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# SOIL AND HABITAT CONDITIONS OF THE SELECTED ECOLOGICAL GRASSLANDS IN „NATURE 2000" REGION LOCATED NEARBY KOŹMIN BROWN COAL PIT

*Summary*

*The paper presents the results of soil and floristic research conducted in the valley of the central course of Warta River in the "Nature 2000" area, which is located nearby KWB Adamów brown coal pit. The state of grasslands' vegetation was characterized on the basis of its floristic composition, and such soil properties as texture, specific density, bulk density, porosity, maximal hygroscopic capacity, saturated hydraulic conductivity, the potential of water bonding and total and readily available water were analyzed. Grasslands located in the detention basin were diverse and the diversion depended mostly on their location and utilization. Foxtail, oatgrass, and fescue-poa grasslands were dominant, whose new growth is rich in species of economically useful herbs and weeds. Examined soils showed great variation in their physical and water properties. It stems out from their specific origin which was strongly conditioned by the fact that are much more influenced by geological than soil-formation processes. These changes were caused mainly by different texture of each genetic level and the character of sludge accumulation which influences the content of total carbon. The presented results did not differ significantly from typical values found in alluvial soils of Polish river valleys. The conducted pedological characteristics of habitats suggests that the examined area is not undergoing degradation due to the activities of an opencast mine located nearby. It has also been confirmed by the high level of soil and ground waters.*
***Key words**: grassland communities, physical and water properties, soil degradation, brown coal pit*

# WARUNKI GLEBOWE I SIEDLISKOWE WYBRANYCH EKOLOGICZNYCH UŻYTKÓW ZIELONYCH OBSZARU „NATURA 2000" POŁOŻONYCH W SĄSIEDZTWIE ODKRYWKI WĘGLA BRUNATNEGO KOŹMIN

*Streszczenie*

*W pracy przedstawiono wyniki badań gleboznawczych i florystycznych przeprowadzonych w Dolinie Środkowej Warty na terenie obszaru „Natura 2000", sąsiadującego z działającą odkrywką węgla brunatnego KWB Adamów. Scharakteryzowano stan pokrywy roślinnej użytków zielonych na podstawie ich składu florystycznego oraz przeanalizowano takie właściwości gleb, jak: skład granulometryczny, gęstość fazy stałej, gęstość gleby, porowatość, maksymalną pojemność higroskopową, filtrację, potencjały wiązania wody przez glebę, potencjalną i efektywną retencję użyteczną. Zbiorowiska łąkowe zlokalizowane na polderze zalewowym wykazały zróżnicowanie, uzależnione w głównej mierze od ich usytuowania i użytkowania. Dominowały łąki wyczyńcowe, rajgrasowe i kostrzewowo-wiechlinowe, w runi których stwierdzono duży udział gatunków z grupy użytkowej ziół i chwastów. Badane gleby wykazywały silne zróżnicowanie w obrębie ich właściwości fizycznych i wodnych. Wynikało ono z ich specyficznej genezy, warunkowanej zdecydowaną przewagą wpływu na nie procesów geologicznych nad glebotwórczymi. Opisane różnice powodowane były głównie przez odmienne uziarnienie poszczególnych poziomów genetycznych oraz charakter zamulenia, wpływające na zawartość węgla ogólnego. Zaprezentowane wyniki nie odbiegały od typowych wartości, stwierdzanych w madach dolin rzecznych Polski. Przeprowadzona charakterystyka pedologiczna siedlisk sugeruje, iż teren badań w chwili obecnej nie ulega degradacji wskutek działalności zlokalizowanej w pobliżu kopalni odkrywkowej. Potwierdza to również wysoki stan wód glebowo-gruntowych.*
***Słowa kluczowe**: zbiorowiska łąkowe, właściwości fizyczne i wodne, degradacja gleb, kopalnia węgla brunatnego*

