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Chapter VII

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Hydrological Changes in the Soils of Warta Pravalley within the Influance of "Koźmin" Lignite Pit

INTRODUCTION

All unfavourable changes leading to deterioration of soil properties are commonly referred to as soil degradation. A key role in these processes is played by anthropogenically initiated geomechanical, hydrological and chemical transformations which may either disturb soil pedon morphological structure or lead only to a disruption in the equilibrium between physical, chemical and biological parameters in unchanged genetic horizons. Among most frequent, classical examples of soil degradation as expressed by a decline in their productivity is decession of organic matter or changes in water management regimes. Such processes often occur in soils neighbouring with lignite opencast mines. Formations which are particularly sensitive to the above-mentioned degradation changes are organic soils, whereas mineral soil complexes found in locations in close vicinity to brown coal pits appear to be less prone to processes mentioned above. The evaluation of the impact of these processes is particularly difficult in the case of river fen soils which, due to their location in valleys and marginal stream valleys, exhibit fairly considerable moisture content in natural systems. The deposition depth of the leveled ground water table within the range of a given soil profile may differ widely depending on a number of geomorphological and geological factors associated both with the position in the land relief and the type of parent materials (alluvia) of erosive-sedimentary nature. The objective assessment of the consequences of changes in air-water properties is much simpler in the case of heavy and very heavy fen soils. The analysis of changes in the water regimes of light and very light fen soils, i.e. formations of high permeability, poor water retention potentials and characterized by low capillary rise capabilities, is more complex and, hence, more difficult.

This problem will be analyzed in detail taking on the basis of alluvial soils which are prevailing with regard to the occupied area in the neighbourhood of "Koźmin" lignite opencast mine. The soil-ground water that occurred in those soils in the past - sometimes in the central, less frequently, in the lower part of the soil profile (below 100 cm) - did not then and still does not exert a significant influence on the growth and development of the majority of plants. The lowering of levels of those waters as a result of lack of supplies with precipitation waters or river flooding (natural causes) or opencast mine activities following the establishment of the exploitation hollow drainage barrier (anthropogenic factor) leads only to the drying of the mineral overlayer which need not necessarily mean deterioration in soil production potentials because - both in the case of the water table situated at the depth of 100-120 cm in the past (capillary rise in sandy formations does not exceed 20 cm) as well as the current water table depth of 200 or even 300 cm - crop plants did not use this water. The only source of plant-available water on arable lands and grasslands in such formations as light and very light fen soils – not affected by floods from the Warta River – situated in Brudzew commune is atmospheric precipitation. The level of the obtained plant biomass in this area is determined, primarily by the quantity and distribution of atmospheric precipitation and, hence, drainage of the overlayer does not always have to result in soil degradation. Irrespective of the depth of occurrence of the leveled ground water level, majority of river fen soils developed in the neighbourhood of the "Koźmin" brown coal opencast mine, both prior to its establishment and observed at the present time, exhibited and continue to exhibit the type of precipitation-water (precipitation-retentive) regime. Detailed analysis of the impact of natural and anthropogenic factors on changes in ground water levels in fen soils of Brudzew commune constitutes the main cognitive and utilitarian objective of the presented article.

RESEARCH OBJECT AND METHODOLOGY

The object of investigations was the area of Brudzew commune where two opencast lignite mines: "Bogdalów" and "Koźmin" are situated. The "Bogdałów" opencast lignite mine ended its activities in 1991 [40 YEARS OF THE MINE … 2000]; its exploitation hollow was filled up and agriculturally restored, while its final fragment is being used as a water reservoir. On the other hand, the Koźmin" opencast mine began to be exploited in 1989 in its south-eastern part of Brudzew commune and, since then, it has been moving its working front northwards [POLTEGOR-PROJECT 1995].

