Zbigniew KACZMAREK[1], **Mieczysław GRZELAK**[2], **Eliza GAWEŁ**[4], **Piotr GAJEWSKI[1]**, **Sławomir JANYSZEK[3]**, **Bartłomiej GLINA[1],Wojciech OWCZARZAK[1]**
Poznań Life Sciences University
[1] Department of Soil Science and Land Protection, ul. Szydłowska 50, 60-656 Poznań, Poland
[2] Department of Grassland Science and Environmental Landscape, ul. Dojazd 11, 60-632 Poznań, Poland
[3] Department of Botany, ul. Wojska Polskiego 71 C, 60-625 Poznań, Poland
[4] Institute of Soil Science and Plant Cultivation - State Research Institute, ul. Czartoryskich 8, 24-100 Puławy, Poland
e-mail:kazbig42@up.poznan.pl

Received: 2017-07-13 ; Accepted: 2017-08-08

IMPACT OF HABITAT CONDITIONS ON THE FORMATION OF FLORISTIC DIVERSITY OF *Glycerietum maximae* Hueck 1831 COMMUNITY

Summary

Research on the floristic formation of Glycerietum maximae community under influence of a habitat in the valley of Noteć Leniwa, was conducted in the years 2013 and 2014 on the area of 60 ha. In the community, the following parameters were determined: systematics, botanical composition, distribution of constancy levels in an association and a current state of habitat conditions on the basis of Ellenberg's indicative numbers, and identification of moisturization conditions with Oświt's method. Two soil profiles were completed (of a peaty soil and a mucky one). In the samples collected from each genetic horizon, such properties were marked: pH, content of total nitrogen calcination loss, texture, bulk density and particle density, hygroscopic moisture and maximum hygroscopic capacity, soil's water bonding potential, total and drainage porosities, total and readily available waters and filtration ratio. The investigated soils were rich in organic matter, had a favorable reaction and a satisfactory content of nitrogen. Their water permeability may be considered as optimal and retention values – good. At balanced utilization, natural evolution-degradation processes will proceed with a natural pace. The soils are a very favorable ground for the development of valuable plant communities.
***Key words**: grassland and reed communities, Noteć valley, mucky and peaty soils*

WPŁYW WARUNKÓW SIEDLISKOWYCH NA KSZTAŁTOWANIE SIĘ RÓŻNORODNOŚCI FLORYSTYCZNEJ ZBIOROWISKA *Glycerietum maximae* Hueck 1831

Streszczenie

Badania nad kształtowaniem się różnorodności florystycznej zbiorowiska Glycerietum maximae pod wpływem siedliska w dolinie Noteci Leniwej, przeprowadzono w 2013 oraz 2014 roku. Na obszarze o powierzchni 60 ha. W zbiorowisku określono systematykę, skład botaniczny zespołu, rozkładu stopni stałości w zespole oraz aktualny stan warunków siedliskowych na podstawie wartości liczb wskaźnikowych Ellenberga (F, R , N), a także identyfikację warunków wilgotnościowych metodą Oświta. Wykonano 2 profile glebowe (gleby: torfowa i murszowa). W próbkach, pobranych z poszczególnych poziomów genetycznych oznaczono takie właściwości, jak: pH, zawartość azotu ogólnego, straty prażenia, uziarnienie, gęstość gleby oraz jej fazy stałej, porowatość całkowitą i drenażową, wilgotność higroskopową oraz maksymalną pojemność higroskopową, potencjał wiązania wody przez glebę oraz jej potencjalną i efektywną retencję użyteczną, retencję całkowitą, współczynnik filtracji. Badane gleby wykazywały znaczną zawartość materii organicznej, korzystny odczyn, zadowalającą zawartość azotu. Ich wodoprzepuszczalność można uznać za optymalną a zdolności retencyjne za dobre. Przy zrównoważonym ich użytkowaniu, naturalne procesy ewolucji – degradacji, będą zachodzić w nich w naturalnym tempie. Stanowią one bardzo dobre podłoże dla wykształcania się na nich cennych zbiorowisk roślinnych.
***Słowa kluczowe**: zbiorowiska łąkowe i szuwarowe, dolina Noteci, , gleby murszowe i torfowe*