## 1. Introduction

*Nature 2000* was a form of environment protection established in Polish law in 2004 [1]. Its main aim is to protect natural habitats and endangered species of flora and fauna. No actions which may have a negative impact on the protected targets – either on their own or with other actions – cannot be undertaken in such areas [2, 3, 5]. Opencast mining works conducted on vast terrains of Central Polish Plain cause significant changes in hydrography and hydrology of the areas under their dehydrating impact. Developing a system of opencast pits is connected with dramatic changes in the landscape and in the natural habitats. Preparation works, which precede the exact carbon exploitation, usually consist in dehydration of the lode which also leads to the dehydration of the area nearby the future exposure [19]. Hydrological dehydration brought up by such actions, may impair the physical soil properties significantly which has got key impact on their fertility and the pace of physiochemical and biochemical soil processes; it also directly contributes to changes in vegetation [8, 11]. The aim of this study was the analysis of basic soil physical and water properties in a selected region of the central course of Warta River extended by a floral characteristics of grasslands, which allows the assessment of potential degrading influence of the neighboring *Koźmin KWB Adamów* opencast mine on them.

## 2. Objects and methodology

The research was conducted in the vegetation period in 2012. the object of the research was *Nature 2000* area – the central course of River Warta located nearby Radyczyny village, in the eastern part of Przykona municipality, 13 km east from Turek. Within 4 km west and 9 km north from the village, there are *KWB Adamów* exposures (Koźmin lode). The examined area is located within left-side berms of Warta urstromtal. Its eastern part is located on a low berm at about 101 meters above sea level. It is a floodplain protected with embankments. The eastern part is situated on a high berm at 104 meters above sea level. The area has been examined due to the potential danger of it being incorporated by a perspective dehydrating depression curve. Grasslands in the area are mainly (90%) hay meadow (Latin: *pratum*). Eight floral inventories have been conducted according with the method of phitosociological descriptions of Braun-Blanquet in order to prepare a floral and utility characteristics of the grasslands [21]. The assessment of the use value of green growth in the selected communities included the determination of percentage part of farm-useful species (feed grasses and fabaceae) and calculating the number of green growth use value – Lwu [7]. Furthermore, indicative properties of plants regarding moisturization have been used for a full characteristics.

Soil cover of the object is composed of alluvial soils. They cover river berms and are composed of alluvial sediments of various origin. Their mineral material is often flat and individual facies – intensively sorted, equigranular, with mineral grains strongly ground. What is typical to them, is a characteristic layered structure [13]. The material for laboratory analysis was collected from four soil profiles. During field works, their morphological structure was described, the depth of ground water surface was determined and their natural and utility classification was completed. All the examined soils were proper alluvial soils (Haplic Fluvisol) and represented typical grassland communities [17]. Three of them (profiles 1, 2, 3) represented the 4$^{th}$ valuation class and the 2$^{z}$ agricultural suitability. Soil no. 4 was classified as the 5$^{th}$ valuation class and 3z suitability. Firm surface of soil-ground waters in individual profiles was: no. 1 – 0.7m, no. 3 and 4 – 1.0m. Samples of affected and intact structure (V=100cm$^3$) were collected for laboratory research from each genetic level. The following properties were marked in the samples: texture – with Bouyoucos' method modified by Prószyński [16], specific density – with pycnometric method [20], bulk density – with Nitzsch's vessels of 100cm$^3$; porosity was calculated on the basis of density and moisture – with a drier-weight method [12], maximal hygroscopic capacity – in a vacuum chamber at vacuum of 0,8 atm and with $K_2SO_4$ solution [12], saturated hydraulic conductivity – with the method of constant pressure drop [9], soil water binding potential – with Richards' method of pressure chambers [8], total (TAW) and readily (RAW) available water were calculated in the basis of pF marking. All the presented results are averaged values from five replications.

