	5	0	0	5	5
Herb layer cover [%]	95	95	98	98	90	95	95	95	95	95	95	95	95	20	30	95	95
Moss layer cover [%]	60	60	1	1	60	50	60	70	60	60	50	70	70	95	95	70	70
Tree height [m]	6	12	6	8	11	6	6	5	6	7	4	6	6	5	6	7	7
Number of species in relev	31	21	22	18	30	35	33	44	42	37	46	27	25	8	9	42	47
Forms	dry – A					normal – B								peaty – C			
Epilobium palustre	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	.	.
Glechoma hederacea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Chaerophyllum hirsutum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium aureum	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lapsana communis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
Viola palustris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Oxalis fontana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Hypogymnia physodes (d_1)	.	.	.	.	+	.	.	.	+	+	.	.	+	.	.	+	+
Lepraria sp. (d_1)	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	+	+
Sphagnum fimbriatum (d)	2	2	.	.	.	+	.	+	+	.	+	+	.	5	5	2	2
Plagiomnium affine (d)	+	.	.	.	.	2	1	2	2	2	2	2	+	.	.	+	1
Brachythecium rutabulum (d)	1	1	.	.	.	1	2	1	+	+	.	2	2	.	.	1	1
Hypnum cupressiforme (d)	2	.	.	.	.	+	.	+	+	2	.	.	1	1	.	1	2
Brachythecium salebrosum (d)	.	.	.	.	2	2	1	1	2	.	+	1	2	.	.	1	1
Polytrichastrum formosum (d)	.	.	.	.	.	+	.	+	+	+	+	.	.	.	.	+	.
Amblystegium serpens (d)	.	.	.	.	1	.	+	+	.	.	.	+	+	.	.	+	1
Polytrichum commune (d)	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Mnium hornum (d)	+	.	.	.	.	+	2	.	.	.	.	2	1	.	.	.	.
Aulacomnium androgynum (d)	.	.	.	.	.	.	+	+	.	.	.	+	+	.	.	.	.
Sanionia uncinata (d)	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	+	+
Atrichum undulatum (d)	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.
Plagiothecium laetum (d)	.	.	.	.	.	.	.	+	.	+	+	.	.	.	.	.	.
Plagiothecium denticulatum (d)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+

Sporadic species – trees and shrubs: *Pinus sylvestris* (a) 50, 44, *Carpinus betulus* (a) 13, *Pyrus communis* (a) 35, *Betula pubescens* (a) 45. *Sorbus aucuparia* (b) 49, 46, *Picea abies* (b) 43. *Rubus idaeus* (c) 13, *Pyrus communis* (c) 38, *Crataegus monogyna* (c) 37, *Pinus sylvestris* (c) 45. Herbs: Ch. Cl. *Phragmitetea*: *Typha latifolia* 36. Ch. O. *Molinietalia*: *Lotus uliginosus* 14, 13, *Achillea ptarmica* 34, *Lythrum salicaria* 38. Ch. Cl. *Epilobietea angustifolii*: *Fragaria vesca* 47. Other species: *Hedera helix* 38, 47, *Carex nigra* 41, 48, *Moehringia trinervia* 41, 43, *Veronica officinalis* 47, 45, *Calla palustris* 49, 50, *Hieracium murorum* 17, *Stellaria uliginosa* 38, *Artemisia vulgaris* 36, *Epilobium ciliatum* 36, *Viola canina* 47, *Ranunculus flammula* 44. Lichens: *Cladonia coniocraea* (d_1) 15, 47, *Parmelia sulcata* (d_1) 47. Mosses and liverworts: *Polytrichum piliferum* (d) 15:1, 50, *Ceratodon purpuraeus* (d) 17, 15, *Pohlia nutans* (d) 17, 15, *Brachythecium campestre* (d) 38, 36, *Cephalozia bicuspidata* (d) 47, 50, *Dicranella cerviculata* (d) 15, *Calliergon giganteum* (d) 36, *Rhytidiadelphus squarrosus* (d) 48, *Plagiothecium cavifolium* (d) 49, *Tetraphis pellucida* (d) 46.