In connection with opencast mining activities, beginning with 1986, special one- two- or even three-stage soil science investigations were conducted in Brudzew commune, especially in its south-eastern and eastern parts. However. the main objective of those studies was always to determine the impact of the opencast exploitation hollow on drainage of adjacent land and the possible resulting soil drainage degradation. Very comprehensive documentation material was collected in the course of the performed experiments which, until now, has only been published mainly in the form of various kinds of expert opinions, studies and soil science expertise [MOCEK, OWCZARZAK 2006]. The above-mentioned studies discussed in great detail soil physical and chemical properties, in particular, such water properties as: water capacity, retention capabilities, water permeability (filtration, infiltration). The authors analyzed both geological, hydrological and climatic preconditions of this area as well as areas situated further away with the aim, primarily, of assessing changing types of water regimes within the boundaries of the depression sink either in the result of natural factors and conditions or anthropogenic activities.

The investigations which were carried out in years 2007-2008 in the area of Brudzew commune, in a way, recapitulate problems associated with the impact of lignite opencast mine excavation hollows on changes in the soil environment. Generally speaking, the scope of field work comprised the following three issues:

- First selection and then carrying out 43 exploratory drillings, the so called bench-mark points, in characteristic soils, primarily, in grasslands,
- Selection and carrying out 45 drillings in villages which, in the past, were situated within the range of influence of “Koźmin” opencast mine (such villages as: Kwiatków, Koźmin, Dąbrowa, Kuźnica Janiszewska) as well as those villages which will be affected in the near future by similar drainage (villages: Brudzew, Cichów, Janów),
- Site-floristic and utilization evaluation of extensive meadow-pasture complexes, the so called phytosociological complexes.

Soil samples were collected from characteristic genetic soil horizons with the aim to determine essential physical, chemical and water properties. Levels of ground water deposition were determined 7 times in the case of bench-mark points and 6 times in the case of the remaining drillings. At various times series of photographs were taken in order to document the condition of plant vegetation as well as characteristic landscape situations.

Methods commonly employed in soil science [MOCEK et al. 2006] were applied to determine soil properties such as: texture, soil density, porosity, moisture content, reaction, organic matter, content of macroelements (P,K, Mg), whereas Richard’s low- and high-pressure chambers [KLUTE 1986] were used to determine water properties such as water capacity, while soil retention capability was established on the basis of the obtained water characteristics and filtration coefficient – using the method of the constant pressure drop [BLACK 1965; KLUTE, DIRKSEN 1986].

During the vegetation season of 2008, a site-floristic and utilization assessment was carried out in Brudzew commune of large meadow-pasture areas. The current condition of grasslands was determined on the basis of the analysis of:

- Site conditions – soil reaction and availability of macro- and microelements;
- Phytosociological surveys performed with the aid of the Braun-Blanquet method [1921];
- Sward use value calculated by Filipek's method [1973];
- Costs required to improve sward floristic composition or possible restoration of meadows and pastures to economic value.

The elaboration of research results mainly comprised comparative analyses and syntheses of research results carried out earlier and at present. The results of the performed analyses and syntheses were used to prepare a soil-agricultural map of Brudzew commune at 1:25 000 scale with zones showing the drainage effect of the "Koźmin" opencast mine. These areas formed the basis for further identification of arable land areas (arable land and grasslands) in which it was possible to separate their natural degradation from the opencast mine – dependent degradation or when the two types of degradation overlapped.

RESEARCH RESULTS AND DISCUSSION

Special soil science investigations in the region of the Adamów opencast mine have been carried out since 1970s. Specific hydrological conditions prevailing in areas adjacent to them are closely associated with geological structure, climatic conditions, position in relation to the Warta River, landform features as well as with the network of water courses, ditches, old river-beds, boggy depressions, etc. [MOCEK, OWCZARAK 2006]. The performed complex and comprehensive analysis as well as synthesis of the authors' own research results and observations made it possible to distinguish the following three fields differing distinctly with regard to hydrogeological and soil conditions.