## 3. Results

### 3.1. Floral-utility characteristics

The structure of grasslands located in Warta polders nearby Radyczyny is dominated by hay meadow in a fescue-poa type which occupy 50% of the area. On the lower berms, they compose mosaic with foxtail grassland (25%), whereas on the higher ones – with oatgrass (25%) (tab. 1). Foxtail is also dominant on the polders located closest to the Warta river bed. Their botanical composition includes 24 species. These communities are degraded to a large extent due to them being used inadequately and to a limited number of fertile polders. Foxtail grass lives in the green growth of 10-20%, reed canarygrass – of about 5%, however, floral composition especially of herbs and weeds shows successive changes in the direction of dried communities. Sodding was there about 75-80%. Utility value of green growth was assessed as good LWU=6,71. In the green growth of fescue-poa grasslands there were 32 plant species. Grasses were dominant with mainly poa (average of 25%) and red fescue (average of 20%). Moreover, one could also encounter foxtail and reed canarygrass – species of humid, often flooded communities. Sometimes, but not regularly, these communities are girdled, especially in the zone behind the embankment. It may be proved by a significant appearance of herbs and weeds, including sorrel (about 15%), ribwort plantain (about 12%), common silverweed and shepherd's purse (about 4% each). Green growth of this community is dense (90% of the cover) and of good utility value (LWU=6,14).

The driest parts of the polder are covered by grasslands similar to oatgrass. 28 taxas were noted here, with the domination of dry communities such as common yarrow, sand-rock crees, lamb's quarters, meadow cranesbill. There are not numerous grasses (34,9%) which usually are oatgrass (20%), poa (10%) and red fescue(about 3%). Weeds and herbs were dominant (64,4%). Such floral composition reflects the utility value (LWU=4,20) which is mediocre. What is noticeable in the green growth of polder's grassland is the advantage of fresh communities species which is visible in, among all, a large number of taxas of a moisture number (F) lower than 6. Such a state may be due to the limitations in river polders connected with the activity of Jeziorsko reservoir.

### 3.2. Soil science characteristics

Each genetic level of the examined soils showed various texture. Their strong heterogeneity (also within one soil profile) is a property characteristic to river alluvial soils and reflects the character and intensity of the past alluvial processes. Profiles 1 and 2 were formed from sandy clays (SL), sandy in the subsoil, underlaid shallowly or at medium depth with deep loose sand (S). The topsoil of profile 4 is loose sand and endopeons showed loose sand (S) graining. Profile 3 was most differentiated in terms of texture and was composed of clay silt (SL), loose sand (S) and clay sands (LS) at various levels [6, 15] (tab. 1).

In each case, specific density oscillated between 2.60 and 2.65 $Mg \cdot m^{-3}$. Such a level of this property is characteristic to most of Polish mineral soils and stems from the fact quartz is dominant in these soils [12]. Specific density lower than 2.65 was obtained in the layers of higher total carbon content and due to the higher content of organic matter from organic alluvion (tab. 2). The content of total carbon in the analyzed soils oscillated broadly from 1,9 (prof. 4; A) to 48,9 g·kg$^{-3}$ (prof. 4; 3C). It was usually much higher in the deeper layers than in epipedones (tab. 2). Such untypical situation for mineral soils was a result of the specificity of alluvial sediments – irregular presence of *fluvic* materials. Similar distribution of coal content in genetic horizons of various genesis and graining is also given by Niedźwiecki et al. 2010 [13] and Orzechowski et al. 2004 [14]. Bulk density and porosity were also strongly determined by the amount of total carbon. The highest porosity values: 61,92 (prof. 2; A), 62,21 (prof. 1; 2Cg), 70,23% (prof. 3; A) at the density of, respectively, 0,99, 0,98, 0,78 Mg·m$^{-3}$, appeared at high content of total carbon (27,1-44,6 g·kg$^{-1}$) (tab. 2). Maximal hygroscopic capacity was strongly differed and depended on the content of carbon and loam fractions. Its lowest values were reached in thoroughly cleaned, low-humus loose alluvial sands (0,45 – 2,99 %v/v), whereas the highest – in endopedeon clays (6,78 – 33,15 %v/v) (tab. 1, 2).