18	19	20	21	22	23				
49	50	46	45	44	43				
c3	c3	c3	c3	c3	c3				
25	25	25	19	18	18				
08	08	08	08	08	08				
10	10	10	10	10	10				
20	20	20	20	8	20				
50	80	50	30	30	60				
10	5	5	5	0	5				
90	70	95	95	40	20				
70	90	60	60	90	90				
8	7	7	7	7	6				
42	45	41	38	25	33	Number of occurrences	Constancy (S)	Constancy (S)	Constancy (S)
peaty – C						A	B	C	ABC
.	.	.	.	.	1	-	I	I	I
1	2	.	.	.	.	-	-	II	I
+	.	.	+	1	.	-	-	II	I
.	+	+	.	.	.	1	-	I	I
+	.	.	.	.	.	-	-	II	I
+	+	.	.	.	.	-	-	II	I
+	.	+	.	.	.	-	-	II	I
.	.	.	.	.	+	1	III	II	II
.	+	+	.	.	.	-	III	III	II
1	3	2	2	4	3	2	IV	V	IV
1	1	1	1	+	+	1	V	IV	IV
2	1	+	+	+	.	2	V	IV	IV
1	+	+	1	.	.	1	IV	IV	III
+	+	+	.	.	.	1	V	III	III
+	.	.	+	+	+	-	IV	III	III
.	+	.	.	.	.	1	III	II	II
.	1	1	2	1	1	-	-	III	II
.	+	.	.	.	.	1	III	I	II
+	+	.	.	.	.	-	III	I	II
.	.	.	.	.	.	1	I	I	I
+	+	.	.	.	.	-	I	II	I
.	.	.	.	.	.	-	III	-	I
.	.	+	.	.	.	-	-	II	I

Appendix 4. *Typhetum latifoliae* Soó 1927

Successive No.	1	2	3	4	5	6	7	8	9	10	11	Constancy (S)
Relev No.	22	18	24	20	28	27	25	21	19	26	23	
Group in dendrograms	d	d	d	d	d	d	d	d	d	d	d	
Date (day/month/year)	11	11	12	11	12	12	12	11	11	12	12	
	08	08	08	08	08	08	08	08	08	08	08	
	10	10	10	10	10	10	10	10	10	10	10	
Releve area [m^2]	20	20	20	20	20	20	20	20	20	20	20	
Tree layer cover [%]	30	20	20	10	70	50	70	15	20	50	30	
Shrub layer cover [%]	5	5	5	5	0	0	0	5	5	0	0	
Herb layer cover [%]	98	95	95	95	85	95	90	95	95	95	98	
Moss layer cover [%]	40	25	25	60	70	60	80	40	70	60	45	
Tree height [m]	8	8	6	9	7	6	8	6	5	7	5	
Number of species in relev	30	36	30	41	43	42	47	32	37	36	40	
Trees and shrubs												
Salix cinerea (a)	.	.	.	.	3	3	3	1	1	3	2	IV
Salix capraea (a)	2	1	2	+	.	.	+	.	+	.	+	IV
Betula pendula (a)	+	+	+	+	+	.	+	.	.	.	.	III
Quercus rubra (a)	+	.	.	+	+	+	.	.	.	.	.	II
Rubus idaeus (b)	.	+	+	+	.	.	.	+	+	.	.	III
Sorbus aucuparia (c)	+	+	.	.	+	+	+	.	.	+	+	IV
Betula pendula (c)	+	.	+	+	+	+	.	.	+	.	.	III
Quercus rubra (c)	.	+	+	.	.	+	.	+	.	+	+	III
Picea abies (c)	.	.	.	+	.	.	+	.	.	+	+	II
Betula pubescens (c)	.	+	.	.	.	.	.	1	.	.	+	II
Rubus caesius (c)	.	.	.	.	+	.	.	.	.	+	+	II
Herbs												
Ch.Ass. *Thyphetum latifoliae*												
Typha latifolia	2	1	1	3	2	1	2	2	3	4	5	V
Ch.O. *Phragmitetelia*/Ch.Cl. *Phragmitetea*												
Cicuta virosa	1	1	1	1	1	+	1	1	1	1	1	V
Rumex hydrolapathum	1	1	1	1	1	+	1	1	.	.	1	V
Alisma plantago-aquatica	1	1	+	2	.	.	+	2	.	+	.	IV
Carex pseudocyperus	.	+	1	.	+	+	+	+	.	.	.	III
Phragmites australis	2	1	.	2	.	.	.	.	1	.	.	II
Galium palustre	1	.	.	.	.	.	.	+	.	+	1	II
Scutellaria galericulata	.	.	+	.	+	.	+	.	.	.	.	II
Ch.Cl. *Lemnetea*												
Lemna minor	5	5	5	2	5	5	5	5	4	.	2	V
Ch.Cl. *Potametea*												
Hottonia palustris	2	2	2	2	1	2	2	2	2	1	1	V
Ch.Cl. *Bidentetea tripartiti*												
Polygonum minus	.	.	.	.	+	+	+	+	+	+	+	IV
Ch.Cl. *Alnetea glutinosae*												
Lycopus europaeus	+	+	+	+	+	+	+	+	+	+	+	V
Solanum dulcamara	.	.	.	+	+	+	.	.	+	.	.	II
Ch.O. *Molinietalia*												
Lysimachia vulgaris	+	+	+	+	+	1	+	+	+	+	+	V
Lythrum salicaria	+	+	.	1	+	+	+	+	+	+	+	V
Cirsium palustre	+	+	+	.	.	.	+	+	+	.	+	IV
Deschampsia caespitosa	1	.	+	+	.	.	.	1	.	.	1	III
Ch.O. *Arrhenatheretalia*												
Dactylis glomerata	+	+	.	+	+	+	+	+	.	+	1	V
Achillea millefolium	.	+	.	+	+	+	+	+	+	.	+	IV
Trifolium repens	.	+	+	+	.	+	+	.	.	+	+	IV
Ch.Cl. *Molinio-Arrhenatheretea*												
Trifolium pratense	+	+	+	+	+	1	+	.	+	+	+	V