1. Introduction

Glycerietum maximae Hueck 1831 association is dominated by Great Manna Grass (*Glyceria maxima* L) in its typical form as well as in all the association variants. This species is a main component of over ground mass and accounts for even 90% of the whole crop. It is quite often observed in the valley of Noteć and Warta, in the patches of 20-500 m^2, where the terrain is silty as a result of drying of regular deluges [1, 12, 30]. Furthermore, it grows on the banks of water reservoirs and streams of very slow current. It is one of the most popular marsh communities. It covers fertile soils, usually with a peaty ground, which are flooded for the most of the year (up to 30-40 cm ppt.) [9, 10]. They are usually marshy areas in a significant part of the valley, located within the range of annual and long-term surface deluges. It is usually adjacent to an association of acute sedge (*Caricetum gracilis*) and is often temporary. The association has got a vast ecological scale, which is mainly a result of changeable soil and water conditions. Due to the possibility of obtaining a great amount of green mass, its economical importance may be significant. When it is mown early, it may be a good source for silage (rarely: for zero grazing or hay) due to the danger of the appearance of cyanogenic glycosides and Fasciola larvas [24]. The association is usually located on well distributed, silty low peats or mucks. Ground water level stays on a ground level or drops to the depth of 30-40 cm. The aim of the research was an assessment of the impact of current habitat conditions on the formation of floristic composition of flowering grasslands in the Noteć valley. The paper contains a characteristic of such a habitat, with regard to the differentiation of floristic composition and soil conditions.

2. Object and methodology

2.1. Floristic research

The research was conducted in vegetation seasons in the years 2013 and 2014 in the area of 60 ha in the villages: Wizany, Lubcz Wielki, Lubcz Mały, Herburtowo and Marianowo, Nowe Dwory (WielkopolskaVovoidship, Czarnków-Trzcianka County). It was conducted in small, homogenous patches of 20-100 m^2. Twenty-six phytosociological relevés taken with Braun-Blanquet's method were used [2]. The following parameters were determined for the association: systematics, botanical composition, percentage share of species, the distribution of constancy level and a current state of habitat conditions on the basis of Ellenberg's indicative numbers, and identification of moisturization conditions with Oświt's method [25]. The community underwent a floristic and phytosociological analysis and classified with a syntaxonomical system after Matuszkiewicz [21]. Nomenclature of the species was adopted after Mirek et al. [22].

2.2. Soil science research

In terms of geomorphology, the object was situated in Noteć's glacial valley. It was covered with organic soils, formed of low peat which was mucked to various extent in top horizons, and of alluvial soils. Ground water level was located at the depth of ca. 30-40 cm. Two soil profiles were made: profile 1 – organic, sapric-mucky soil (Sapric Histosol), profile 2 – typical peaty hemic soil (Hemic Histosol) [13, 28]. From each genetic horizon, samples of disturbed and undisturbed structure were collected, in order to determine such properties as: texture – with a sewage method (sand) and aerometric method (loam and silt) after dispersion with sodium hexametaphosphate [27], particle density (in mineral deposits) with a picnometric method and with Okruszko's formula [26] (in organic deposits), soil density – with Nitzshe's vessels of 100 cm^3, total porosity – determined on the basis of particle density and dry soil density [23], calcination loss after being burnt in 550 ^oC [23], filtration ratio – with the method of constant pressure loss [19], maximum hygroscopic capacity (moisture at pF=4.5) – in a vacuum chamber at a negative pressure of 0,8atm and with a saturated K_2SO_4 solution, water bonding potential of a soil – with the method of Richard's pressure chambers [18], total and readily available waters – calculated on the basis of pF, the content of carbon and total nitrogen – with Vario Max CNS analyzer and pH – potentiometrically. All the published results are averages from five replications.

3. Results and discussion

3.1. Floristic research

In terms of syntaxonomy, a differentiated *Glycerietum maximae* Hueck 1831 association belongs to (Cl.) *Phragmitetea* R. Tx. et PRSG 1942 class, (O.) Phragmitetalia KOCH 1926 order and (All.) Phragmition KOCH 1926 association, i.e. to the group of reed bed of various water level. It is a reed bed of high crop production, and quite good fodder value, especially when mown before blooming. In as many as eleven species, the 2nd (30.6%) and the 3rd (25.0%) constancy level was observed. Only two species (5,6%) reached the 5th constancy level (tab. 1).