Table 1. Floral-utility characteristics of the grasslands in Warta's detention basin nearby Radyczyny
*Tab. 1. Charakterystyka florystyczno-użytkowa łąk polderu Warty w rejonie Radyczyny*

| **Type of grassland** | | | **Foxtail grassland** | **Fescue – poa grassland** | **Oatgrass grassland** |
|---|---|---|---|---|---|
| No. of species | | | **24** | **32** | **28** |
| Utility gro gro | No. of species | Grass | 11 | 10 | 8 |
| | | Cyperaceae | 0 | 1 | 1 |
| | | Fabaceae | 1 | 1 | 0 |
| | | Herbs and weeds | 12 | 20 | 19 |
| | total | | **24** | **32** | **28** |
| | % part of area | Grass | 55 | 55,4 | 34,9 |
| | | Cyperaceae | 0 | 0,2 | 0,7 |
| | | Fabaceae | 0,2 | 3,6 | 0 |
| | | Herbs and weeds | 44,8 | 40,8 | 64,4 |
| | total | | **100** | **100** | **100** |
| LWU | | | **6,71** | **6,14** | **4,20** |
| Species ecological scale in relation to moisturization | No. of species | F≤5* | 9 | 14 | 15 |
| | | F≥6** | 9 | 10 | 7 |
| | | F indefinite | 6 | 8 | 6 |

* F≤5 – species in dry and fresh communities, **F≥6 – species in fresh, moisture, wet communities

*Source: Own work / Źródło: opracowanie własne*

Table 2. Texture of investigated soils
*Tab. 2. Skład granulometryczny badanych gleb*

| Profile number | Genetic horizon | Depth [cm] | Percentage content of fraction on diameter [mm] | | | | | | Texture according | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2,0 - 0,10 | 0,10 - 0,05 | 0,05 - 0,02 | 0,02 - 0,005 | 0,005 - 0,002 | < 0,002 | PTG 2008 [15] | FAO/USDA [6] |
| 1 | A | 0-28 | 71 | 9 | 12 | 2 | 3 | 3 | pg | LS |
| | A2 | 28-32 | 81 | 12 | 5 | 1 | 0 | 1 | pl | S |
| | 2Cg | 32-60 | 37 | 12 | 12 | 9 | 25 | 5 | gp | SL |
| | 3G | 60-100 | 85 | 10 | 3 | 1 | 1 | 0 | pl | S |
| 2 | A | 0-28 | 55 | 16 | 20 | 2 | 6 | 1 | pg | LS |
| | A2 | 28-41 | 51 | 14 | 8 | 9 | 14 | 6 | gp | SL |
| | C | 41-52 | 54 | 10 | 8 | 6 | 15 | 7 | gp | SL |
| | 2Cg | 52-150 | 83 | 11 | 3 | 1 | 2 | 0 | pl | S |
| 3 | A | 0-16 | 32 | 14 | 28 | 9 | 14 | 3 | pyg | SiL |
| | C | 16-43 | 66 | 16 | 9 | 5 | 4 | 0 | pg | LS |
| | 2C | 43-50 | 87 | 7 | 4 | 2 | 0 | 0 | pl | S |
| | 3C | 50-100 | 63 | 15 | 12 | 7 | 3 | 0 | pg | LS |
| 4 | A | 0-10 | 96 | 2 | 0 | 2 | 0 | 0 | pl | S |
| | AC | 10-27 | 92 | 5 | 1 | 1 | 1 | 0 | pl | S |
| | C | 27-60 | 30 | 31 | 26 | 7 | 4 | 2 | gp | SL |
| | 2C | 60-120 | 55 | 12 | 13 | 6 | 11 | 3 | gp | SL |

*Source: Own work / Źródło: opracowanie własne*

Table 3. Basic physical and water properties of investigated soils
*Tab. 3. Podstawowe właściwości fizyczne i wodne badanych gleb*