Geological Conditions

Brudzew commune is situated in region which is geologically exceptionally diverse, especially in the area of the occurrence of soil-forming rocks as well as shallow and deep foundation which affects ground water levels which are influenced by opencast mine drainage of the lignite deposit [KRYGOWSKI 1961, MANAGEMENT PROJECT … 1995]. The above-mentioned diversification was created by an uplift of Cretaceous limestones found close to eastern boundaries, extensive, partially accumulative and partially erosive post-glacial trough situated meridionally along the above-mentioned Cretaceous limestone as well as various forms of deposits of the Central Polish glaciation. This area comprises a belt of land some to several kilometers wide. Opencast mining modified not only the geological structure but also hydrogeological and hydrographic conditions of this area.

The above-mentioned Cretaceous limestones occurring at the distance of a couple of kilometers from eastern boundaries of the commune, stretching from Uniejów, Rożniatów to Koło, disrupted the eastward deposition continuity of Pliocene and the Central Polish glaciation clays. Those deposits, usually a couple to several meters in thickness, in the case of clays – from twenty to fifty meters – in the case of grey silts situated from some to several kilometers from the Cretaceous uplift, phase out and disappear completely in a deep deposit of sandy sediments which extend from the surface to Miocene sends. Therefore, there is extensive hydraulic contact between surface and ground waters and waters of Miocene sands. This is the zone of supply of Miocene waters with near-surface waters. This kind of geological and hydrological situation creates conditions for an extensive and deep soil drainage and its foundation in the case of lignite opencast mine drainage.

The post-glacial trough situated meridionally which, in the past, carried off post-glacial waters from moraines of the Northern-Polish glaciation of Leszno and Poznań stadials towards south includes mainly the eastern part of Brudzew. It is in this trough that the Warta River formed the pradolina and valley carrying waters off towards north.

The above-mentioned trough found in the area of Brudzew commune is dichotomic. Its main bed is taken up by the Warta River, whereas the high, shallow bed was formerly used by the Teleszyna River. There is another, western branch of the trough occupied by the Kiełbaska River to which the Teleszyna River was transferred. The area between the two trough depressions is occupied by an extensive Pleistocene “island” made up of grey silts of the Central Polish glaciation. The eastern branch of the postglacial trough is large, deposited on sandy sediments reaching down to Miocene sands on which the Warta River meanders. The western branching of the trough is narrow, situated higher and is deposited on non-permeable sediment of marly clays of the Central Polish glaciation.

Climatic Conditions

According to Romer’s division, the climatic conditions of the examined area classify it as the Gniezno-Kujawy Region, within the boundaries of the “Region of Great Valleys” characteristic for the Central Polish Lowland [ROMER 1949]. The most important element of the climate, both from the point of view of agriculture (plant vegetation) as well as soil water balance, is atmospheric precipitation or, more accurately, its quantity and distribution in a long-term period (of many years), annual, during the vegetation period as well as in individual months. Both differences in the annual total precipitation as well as in the total precipitation during the vegetation season between Koło, Turek, Uniejów and Władysławów, which are 10 to 25 km apart, are sometimes quite considerable.

Analysing meteorological data from the 18-year long period (1990-2007) collected for the four above-mentioned places [MOCEL ET AL., 2008], the following important conclusions can be drawn:

- Mean values of annual precipitation from the above-mentioned 18-year period ranged from 543 mm (Koło) to 631 mm (Władysławów),
- Very significant differences in annual precipitation occurred between individual years; differences between extreme precipitation reached 437 mm (Turek, 1997 and 2003), 237 mm (Władysławów 2002 and 2003), 287 mm (Koło 2000 and 2003) and 358 mm (Uniejów 1992 and 1999),
- Mean precipitation values during the vegetation season from the above long-term period fluctuated between: 352 mm (Turek), 339 mm (Władysławów), 343 mm (Koło) and 350 mm (Uniejów),
- Significant variations in extreme values also occurred in summer months (June - August): 259 mm (Turek, 1991 and 1997), 185 mm (Władysławów 2005 and 2007), 246 mm (Koło 2000 and 2005) and 239 mm (Uniejów 1994 and 1999) – at a uniform mean from the long-term period of 201-204 mm,
- During the analyzed 18-year period, a distinct cyclicity in quantities of precipitation was observed both in annual and vegetation periods,
- Low precipitation levels during the vegetation period, especially in summer, accompanied by simultaneous evapotranspiration also caused distinct lowering in ground water levels as well as disappearance of water in surface water courses.

Recapitulating, it should be emphasized that atmospheric precipitation is the principal source of soil water and precipitation infiltrating down the soil also affects levels of ground waters. However, both the quantity and distribution of precipitation during the vegetation period exert a decisive influence on crop plant growth and yields because rainfalls provide the root zone with necessary water the quickest.

Morphology and Soil Natural and Functional Classification

The presented study deals only with the discussion of the morphological structure as well as the taxonomic membership and utilization value of areas situated in lower parts of the analyzed region managed as grasslands. Bearing in mind the position of the area (in hypsometric approach) and, in the past, shallower presence of the leveled ground water table within the soil profile, the discussed polypedons can serve as the best indicator of changes in the degree of soil moisture content in the region of Brudzew commune.

Due to geological structure and surface features as well as human activities, the following three arbitrary areas characterized by differing geomorphological properties can be distinguished in Brudzew commune: Area I – a belt of land situated at the lowest level in relation to the Warta River (floodplain terrace), Area II – a relatively flat low terrace with numerous lateral postglacial troughs, Area III – includes distinctly elevated areas of varying surface features, partly forested but sizable parts constitute farming idle land (Fig. 1).

The area that was analyzed first was the strip of soils running parallel to the Warta riverbed marked on the enclosed map as Area I. It comprises a relatively extensive floodplain terrace approximately 3 – 3.5 km wide. Due to its origin, the discussed area is covered by alluvial soils classified as river fen soils [PTG 1898]. They developed as a result of erosive-sedimentations activities of surface waters, mainly Warta and Teleszyna rivers hence, they exhibit the character of alluvial sediments which constitute soil parent material.

Depending on the flood frequency and the material brought by river waters, the morphological structure of river fen soils is characterized by layering with thickness and texture varying in different layers. In Brudzew commune, proper river fen soils are prevalent, whereas the remaining sub-types, i.e. humic river fens soils and brown river fen soils are found much less frequently forming small ‘islets’ among proper river fen soils.

Top layers of the majority of the discussed fen soils exhibited the texture of common loams and clay sands, less frequently of slightly loamy sand [PTG 1989]. The thickness of those mineral deposits usually extended from 30 to 40 cm and well-washed loose sands sporadically layered with formations of slightly heavier texture were deposited below. The above-described profile structure indicates their low use value. The prevailing soils are those classified as 3z complex, i.e. poor or very poor grasslands. When the layer thickness of the top ordinary or clay loamy deposits is greater (>50 cm), 2z complexes can be observed, i.e. grasslands of medium or higher agricultural value.

No soils of organic nature (peats and muck soils - Histosols) are found in Area I which indicates that, in the past, the Warta River frequently flooded the area and prevented the development of organic formations from marshy plants which would later on turn into peat deposits.