Thirty-six plant species of high water requirements were observed in the association. The most numerous (seven species) was *Poaceae* family. A dominant species was *Glyceria maximae* (S=V i D 6480.0). High constancy was observed in Rumex hydrolapathum (S=V i D=87.2), and a high (the 4th) constancy level – in: *Lythrum salicaria, Mentha aquatica, Rorippa amphibia* and *Phragmites australis* (tab. 2).

The community was located on flooded eutrophic areas, of a high ground water level. According to Ellenberg's classification, it was a near-water habitat and according to Oświt – a marshy habitat. Soil's reaction was neutral or slightly neutral and the content of nitrogen was high (tab. 3).

Table 1. Characteristic of distribution of constancy degrees in Glycerietum maximae association
Tab. 1. Charakterystyka rozkładu stopnia stałości w zespole Glycerietum maximae

Degree of constancy	Quantity of species	Percentage content	Species of varied highest quantity and constancy
V	2	5.6	*Glyceria maxima , Rumex hydrolapathum*
IV	6	16.6	*Mentha aquatica, Lythrum salicaria, Ranuncukus repens, Phragmites australis, Galium palustre, Agrostis alba*
III	9	25.0	*Phalaris arundinacea, Poa palustris, Rorippa amphibia, Iris pseudoacorus, Glyceria fluitans, Myosotis palustris, Lysimachia vulgaris*
II	11	30.6	*Carex gracilis, Lysimachia thyrsiflora, Lychnis flos-cuculi, Sium latifolium, Carex acutiformis, Carex riparia, Filipendula ulmaria, Stachys palustris, Alisma plantago-aquatica, Equisetum limosum, Rumex crispus*
I	8	22.2	*Symphytum officinalis, Deschampsia caespitosa, Sparganium ramosum, Carex vesicaria, Ranunculus linquaq, Equisetum palustre, Sagitaria sagittifolia, Caltha palustris*

Source: own work / Źródło: opracowanie własne

Table 2. Botanical composition of Glycerietum maximae association
Tab. 2. Skład botaniczny zespołu Glycerietum maximae

Botanical family	Number of species from a family	Phytosociological constancy	Systematic value
Poaceae	7		
- *Glyceria maxima*		V	6480.0
- *Phragmites australis,*		IV	60.2
- *Agrostis canina*		III	164.8
- *Agrostis alba*		III	92.1
- *Phalaris arundinacea*		II	56.4
- *Glyceria fluitans*		II	18.8
- *Deschampsia caespitosa*		II	5.0
Cyperaceae	4		
- *Carex gracilis,*		II	122.8
- *Carex acutiformis*		II	20.2
- *Carex riparia*		II	5.0
- *Carex vesicaria*		II	2.0
Fabaceae	1	II	5.0
Herbs and weds *	24	V	87.2
- *Rumex hydrolapathum*		IV	22.6
- *Lythrum salicaria*		IV	5.0
- *Mentha aquatica*		IV	5.0
- *Rorippa amphibia*		III	27.6
- *Iris pseudoacorus*		III	5.0
-*Myosotis palustris*		III	2.0
- *Lysimachia vulgaris*		III	2.0
- *Galium palustre*		II	52.6
- *Lysimachia thyrsiflora*		II	12.2
		I	5.0

* Short list of species

Source: own work / Źródło: opracowanie własne

Table 3. A characteristic of Glycerietum maximae habitat based on Ellenberg's and Oświt's phytoindication methods
Tab. 3. Charakterystyka siedliska zespołu Glycerietum maximae wg Ellenberga i Oświta

Average of index	Moisture F	Soil reaction R	Nitrogen content N
According to Ellenberg's index	9,11	6,5	7,7
According to Oświt moisture index	8,7	-	-
Assessment of a habitat	Near-water habitats	Indifferent and slightly indifferent	big

Source: own work / Źródło: opracowanie własne

3.2. Soil science research

Epipedons were built of muck (prof. 1) and low peat (prof. 2). They were deeply covered with sand [3] (tab. 4).