| Profile number | Genetic horizon | Depth [cm] | Total carbon [g·kg$^{-3}$] | Specyfic density [Mg·m$^{-3}$] | Bulk density [Mg·m$^{-3}$] | Porosity [%v/v] | Saturated hydraulic conductivity [μm·s$^{-1}$] | Maximum higro-scopic capacity [%v/v] |
|---|---|---|---|---|---|---|---|---|
| 1 | A | 0-28 | 17,1 | 2,63 | 1,31 | 50,19 | 46,11 | 19,11 |
| | C | 28-32 | 20,7 | 2,62 | 1,40 | 46,56 | 71,26 | 0,45 |
| | 2Cg | 32-60 | 27,1 | 2,62 | 0,99 | 62,21 | 1,83 | 32,21 |
| | 3G | 60-100 | 2,5 | 2,65 | 1,75 | 33,96 | 86,54 | 14,81 |
| 2 | A | 0-28 | 44,6 | 2,60 | 0,99 | 61,92 | 54,17 | 31,13 |
| | A2 | 28-41 | 10,2 | 2,63 | 1,32 | 49,81 | 23,13 | 11,35 |
| | C | 41-52 | 5,5 | 2,65 | 1,23 | 53,58 | 7,71 | 14,55 |
| | 2Cg | 52-150 | 5,0 | 2,65 | 1,65 | 37,74 | 263,95 | 2,78 |
| 3 | A | 0-16 | 29,0 | 2,62 | 0,78 | 70,23 | 133,79 | 9,30 |
| | C | 16-43 | 20,1 | 2,63 | 1,28 | 51,33 | 44,26 | 16,87 |
| | 2C | 43-50 | 2,9 | 2,65 | 1,57 | 40,75 | 154,00 | 1,23 |
| | 3C | 50-100 | 48,9 | 2,60 | 1,20 | 53,85 | 27,18 | 29,00 |
| 4 | A | 0-10 | 1,9 | 2,65 | 1,50 | 43,40 | 230,36 | 0,86 |
| | AC | 10-27 | 5,8 | 2,65 | 1,60 | 39,62 | 20179 | 2,99 |
| | C | 27-60 | 6,6 | 2,65 | 1,36 | 48,68 | 3,14 | 23,56 |
| | 2C | 60-100 | 13,3 | 2,63 | 1,58 | 39,92 | 2,93 | 33,15 |

*Source: Own work / Źródło: opracowanie własne*

Table 4. Soil water potentials and the total and readily available water
*Tab. 4. Potencjały wiązania wody przez glebę oraz potencjalna i efektywna retencja użyteczna*

| Profile number | Horizon | Depth [cm] | Texture acc. PTG 2008 | Water capacity at pF: [%v/v] | | | | | | Readily available water [%v/v] | Total available water [%v/v] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0,0 | 2,0 | 2,5 | 3,7 | 4,2 | 4,5 | 2,0 – 3,7 | 2,0 – 4,2 |
| 1 | A | 0-28 | LS | 48,21 | 48,54 | 46,78 | 40,32 | 13,50 | 5,21 | 8,22 | 35,04 |
| | C | 28-32 | S | 44,54 | 12,03 | 10,32 | 3,20 | 2,01 | 0,80 | 8,83 | 10,02 |
| | 2Cg | 32-60 | SL | 60,02 | 56,06 | 54,97 | 48,97 | 16,50 | 11,62 | 7,09 | 39,56 |
| | 3G | 60-100 | S | 32,45 | 11,34 | 8,50 | 2,34 | 1,50 | 0,94 | 9,00 | 9,84 |
| 2 | A | 0-28 | LS | 58,22 | 44,40 | 42,01 | 22,33 | 15,30 | 11,23 | 22,07 | 29,1 |
| | A2 | 28-41 | SL | 47,30 | 31,21 | 30,01 | 11,84 | 10,05 | 8,60 | 19,37 | 21,16 |
| | C | 41-52 | SL | 50,08 | 45,28 | 40,02 | 31,41 | 13,60 | 5,01 | 13,87 | 31,68 |
| | 2Cg | 52-150 | S | 34,12 | 10,02 | 8,08 | 2,13 | 1,50 | 0,90 | 7,89 | 8,52 |
| 3 | A | 0-16 | SiL | 68,49 | 55,21 | 49,02 | 30,11 | 14,01 | 7,45 | 25,10 | 41,20 |
| | C | 16-43 | LS | 48,32 | 42,07 | 37,08 | 28,45 | 16,21 | 4,88 | 13,62 | 25,86 |
| | 2C | 43-50 | S | 38,99 | 13,20 | 10,11 | 2,03 | 1,80 | 1,12 | 11,17 | 11,40 |
| | 3C | 50-100 | LS | 51,54 | 46,27 | 42,07 | 30,08 | 11,24 | 6,50 | 16,19 | 35,03 |
| 4 | A | 0-10 | S | 41,22 | 15,67 | 14,13 | 4,63 | 2,50 | 0,57 | 11,04 | 13,17 |
| | AC | 10-27 | S | 37,10 | 11,14 | 7,80 | 2,08 | 1,80 | 1,10 | 9,06 | 9,34 |
| | C | 27-60 | SL | 46,04 | 43,31 | 41,29 | 34,30 | 9,88 | 5,25 | 9,01 | 33,43 |
| | 2C | 60-100 | SL | 37,10 | 31,24 | 28,77 | 22,21 | 15,60 | 13,84 | 9,03 | 15,64 |