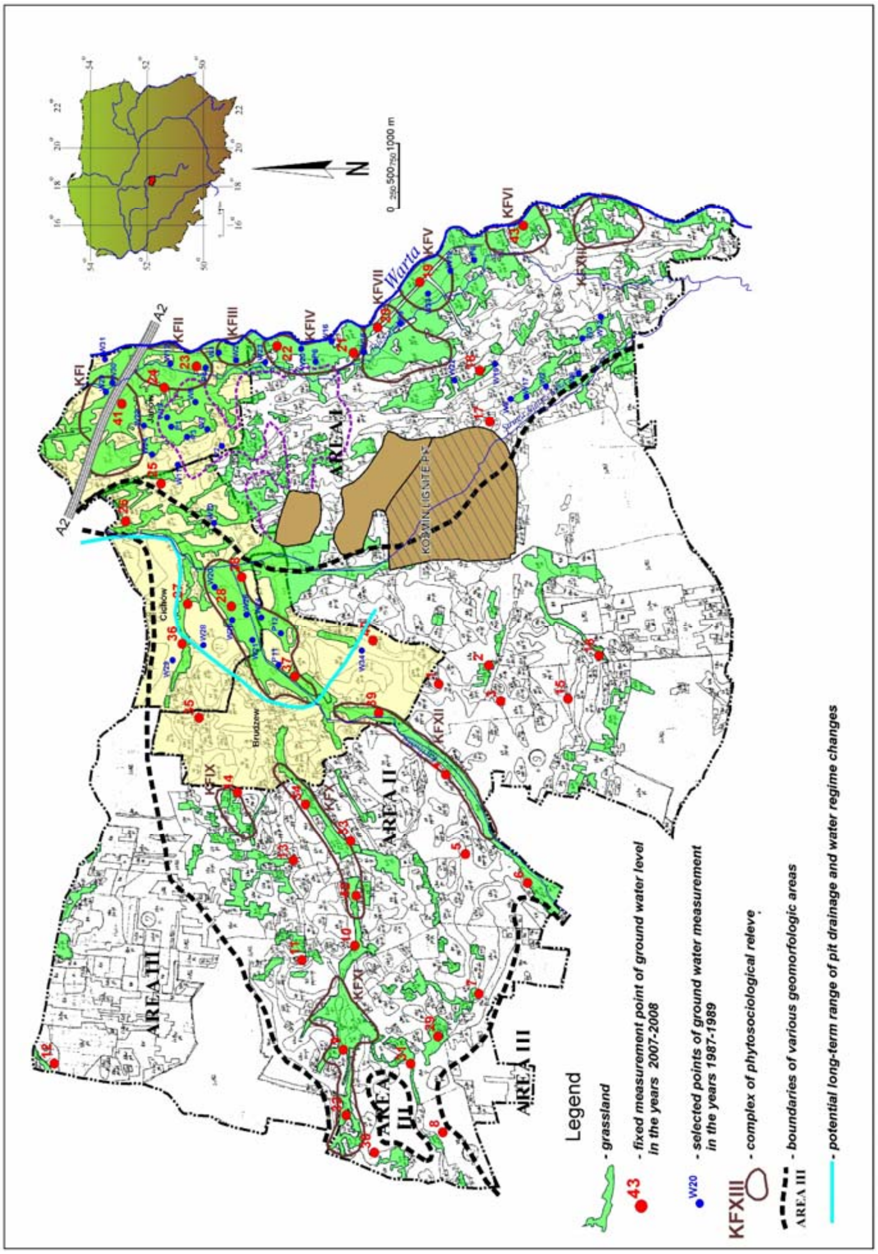

Fig. 1. Soil map of Brudzew borough with the grassland and the areas of Koźmin lignite pit influence draining