Particle density in organic deposits was the highest in epipedons - from 1.86 (prof. 2) to 2.11 $Mg \cdot m^{-3}$ (prof. 1) $Mg \cdot m^{-3}$. In organic endopedons the values decreased to 1.64 (prof. 2; Oe2, Oei) to 1.97 $Mg \cdot m^{-3}$ (prof. 1; MOe). In sands, which are underlying rocks, this property was close to quartz's density - 2,65 $Mg \cdot m^{-3}$ (tab. 5).

Due to high content of organic matter, bulk density of organic deposits was low: from 0.41 (prof. 2; Oei) to 0.76 $Mg \cdot m^{-3}$ (prof. 1; MOe). In sands, respective values of density were higher: from 1.42 (prof. 2; Cg) do 1.43 $Mg \cdot m^{-3}$ (prof. 1; Cg) (tab. 5).

Total porosity of muck and peat was high: from 58.29 (prof. 1; M) to 73.66 %v (prof. 2; Oe1). The tendency to the decrease of porosity along with the depth was not observed [23]. Porosity was the lowest in sands (ca. 46%v) (tab. 5).
The content of organic matter was characteristic to various deposits. Its highest values were observed in peat horizons: from 523.7 (prof. 1; MOe) to 825.1 $g \cdot kg^{-1}$ (prof. 2; Oe2), a bit lower ones – in muck (396.6 $g \cdot kg^{-1}$), and trace amounts – in sands (ca. 0.2 $g \cdot kg^{-1}$) (tab. 5).

Due to a trace amount of mineral colloids, hygroscopic moisture (H) and maximum hygroscopic capacity (MH) were dependent on the content of organic matter [23]. The lowest values of hygroscopic moisture and maximum hygroscopic capacity were observed in partly mineralized top horizons: H - from 4.96 (prof. 1) to 5.46 %v (prof. 2); MH 9.34 and 10.11 %v, respectively. In In endopedons, these values were higher and oscillated between: H – from 5.70 (prof. 2; Oei) to 7.88 %v (prof. 2; Oe3); MH - from 10.15 (prof. 1; MOe) to 21.67 %v (prof. 2; Oe2). In sandy underlying rocks, both H and MH were extremely low (from 1.06 to 1.17 %v) (tab. 5).

Natural moisture of epipedons located in the sphere of capillary rise was high (from 35.83 to 48.11 %v). In endopedons, the values were much higher (from 36.96 to 69.91 %v), due to their direct contact with soil-ground waters. Because of it, moisture in organic deposits which were located deeper, was often close to the values of total porosity (tab. 5).

The speed of filtration was balanced and high. In organic deposits, the values of filtration ratio oscillated from 8.4 (prof. 1; Ose) to 24.3 $\mu m \cdot s^{-1}$ (prof. 2; Oei). The highest speed of filtration was in sandy deposits, where it oscillated from 89.5 (prof. 2; Cg) to 103.13 $\mu m \cdot s^{-1}$ (prof. 1; Cg) (Tab. 5). The values were in accordance with the ranges cited by various authors for the soils of similar origin and texture [5, 7, 8, 11, 14, 16, 17, after: 32].

Table 4. Texture of mineral horizons of the studied soils
Tab. 4. Uziarnienie poziomów mineralnych badanych gleb

Profile number	Horizon	Depth (cm)	Percent of fractions (mm)						Texture acc. FAO
			2.0-0.1	0.10-0.05	0.05-0.02	0.02-0.005	0.005-0.002	<0.002	
1	Cg	>245	90	5	2	2	0	1	S
2	Cg	>187	93	3	1	1	1	1	S

Explanation: S – sand

Source: own work / Źródło: opracowanie własne

Table 5. Basic physical and chemical properties of the studied soils
Tab. 5. Podstawowe właściwości fizyczne i chemiczne badanych gleb