Carex hirta	1	+	1	1	1	1	1	.	.	1	.	IV
Ranunculus acris	.	+	.	.	+	+	+	+	+	+	+	IV
Agrostis stolonifera	.	.	+	+	+	.	+	+	.	.	+	III
Prunella vulgaris	.	.	.	.	+	+	+	.	.	+	.	II
Ranunculus repens	.	.	+	+	.	+	.	.	.	.	.	II
Vicia cracca	.	.	+	+	.	.	.	.	+	.	.	II
Ch.Cl. *Epilobietea angustifolii*												
Calamagrostis epigejos	.	+	1	+	+	+	1	.	+	1	1	V
Other species												
Plantago major	+	+	+	+	.	+	.	+	+	+	+	V
Trifolium campestre	.	+	+	+	+	+	+	+	+	+	.	V
Athyrium filix-femina	.	.	.	+	+	.	+	+	.	1	+	III
Oxalis acetosella	.	+	.	+	.	.	.	+	+	.	.	II
Agrostis canina	.	+	+	.	.	.	+	.	.	.	.	II
Hieracium murorum	.	+	.	.	+	.	+	.	.	.	.	II
Epilobium ciliatum	.	.	+	.	.	.	+	.	.	.	+	II
Epilobium palustre	.	.	.	.	+	.	+	.	.	.	+	II
Urtica dioica	.	.	.	.	.	+	.	.	+	+	.	II
Moehringia trinervia	.	.	.	.	.	+	.	.	+	.	+	II
Hypogymnia physodes (d_1)	+	+	.	+	+	+	.	.	+	.	1	IV
Brachythecium rutabulum (d)	+	2	.	2	2	+	1	.	2	1	1	V
Brachythecium salebrosum (d)	1	.	1	.	1	2	1	2	+	2	+	V
Plagiomnium affine (d)	.	.	.	.	2	2	2	+	1	1	+	IV
Amblystegium serpens (d)	.	.	.	.	+	.	+	+	2	+	.	III
Hypnum cupressiforme (d)	1	.	.	.	+	.	.	.	+	+	.	II
Pohlia nutans (d)	+	.	.	1	.	+	+	.	.	.	.	II
Sphagnum fimbriatum (d)	+	.	.	.	.	.	2	.	.	2	.	II
Mnium hornum (d)	.	.	1	.	.	+	.	1	.	.	.	II
Polytrichum juniperinum (d)	.	.	.	+	.	+	1	.	.	.	.	II