In the past, the above-mentioned soils of organic nature (currently, frequently organic-mineral) can be found outside flooded areas and, on the enclosed map, are referred to as Area II. In distant past (about 7 to 12 thousand years ago), anaerobic conditions caused by high levels of soil-ground waters occurred in local depressions in this area. These conditions favoured the development of marshy vegetation (reeds, sedges etc.) which, at limited mineralization, accumulated in the form of shallow peat deposits. As a rule, their thickness did not exceed 30-50 cm with fluvioglacial mineral formations of loose sand texture deposited beneath. Intensive utilization of these soils, together with a natural lowering of ground water levels, led to the suppression of peat-forming processes accumulating organic matter and resulted in organic matter decession. The final effect of these processes was the transformation of shallow peat soils into soils of muck nature (muck, mucky and muckous soils - Phaeozems) the majority of which are utilized as grasslands. Depending on the thickness of the surface formations of organic-mineral, less frequently organic nature, these soils are classified either as 2z (medium) or 3z (poor and very poor grasslands). The discussed soils neighbor with typically mineral rusty soils (Arenosols) and grey-brown podzolic (Cambisols) soils managed as arable land and classified as rye complexes. Intermediate places – with regard to hypometric systems – are covered by soils classified as black earths (Phaeozems or Chernozems) forming sporadic small islands classified as the 4th very good rye complex or as the 2nd good wheat complex. Some areas of black earths showed symptoms of organic matter degradation in top layers already in 1960s and 1970s following the lowering of ground water levels. They were then designated as Dz – degraded black earths.

Areas designated on the enclosed map as Area III constitute local elevations exhibiting the character of mineral deposits many of which are forested or are used as arable land of very low usefulness. They comprise very light soils characterized by the texture of deep loose sands or slightly loamy sands with a shallow substrate of loose sands. Typologically, they belong to rusty soils (Aarenosols), sporadically to podzolic soils (Podzols). From the point of view of soil valuation, they belong to the 4th class and are classified as very poor rye complex (7).

Water Properties

Values of water capacities of the examined soils and retention calculated on their basis did not differ significantly from data quoted by many researchers for soils of similar typology and texture which are found in the region of the Central Polish Lowland [RZĄSA et al. 1999; ŚLUSARCZYK 1979]. Their values depended, primarily, on texture and compactness. In the case of genetic horizons made up of sands and loamy sands, values of field water capacity were low ranging from 7-9% and 11-16% vol., respectively. The limit of water availability was also low (about 2.5 – 4% vol.). In the case of levels of heavier composition, i.e. loamy sands and sandy clays, the obtained values ranged from 6 to 24% vol. High values of water field capacity (25-35% vol.) were also recorded in levels containing ordinary silts and loamy silts. The impact of the higher organic carbon content in surface (humus) layers was also observed. This factor was found to increase water capacity slightly. Low values of effective and potential useful retention ranged from about 3 to 9% vol. Useful retention of about 17 to 24% vol. was observed rarely in few genetic horizons characterized by silt texture composition.

Retention calculated for 0-50 cm and 0-100 cm layers as well as for the entire soil profiles (0-150 cm) varied. In soils containing sands and loamy sands, its values were extremely small, at the level of 30 mm – in the 0-50 cm layer and 59-83 mm – in the layer extending from 0 to 150 cm. Soils whose profile contained layers of silt texture exhibited considerably greater (160-288 mm) capability of water storage in the entire profile.

The analyzed profiles were characterized by capabilities for rapid water filtration. The filtration coefficient determined in them was very high in the case of loose and slightly loamy sands (10.10 – 38.7 $\mu m \cdot^{-1}$), lower in ordinary loams and distinctly lower in silty clay (4.8 – $40.6 \cdot 10^{-1}$ $\mu m \cdot^{-1}$). Hence, filtration velocity exhibited the dependence on texture as in the case of moisture content and retention. Specific Ks values were also associated with drainage porosity and compactness (volume density).

The examined soils vary in their capability to supply plants with water and this capability depends, primarily, on their texture. Light soils, which are dominant on the discussed object, meet these requirements very poorly, insufficiently. Plant vegetation on these soils depends, practically exclusively, on atmospheric precipitations, mainly on their distribution during the vegetation period.

Dynamics of Changes in the Hydrology of the Examined Area

The results of measurements of deposition of ground water levels are shown in Tables 1 and 2. Table 1 presents depths of ground waters at the so called bench-mark points in the entire Brudzew commune in general situated at a considerable distance from the lignite opencast exploitation hollows recorded in years 2007-2008.