Profile number	Horizon	Depth (cm)	Particle density ($Mg \cdot m^{-3}$)	Bulk density ($Mg \cdot m^{-3}$)	Total porosity (%v)	Organic mater ($g \cdot kg^{-3}$)	Natural moisture (%v)	Hygroscopic water (%v)	Saturated hydraulic conductivity ($\mu m \cdot s^{-1}$)	pH in 1M KCl	Total nitrogen ($g \cdot kg^{-3}$)
1	M	0-27	2,11	0,88	58,29	396,6	35,83	4,96	13,5	6,8	41,27
	MOe	27-42	1,97	0,76	61,42	523,7	41,17	5,81	10,0	6,8	22,82
	Ose	42-85	1,77	0,54	69,49	711,8	64,92	7,29	8,4	6,1	25,23
	Oe1	85-160	1,80	0,63	65,00	683,5	58,71	6,55	11,7	6,2	17,56
	Oe2	160-245	1,82	0,63	65,38	667,1	55,83	6,42	9,6	6,4	17,31
	Cg	> 245	2,65	1,43	46,04	0,3	39.15	0,37	89,5	5,4	0,23
2	Oe1	0-55	1,86	0,49	73,66	630,5	48,11	5,46	14,2	6,3	29,93
	Oe2	55-85	1,64	0,55	66,46	825,1	61, 36	7,52	10,6	6,4	24,53
	Oe3	85-165	1,70	0,51	70,00	770,3	65.29	7,88	11,4	6,0	19,54
	Oei	165-187	1,64	0,41	75,00	831,5	69,91	5,70	24,3	5,9	10,92
	Cg	> 187	2,65	1,42	46,42	0,2	36,96	0,22	103,1	5,5	0,10

Source: own work / Źródło: opracowanie własne

Reaction of each genetic horizon was either neutral or slightly acid in organic deposits (pH from 5.9 to 6.8). Sandy bedrock was acid (pH from 5.4 to 5.5) (tab. 5).

The content of total nitrogen was typical for each deposit – higher in top horizons (from 29.93 (prof. 2) to 41.27 $g \cdot kg^{-1}$ (prof. 1), lower in organic In endopedons: from 10.92 (prof.2; Oei) to 25.23 $g \cdot kg^{-1}$ (prof. 1; Ose), and the lowest in sands (0.21-0.23 $g \cdot kg^{-1}$) (tab. 5).

Water capacities marked in organic horizons at each water bonding potential, may be considered as high, whereas respective values in sands – low. Field capacity (pF=2.0) was the highest in peats: from 42.23 (prof. 1; MOe) to 68.29%v (prof. 2; Oe1). At pF=2.5, moisture was by several or over a few or dozen (ca. 2-16) %v lower. At the point of production water (pF 3.7), moisture was diversified and oscillated from 31.33 (prof. 1; MOe) to 52.54 %v (prof. 2; Oei) in organic deposits and ca.1,2-1.6%v in sands. At a wilting point (pF 4.2), water capacity was respectively lower: by about 14–22 %v (muck and peat) and 1.5-2 %v (sands) (tab. 6).

In organic horizons, readily available water oscillated from 9.37 (prof. 1; M) to 24.86 %v (prof. 2; Oe3). It was much lower in mineral horizons (by about 5 %v). For total available water, all values were higher: from 21.31 (prof. 1; MOe) to 41.19 %v (prof. 2; Oe3) in muck and peat and from 7.15 (prof. 2; Cg) to 8.03 %v (prof. 2; Cg) in sands. Despite good potential water availability, much of it was strongly bound in the examined soils, and therefore – not easily accessible (tab. 6). The values of readily and total available waters were slightly higher than these parameters provided by Ślusarczyk [31], Kaczmarek [15] and Gajewski et al. [6] for various soils and mineral deposits.

Table 6. Soil water potentials and the total and readily available water in the studied soils
Tab. 6. Potencjał wiązania wody oraz potencjalna i efektywna retencja użyteczna

Profile number	Horizon	Depth (cm)	Water capacity at pF: (%v)						Total available water (%v)	Readily available water (%v)
			0.0	2.0	2.5	3.7	4.2	4.5	2.0 – 4.2	2.0 –3.7
1	M	0-27	56,18	46,70	41,21	37,33	23,71	9,34	22,99	9,37
	MOe	27-42	58,72	42,23	35,39	31,33	20,92	10,15	21,31	10,90
	Ose	42-85	67,51	64,21	62,94	49,46	33,68	12,89	30,53	14,75
	Oe1	85-160	62,48	55,41	53,92	44,56	29,54	11,51	25,87	10,85
	Oe2	160-245	61,94	51,52	48,35	40,37	26,11	10,62	25,41	11,15
	Cg	> 245	43,29	9,23	7,46	3,89	1,20	1.17	8,03	5,34
2	Oe1	0-55	71,41	68,29	60,66	52,54	29,74	10,11	38,55	15,75
	Oe2	55-85	64,87	60,76	57,60	45,58	29,78	21,67	30,98	15,18
	Oe3	85-165	68,06	66,64	60,82	41,78	25,45	20,85	41,19	24,86
	Oei	165-187	72,11	53,29	49,83	42,24	19,67	16,22	33,62	11,05
	Cg	> 187	44,15	8,78	6,55	3,40	1,63	1,06	7,15	5,38