Sporadic species – trees and shrubs: *Carpinus betulus* (a) 20, *Sorbus aucuparia* (a) 28. *Rubus caesius* (b) 22, 19, *Rosa canina* (b) 18, 21, *Crataegus monogyna* (b) 18, *Sorbus aucuparia* (b) 20. *Carpinus betulus* (c) 28, 27, *Quercus robur* (c) 25, 19, *Pinus sylvestris* (c) 28, *Crataegus monogyna* (c) 25, *Rubus idaeus* (c) 25, *Rosa canina* (c) 26. Herbs: Ch.O. *Molinietalia*: *Juncus effuses* 18:2, 28, *J. conglomeratus* 21:1, *Lychnis flos-cuculi* 18, *Galium uliginosum* 24, *Lotus uliginosus* 19. Ch.O. *Arrhenatheretalia*: *Leontodon autumnalis* 25, 26, *Arrhenatherum elatius* 27. Ch.Cl. *Molinio-Arrhenatheretea*: *Alopecurus pratensis* 20, *Plantago lanceolata* 25. Other species: *Pteridium aquilinum* 22, 27, *Tussilago farfara* 20, 28, *Eupatorium cannabinum* 26, 23, *Agrostis capillaris* 27:1, *Cirsium arvense* 27, *Stellaria media* 26, *Carex nigra* 23, *C. ovalis* 23, *Trifolium aureum* 23. Lichens: *Lepraria* sp. (d_1) 27, *Cladonia coniocraea* (d_1) 25. Mosses and liverworts: *Atrichum undulatum* (d) 28, 27:1, *Polytrichastrum formosum* (d) 20, 19, *Aulacomnium palustre* (d) 20:2, *Sphagnum girgensohnii* (d) 20:1, *Aulacomnium androgynum* (d) 19:1, *Pleurozium schreberi* (d) 23:2, *Polytrichum piliferum* (d) 22, *Ceratodon purpuraeus* (d) 28, *Lophocolea heterophylla* (d) 28, *Sanionia uncinata* (d) 28, *Calliergon cordifolium* (d) 25, *Brachythecium campestre* (d) 19, *Rhytidiadelphus squarrosus* (d) 26.

Appendix 5. Swamp community with *Juncus effusus*

Successive No.	1	2	3	4	5	6	7	8	9	Constancy (S)
Relev No.	54	53	62	56	63	61	52	51	55	
Group in dendrograms	b^1	b^1	b^1	b^1	b^2	b^2	b^2	b^2	b^2	
Date (day/month/year)	08	08	14	08	14	14	08	08	08	
	09	09	09	09	09	09	09	09	09	
	10	10	10	10	10	10	10	10	10	
Relev area [m^2]	20	20	20	20	20	20	20	20	20	
Tree layer cover [%]	5	5	0	20	1	70	20	50	30	
Shrub layer cover [%]	0	0	0	0	0	0	0	0	0	
Herb layer cover [%]	90	90	95	90	95	95	90	95	90	
Moss layer cover [%]	40	30	20	20	30	50	30	45	40	
Trees height [m]	1	3	0	5	2	5	1	2	1	
Number of species in relev	16	11	14	16	23	32	12	5	22	
Trees and shrubs										
Salix cinerea (a)	+	+	.	1	+	3	1	3	2	V
Herbs										
Ch.O. *Molinietalia**										
Ch.Cl. *Molinio-Arrhenatheretea*										
Diff. species** *Juncus effusus**	1	1	1	1	1	1	1	1	1	V
**Deschampsia caespitosa*	.	.	.	+	1	1	.	.	.	II
**Lysimachia vulgaris*	.	.	.	.	.	+	.	+	+	II
Ch.All. *Magnocaricion*										
Cicuta virosa	1	1	1	1	.	.	1	1	1	IV
Carex pseudocyperus	.	.	1	1	+	2	2	2	1	IV
Iris pseudacorus	.	.	+	.	+	.	+	+	+	III
Phalaris arundinacea	.	.	.	.	1	2	.	.	+	II
Ch.O. *Phragmition*										
Acorus calamus	+	+	+	+	+	.	.	.	+	IV
Sparganium erectum	.	.	.	.	.	.	3	3	.	II
Ch.Cl. *Phragmitetea*										
Rumex hydrolapathum	1	1	1	1	.	.	1	1	1	IV
Glyceria fluitans	+	+	+	+	+	.	+	.	+	IV
Phragmites australis	.	.	.	1	5	4	2	2	5	IV
Typha latifolia	5	5	5	4	.	.	.	.	.	III
Alisma plantago-aquatica	+	.	+	1	.	.	.	.	.	II
Glyceria maxima	.	+	.	.	+	.	.	.	+	II
Ch.Cl. *Lemnetea*										
Lemna minor	2	2	2	2	.	.	2	2	2	IV
Ch.Cl. *Alnetea glutinosae*										
Lycopus europaeus	+	+	+	.	.	+	+	.	.	III
Other species										
Epilobium palustre	.	.	.	.	+	+	.	+	+	III
Viola palustris	.	.	+	.	+	+	.	.	.	II
Hypogymnia physodes (d_1)	.	.	.	+	+	1	.	.	+	III
Calliergon cordifolium (d)	2	2	2	2	1	1	.	.	1	IV
Brachythecium salebrosum (d)	+	.	.	.	+	1	1	+	+	IV
B. rutabulum (d)	.	.	.	.	+	+	.	+	+	III
Sphagnum fimbriatum (d)	1	.	.	.	.	.	.	2	1	II