*Source: Own work / Źródło: opracowanie własne*

In all the analyzed genetic horizons, maximal water capacity was always lower (by about 1-3%) than their total porosity. This difference stems from the fact that it is impossible to vent the capacity soil samples thoroughly in laboratory conditions. It oscillated between 32,45 (horizon 3G profile 1) and 68,49 %v/v (horizon A profile 4). Significant changes in moisture were observed at field capacity (pF 2,0). The lowest field capacity – 10,02% v/v – was observed in the genetic horizon 2Cg profile 2, whereas the highest - 56,06% v/v – in the genetic horizon 2Cg profile 1. At pF of 2,5 moistures were a bit lower – from about 8-9 to 54,97% v/v. At pF 3,7 moisture oscillated between about 2-4,5 % in sands and about 12 – 49 % v/v in sandy clays. At the potential pF 4,2 (permanent wilting point) water content was much lower. In the mentioned objects, it oscillated between about 1-3 up to almost 16,50 % v/v. Readily available water calculated on the basis of pF was between 7,09 (prof. 1; 2Cg) and 25,10 %v/v (prof. 4; A). In epipedones its value was higher than in the deeper soils. Total available water was between 8,52 (prof. 2; 2Cg ) and 41,20 %v/v (poziom A prof. 4). Such regularity as in readily available water was not observed here, though. All the presented water capacities and other parameters depended strongly on graining and total carbon content (tab 1, 3). Similar relations, observed within basic physical properties and the retention of river alluvial soils, were proved in the research by Pranagal i Ligęza 2011 [18]. Values of the saturated hydraulic conductivity were strongly influenced by texture. The highest filtration speed was observed in loose sands (from 71,26 μm·s$^{-1}$ – prof. 1; C – to 263,95 μm·s$^{-1}$ – prof. 2; 2Cg), lower – in clay sands (from 27,18 μm·s$^{-1}$ – prof. 3; 3C – to 54,17 μm·s$^{-1}$ – prof. 2;

A) and the lowest – in sandy clays (from 1,83 $\mu m \cdot s^{-1}$ – prof. 1; 2Cg – to 23,13 $\mu m \cdot s^{-1}$ – prof. 2; A2). What is worth attention is high, similar to the one in loose sands, permeability of alluvial clay sand. Probably, it was determined by its very high porosity (tab.1, 2).

## 4. Summary

Grassland communities located in Warta's detention basin nearby Radyczyny village showed a little differentiation which stemmed usually from the intensity of utilization. The following communities were distinguished: fescue – poa (50%), foxtail (25%) and oatgrass (25%) in which green growth big amount of weeds and herbs was found, which often signalized communities being dried up which probably originated in Warta's overflows. The examined soils showed high differentiation within physical and water properties. It originated in their specific genesis strongly influenced by the advantage of the influence of geological over soil forming processes. Differences were usually caused by various graining of each genetic horizon and various silting which affects total carbon content. Presented results do not differ from typical values marked in alluvial soils in river valleys in Poland. Pedological characteristics of the communities suggests that the examined terrain is not undergoing degradation due to the opencast mine located nearby. It has been confirmed by the high level of soil-ground water.

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