Source: own work / Źródło: opracowanie własne

4. Summary

The investigated community of *Glycerietum maximae* Hueck 1831 was located on flooded, eutrophic areas of high ground water level. *Glyceria maximae* (S= V and D 6480.0) was a dominant species and high constancy was observed in *Rumex hydrolapathum* (S=V and D=87.2). High constancy level (the 4th) was observed in: *Lythrum salicaria, Mentha aquatica, Rorippa amphibia* and *Phragmites australis*. It was a near-water habitat according to Ellenberg, and a marshy habitat according to Oświt. The most (eleven) species had the 2nd (30.6%) and the 3rd (25%) constancy level. Only two species had the highest (the 5th) constancy level.

As an important element of the habitat, the examined organic soils had characteristics typical of Polish soils of a similar origin. They were rich in organic matter, had a favorable reaction and a satisfactory content of nitrogen. Their water permeability may be considered as optimal and retention values – good. At balanced utilization, natural evolution-degradation processed will proceed in a natural pace. They are a very good ground for the development of valuable water communities.

5. References

[1] Borysiak J.: The structure of the alluvial land vegetation in the middle and lower course of the Warta River. Adam Mickiewicz University Press. Poznań, 1994.

[2] Braun-Blanquet J.: Pflanzensoziologie. 2 Aufl. Wien, 1951.

[3] FAO: Guidelines for soil profile description.: Land and water Development Division FAO, Rome, 2006.

[4] Ellenberg H., Weber H., Dull R., Wirth V., Werner W., Paulissner D.: Zeigerwerte von Pflanzen in Mitteleuropa. Scripta Geobotanica, 199218,.

[5] Gajewski P., Kaczmarek Z., Grzelak M., Owczarzak W.: Współczynnik filtracji w glebach płowych wytworzonych z glin zwałowych równiny dennomorenowej. Roczn. Glebozn., 2007, 58, 1-2, 53-61.

[6] Gajewski P., Owczarzak W., Kaczmarek Z.: Pojemność wodna oraz zdolności retencyjne gleb hydrogenicznych Doliny Grójeckiej. Rocz. Glebozn., 2008, 59, 2, 39-47.

[7] Gajewski P., Grzelak M., Kaczmarek Z.: The influence of habitat conditions on the development and floral diveristy of grass communities. Journal of Research and Applications in Agricultural Engineering, 2014, Vol. 58(3), 45-49.

[8] Gajewski P., Kaczmarek Z., Mocek A., Grzelak M., Knioła A., Glina B.: Geobotanical conditions of ecological grasslands on light river alluvial soils. Journal of Research and Applications in Agricultural Engineering, 2015, Vol. 60(3), 47-51.

[9] Grzelak M.: Zróżnicowanie fitosocjologiczne szuwaru mozgowego Phalaridetum arundinaceae (Koch 1926 n.n.) Libb. 1931 na tle warunków siedliskowych w wybranych dolinach rzecznych Wielkopolski. Rocz. AR Pozn., Rozpr. Nauk., 2004, 354.

[10] Grzelak M., Bocian T.: Zróżnicowanie geobotaniczne zbiorowisk seminaturalnych doliny Noteci Bystrej oraz ich rola w krajobrazie. Annales Universitatis Mariae Curie-Skłodowska, 2006, 61, sectio E, 257–266.

[11] Grzelak M., Gajewski P., Kaczmarek Z.: Warunki geobotaniczne ekologicznych użytków zielonych w dolinie Noteci Leniwej. Journal of Research and Applications in Agricultural Engineering, 2012, Vol. 57(3), 132-147.

[12] Grzelak M., Murawski M.: Waloryzacja przyrodniczo-użytkowa szuwaru mozgowego w dolinie Noteci. Journal of Research and Applications in Agricultural Engineering, 2013, 58(3), 183-188.