Sporadic species – trees and shrubs: *Betula pendula* (a) 61; *Betula pubescens* (c) 56, 63, *B. pendula* (c) 61, *Frangula alnus* (c) 61, *Picea abies* (c) 61. Herbs: Ch.O. *Molinietalia**, Ch.Cl. *Molinio-Arrhenatheretea*: *Carex hirta* 56, 61:1, *Juncus conglomeratus** 54, 55, *Lythrum salicaria** 54. Ch.All. *Magnocaricion*: *Galium palustre* 53, 61, *Scutellaria galericula* 61. Ch.Cl. *Alnetea glutinosae*: *Solanum dulcamara* 54, 61. Other species: *Calla palustris* 63:1, 61:1, *Epilobium ciliatum* 61, 55, *Athyrium filix-femina* 63, *Agrostis canina* 61, *Pteridium aquilinum* 61, *Polygonum hydropiper* 61, *Stellaria uliginosa* 61. Lichens: *Parmelia sulcata* (d_1) 63, 61, *Cladonia coniocraea* (d_1) 61. Mosses: *Sphagnum girgensohnii* (d) 63:2, 61:2, *Hypnum cupressiforme* (d) 61, 51, *Aulacomnium palustre* (d) 61:1, *Polytrichastrum formosum* (d) 55:2, *Aulacomnium androgynum* (d) 63, *Rhytidiadelphus squarrosus* (d) 63.

Appendix 6. The comparison of some water parameters at the study sites in the vicinity of Węgliniec