The adopted distribution of test points was purposeful. The purpose was to determine the natural deposition of ground waters in areas which were not directly affected by the influence of opencast mining. It is quite clear from the data presented in Table 1 that in the great majority of the Brudzew commune area, even in areas located in depressions (troughs), the levels of ground waters were most often below 200 cm. Only in the region of the floodplain terrace (Janów, partly Cichów and Brudzew) as well as in Kwiatkowo (between embankments), natural levels of ground waters remained at levels ranging from 70 to 140 cm. Ground water levels within the floodplain terrace below the depth of 140 cm (160 cm) indicate opencast mine drainage.

Measurement results of ground water levels revealed that considerable areas of Brudzew commune (Areas II and III) can be classified as areas of typical precipitation-water management regimes with small areas of mixed farming at a complete absence of ground-water farming. The observed low deposition of ground water levels was probably caused by significant shortages of atmospheric precipitations during the vegetation period, especially in summer in years 2001/2002-2005.

A much better idea about changes in the ground water deposition can be obtained from the comparison of depth measurements shown in Table 2. It presents analytic comparison between the mean depth of ground waters recorded in years 1987-1989, i.e. prior to the initiation of the activity of the Koźmin opencast mine, and in years 2007-2008, i.e. 20 years of its operation. Column 10 of Table 2 shows differences in ground water deposition between the examined periods. Values marked with (+) indicate a trend for the ground water levels to become shallower, while those accompanied by the (-) mark – for their deepening. Changes in the ground water deposition to the value of (-) 70(80) cm may be considered natural resulting from changing weather conditions, whereas lowering of ground water levels below this value together with a tendency for complete disappearance of ground waters below the depth of 300 cm – as opencast mine drainage.

Site-Floristic Evaluation of Grasslands

The performed geobotanical investigations and the floristic composition analysis conducted on their basis made it possible to classify the identified communities, primarily, to the *Molino-Arrhenatheretea* class and, to a much lesser extent, to *Phragmitetea* and *Koelerio glaucae – Corynephoretea canescentis* [FILIPEK 1973].

Table 1

Ground water level (cm) in fixed measurements points in Brudzew commune in the years 2007-2008