[13] IUSS Working Group WRB.: World reference base for soil resources 2014, update 2015. International Soil Classification System for Naming Soil and Creating Legends for Soil Maps. Food and Agriculture Organization of the United Nations, Rome, 2015.

[14] Kaczmarek Z.: Zdolności filtracyjne gleb płowych i czarnych ziem wytworzonych z glin morenowych w rejonach oddziaływania Konińskiego Zagłębia węglowego. Rocz. AR w Poznaniu, 2001, 355, Roln. 61, 63-76.

[15] Kaczmarek Z.: Pojemność wodna oraz zdolności retencyjne gleb płowych i czarnych ziem wytworzonych z glin morenowych w rejonach oddziaływania Konińskiego Zagłębia Węglowego. Rocz. AR w Poznaniu, 2001, 355, Roln. 61, 49-61.

[16] Kaczmarek Z., Grzelak M., Gajewski P.: Warunki siedliskowe oraz różnorodność florystyczna ekologicznych siedlisk przyrodniczych w Dolinie Noteci. Journal of Research and Applications in Agricultural Engineering, 2010, Vol. 55(3), 142-147.

[17] Kaczmarek Z., Gajewski P., Owczarzak W., Glina B., Grzelak M., Murawski M.: Floral and habitat diversity of ecological grasslands in the Bystra Noteć Valley. Journal of Research and Applications in Agricultural Engineering, 2015, Vol. 60 (3), 75-81.

[18] Klute A.: Water retention: Laboratory methods. [In:] Methods of Soil Analysis, Part 1:Physical and MineralogicaMethods. 2nd edn. Agron. Monogr. 9 ASA and SSSA (KluteA., Editor), Madison, Wi., 1986, 635-660.

[19] Klute A., Dirksen C.: Hydraulic conductivity and diffusivity: laboratory methods. In: Klute A. (Ed.). Methods of Soil Analysis, Part 1: Physical and Mineralogical Methods. 2nd edn. Agron. Monogr. 9 ASA and SSSA, Madison, Wi., 1986.

[20] Krogulec B.: Wpływ metodyki badań na otrzymywane wartości współczynnika filtracji osadów słabo przepuszczalnych. Przegląd Geologiczny, 1994, Vol. 42, 4, 276-279.

[21] Matuszkiewicz W.: Przewodnik do oznaczania zbiorowisk roślinnych Polski. Vademecum Geobotanicum. PWN, 2015.

[22] Mirek Z., Piekoś-Mirkowa H., Zając A., Zając M.: Vascular plants of Poland. A checklist. Krytyczna lista roślin naczyniowych Polski. Pol. Bot. Stud. Guideb. W. Szafer Institute of Botany, Polish Acad. of Scien., Kraków, Ser. 15, 2002.

[23] Mocek A., Drzymała S.: Geneza, analiza i klasyfikacja gleb. Wyd. UP Poznań, 2010.

[24] Nowiński M.: Polskie zbiorowiska trawiaste i turzycowe. PWRiL, 1967.

[25] Oświt J.: Metoda przyrodniczej waloryzacji mokradeł i wyniki jej zastosowania na wybranych obiektach. Mater. Inf. 35. Falenty, Wydaw. IMUZ, 2000.

[26] Okruszko H., Piaścik H.: Charakterystyka gleb hydrogenicznych. Wyd. ART Olsztyn, 1990.

[27] Polski Komitet Normalizacyjny.: Polska Norma PN-R-04032: Gleby i utwory mineralne. Pobieranie próbek i oznaczanie składu granulometrycznego, 1998.

[28] Polish soil classification / Systematyka gleb Polski: Roczniki Gleboznawcze, 2011, 62(3), 1-193.

[29] Soil Conservation Service: Soil Survey laboratory methods manual. Soil Survey Invest. Raport No. 42., U.S. Dept. Agric., Washington, DC., 1992, 105-195.

[30] Szoszkiewicz K., Szoszkiewicz J.: Wybrane zbiorowiska szuwarowe w dolinie Środkowej Noteci. Zesz. Probl. Post. Nauk Rol., 1993, 412, 173-177.

[31] Ślusarczyk E.: Określenie retencji użytecznej dla prognozowania i projektowania nawodnień. Melioracje Rolne, 1979, 3, 1-10.

[32] Zawadzki S.: Gleboznawstwo. PWRiL, 1999.