Study site No.	Parameters											
	pH		Conductance [µS]		CO_2 [mg/dm³]		O_2 [mg/dm³]		TH [mg/dm³]		Ca^{2+} [mg/dm³]	
	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm
I	6.54a ±0.01	6.61a ±0.01	226.03b ±0.06	292.40a ±0.53	24.06b ±0.01	43.97a ±0.07	4.90a ±0.01	4.49b ±0.01	50.05b ±0.01	75.07a ±0.01	10.02b ±0.01	20.04a ±0.01
II	6.78a ±0.01	6.55b ±0.01	244.00b ±1.00	295.00a ±1.00	14.20b ±0.01	41.86a ±0.11	5.10a ±0.01	4.90b ±0.01	75.07b ±0.01	100.07a ±0.06	30.05a ±0.01	30.05a ±0.01
III	6.79a ±0.01	6.73a ±0.01	222.00b ±1.00	261.00a ±1.00	19.79b ±0.01	26.40a ±0.01	5.51a ±0.01	4.08b ±0.01	75.08b ±0.01	100.10a ±0.01	20.04a ±0.01	20.04a ±0.01
IV	6.22ab ±0.01	6.33a ±0.01	383.00a ±1.00	298.00b ±1.00	23.00b ±1.00	29.70a ±0.1	5.51a ±0.01	4.49b ±0.01	100.07a ±0.06	100.10a ±0.1	30.06a ±0.01	30.06a ±0.01
V	6.60a ±0.01	6.40b ±0.01	255.00b ±1.00	315.00a ±1.00	19.80b ±0.01	29.70a ±0.01	5.71a ±0.01	4.49b ±0.01	75.07b ±0.01	125.13a ±0.01	30.06a ±0.01	30.06a ±0.01
VI	6.65a ±0.01	6.27b ±0.01	376.00a ±1.00	295.00b ±1.00	24.20b ±0.01	46.20a ±0.01	5.10a ±0.01	3.67b ±0.01	125.13a ±0.01	125.14a ±0.01	30.06a ±0.01	30.06a ±0.01
VII	6.63a ±0.01	6.32b ±0.01	361.00a ±1.00	281.00b ±1.00	22.00b ±1.00	31.90a ±0.01	5.51a ±0.01	3.67b ±0.01	125.13a ±0.01	125.13a ±0.01	40.36a ±0.56	30.06b ±0.01
VIII	6.57a ±0.01	6.31ab ±0.01	325.00a ±1.00	268.00b ±1.00	26.40b ±0.01	33.00a ±1.00	5.31a ±0.01	3.27b ±0.01	75.08a ±0.01	50.05b ±0.01	30.06a ±0.01	30.06a ±0.01
IX	6.77a ±0.01	6.30b ±0.01	404.00a ±1.00	292.00b ±1.00	24.20b ±0.01	52.80a ±0.01	4.49a ±0.01	3.27b ±0.01	125.13a ±0.01	125.13a ±0.01	40.08a ±0.01	30.06b ±0.01
X	6.62a ±0.01	6.40b ±0.01	313.00ab ±1.00	293.00b ±1.00	28.60b ±0.01	55.00a ±1.00	7.96a ±0.01	2.45b ±0.01	100.07b ±0.06	125.13a ±0.02	30.06b ±0.01	40.36a ±0.56
XI	6.73a ±0.01	6.37b ±0.01	417.00a ±1.00	293.00b ±1.00	23.10b ±0.01	56.10a ±0.01	5.31a ±0.01	3.67b ±0.01	125.13a ±0.01	100.10b ±0.01	30.06a ±0.01	30.06a ±0.01
XII	6.53a ±0.01	6.17b ±0.01	350.00a ±1.00	262.00b ±1.00	36.30b ±0.01	63.80a ±0.01	5.51a ±0.01	2.04b ±0.01	125.13a ±0.01	100.10b ±0.01	30.06b ±0.01	40.08a ±0.01
XIII	6.75a ±0.01	6.19b ±1.00	355.00b ±1.00	412.00a ±1.00	88.00a ±1.00	53.90b ±1.00	5.31a ±1.00	1.22b ±1.00	150.15b ±1.00	175.19a ±1.00	50.07b ±0.06	60.08a ±0.07
XIV	5.88a ±0.01	5.18b ±0.01	153.60a ±0.01	105.50b ±0.01	114.40ab ±0.01	121.00a ±1.00	5.10a ±0.01	2.04b ±0.01	75.08a ±0.01	75.08a ±0.01	40.08a ±0.01	10.11b ±0.16

Explanations: study sites I-XIV, according Table 1; Sp – spring and Sm – summer measurements; n=3, mean values ±SD; the highest and the lowest values of the parameters were marked with grey colour; a, b – differ significantly (between seasons) according to Duncan's test ($p < 0.05$)

Appendix 7. The comparison of some water parameters at the study sites in the vicinity of Węgliniec

Study site No.	Parameters											
	Mg^{2+} [mg/dm^3]		HCO_3^- [mg/dm^3]		Cl^- [mg/dm^3]		SO_4^{2-} [mg/dm^3]		NO_2^- [mg/dm^3]		NO_3^- [mg/dm^3]	
	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm	Sp	Sm
I	6.08a ±0.01	6.08a ±0.01	61.02a ±0.01	61.02a ±0.01	11.88b ±0.01	35.61a ±0.01	10.40b ±0.01	21.11a ±0.01	0.05a ±0.01	0.07a ±0.01	0.07b ±0.01	±0.21a 0.01
II	0.00b ±0.00	6.08a ±0.01	45.73b ±0.03	106.79a ±0.01	19.45b ±0.05	44.78a ±0.02	28.35b ±0.05	34.40a ±0.01	0.15a ±0.01	0.13a ±0.01	0.14b ±0.01	0.22a ±0.01
III	6.08b ±0.01	12.16a ±0.01	61.02b ±0.01	76.28b ±0.01	11.84b ±0.01	50.68a ±0.01	29.92a ±0.04	5.45b ±0.01	0.11a ±0.01	0.00b ±0.00	0.48a ±0.02	0.30b ±0.01
IV	6.08a ±0.01	6.08a ±0.01	45.55b ±0.48	61.01a ±0.01	30.83a ±0.11	3.36b ±0.05	52.12a ±1.02	20.12b ±0.10	0.12a ±0.01	0.00b ±0.00	0.29a ±0.01	0.13b ±0.06
V	0.00b ±0.00	12.15a ±0.01	30.51b ±0.01	61.02a ±0.02	29.21b ±0.01	33.58a ±0.01	59.24a ±0.01	42.81b ±0.01	0.00a ±0.00	0.00a ±0.00	0.28a ±0.01	0.00b ±0.00
VI	12.15a ±0.01	12.15a ±0.01	30.51b ±0.01	61.01a ±0.01	29.96ab ±0.01	32.29a ±0.01	58.70a ±0.61	41.49b ±0.01	0.00a ±0.00	0.00a ±0.00	0.33a ±0.01	0.00b ±0.00
VII	6.08b ±0.01	12.15a ±0.01	30.50b ±0.50	76.09a ±1.01	26.64a ±0.55	8.52b ±0.06	56.25a ±1.09	11.58b ±0.52	0.00a ±0.00	0.00a ±0.00	0.30a ±0.01	0.00b ±0.00
VIII	0.00b ±0.00	12.16a ±0.01	45.78b ±0.01	61.02a ±0.01	22.60a ±0.53	17.78b ±0.02	41.55a ±0.51	6.25b ±0.02	0.00a ±0.00	0.00a ±0.00	0.21a ±0.01	0.00b ±0.00
IX	6.08b ±0.01	12.16a ±0.01	45.77a ±0.01	45.77a ±0.01	26.82b ±0.02	38.14a ±0.02	52.42a ±0.52	50.05b ±0.04	0.00a ±0.00	0.00a ±0.00	0.26a ±0.01	0.00b ±0.00
X	6.08a ±0.01	6.08a ±0.01	61.34b ±0.57	76.43a ±0.52	22.23b ±1.08	48.43a ±0.51	38.23a ±1.08	29.60b ±0.62	0.00a ±0.00	0.00a ±0.00	0.22a ±0.01	0.00b ±0.00
XI	12.15a ±0.02	12.15a ±0.01	30.48b ±0.04	61.34a ±0.57	25.65b ±0.57	33.32a ±0.11	54.38a ±0.54	48.88b ±.083	0.00a ±0.00	0.00a ±0.00	0.25a ±0.01	0.00b ±0.00
XII	12.15a ±0.01	0.00b ±0.00	30.50b ±0.5	60.34a ±1.16	15.05b ±0.06	36.79a ±0.52	28.13a ±0.11	20.71b ±0.25	0.00a ±0.00	0.00a ±0.00	0.20a ±0.01	0.00b ±0.00
XIII	6.08a ±0.01	6.08a ±0.01	106.26b ±1.10	122.01a ±1.00	14.72b ±0.11	33.37a ±0.55	22.38b ±0.54	83.59a ±0.52	0.06b ±0.01	0.12a ±0.01	0.06b ±0.01	0.10a ±0.01
XIV	12.15a ±0.01	12.23a ±0.15	12.20b ±0.01	30.50a ±0.01	6.95b ±0.01	12.15a ±0.01	33.43a ±0.06	6.47b ±0.01	0.00b ±0.00	0.32a ±0.01	0.32b ±0.01	20.00a ±0.01

Explanations: study sites I-XIV, according Table 1; Sp – spring and Sm – summer measurements; n=3, mean values ±SD; the highest and the lowest values of the parameters were marked with grey colour; a, b – differ significantly (between seasons) according to Duncan's test ($p < 0.05$)