Drilling No.	Place	Year -2007			Year -2008				Average 2007-2008
		VII	IX	XI	IV	VI	VIII	X	
W1	Kawony	<300	<300	<300	<300	<300	<300	<300	<300
W2	Kawony	<300	<300	<300	<300	<300	<300	<300	<300
W3	Kawony	<300	<300	<300	<300	<300	<300	<300	<300
W4	Kawony	<300	<300	<300	<300	<300	<300	<300	<300
W5	Marulewek	<300	<300	<300	<300	<300	<300	<300	<300
W6	Bratuszyn	<300	<300	<300	<300	<300	<300	<300	<300
W7	Galew	<300	<300	<300	<300	<300	<300	<300	<300
W8	Izabelin	280	260	210	80	170	240	220	209
W9	Chrząblice	<300	<300	<300	<300	<300	<300	<300	<300
W10	Chrząblice	<300	<300	<300	<300	<300	<300	<300	<300
W11	Smolina	<300	<300	<300	<300	<300	<300	<300	<300
W12	Bierzmo	<300	<300	<300	<300	<300	<300	<300	<300
W13	Brudzyń	<300	<300	<300	<300	<300	<300	<300	<300
W14	Tarnowa	250	210	180	180	240	260	240	223
W15	Kawony	290	280	240	190	220	260	220	243
W16	Bogdałów Kol.	200	180	160	80	140	180	160	157
W17	Koźmin	<300	<300	<300	<300	<300	<300	<300	<300
W18	Koźmin	<300	<300	<300	<300	<300	<300	<300	<300
W19	Dąbrowa	<300	<300	<300	<300	<300	<300	<300	<300
W20	Dąbrowa	180	160	140	160	220	270	300	264
W21	Kwiatków	<300	<300	<300	<300	<300	<300	<300	<300
W22	Kwiatków	110	90	80	70	100	110	80	91
W23	Janów	140	120	100	100	140	180	150	133
W24	Janów	120	70	60	160	180	170	160	131
W25	Cichów	<300	<300	<300	<300	<300	<300	<300	<300
W26	Cichów	240	200	170	160	180	140	130	174
W27	Cichów	<300	<300	<300	<300	<300	<300	<300	<300
W28	Cichów	140	120	100	100	150	180	150	134
W29	Chrząblice	<300	<300	<300	<300	<300	<300	<300	<300
W30	Izabelin	180	160	130	90	120	140	130	136
W31	Chrząblice	<300	<300	<300	<300	<300	<300	<300	<300
W32	Izabelin	180	170	140	100	140	180	150	151
W33	Marulew	<300	280	260	250	<300	<300	<300	<300
W34	Brudzew	150	130	120	140	160	170	150	146
W35	Brudzew	280	270	240	140	190	230	240	227
W36	Cichów	<300	<300	<300	<300	<300	<300	<300	<300
W37	Brudzew	250	230	210	150	170	210	180	200
W38	Brudzew	220	180	140	90	220	180	160	170
W39	Brudzew	240	220	160	140	190	240	210	200
W40	Brudzew	<300	<300	<300	<300	<300	<300	<300	<300
W41	Janów	140	120	80	70	140	110	70	104
W42	Marulew	<300	<300	<300	<300	<300	<300	<300	<300
W43	Kozubów	180	150	140	140	160	190	170	160

Ground water level (cm) in the selected points in the following villages in years 1987-1989 and 2007-2008 — Table 2

Point No. P – profile D - Drilling	Years 1987-9 Average depth of the ground water level	Year – 2007			Year - 2008			Average for the years 2007-2008	Disparity between the two periods
		VII	X	XI	IV	VIII	X		
village – Brudzew									
P-11	193	130	140	90	120	150	160	132	+61
P-12	148	120	130	100	130	170	180	138	+10
W-21	140	110	140	120	130	150	160	135	+5
W-24	140	130	150	130	160	180	190	140	0
W-34	200	160	150	140	180	220	200	175	+25
village – Cichów									
W-10	150	270	250	240	260	280	250	258	-108
W-20	115	200	180	140	160	170	160	168	-53
W-25	135	140	120	110	150	160	150	138	-3
W-26	95	70	80	80	90	110	100	88	+7
W-28	380	<300	<300	<300	<300	<300	<300	<300	-
W-29	360	<300	<300	<300	<300	<300	<300	<300	-
village – Janów									
P-1	108	270	280	180	<300	<300	<300	<300	-200
P-2	128	240	270	250	<300	<300	<300	<300	-170
P-3	103	170	160	240	280	260	260	228	-125
P-4	88	100	80	100	130	160	140	118	-30
W-1	100	110	130	100	140	150	160	132	-32
W-2	150	90	120	100	130	160	150	125	+25
W-7	160	260	280	<300	<300	<300	<300	<300	-140
W-8	170	200	220	240	<300	<300	<300	<300	-130
W-12	110	130	120	90	130	170	150	132	-22
W-17	115	160	220	260	<300	<300	<300	<300	-180
W-19	120	110	90	70	90	110	90	93	+27
W-20	110	260	240	220	260	<300	<300	<300	-190
W-23	120	150	130	120	140	150	130	137	-17
W-24	170	250	230	160	210	240	220	202	-32
W-29	170	110	120	100	130	140	130	122	+48
W-30	140	120	130	100	120	140	130	123	+17
W-31	140	240	220	140	160	180	160	183	-43
village – Kwiatków									
P-6	125	<300	<300	<300	<300	<300	<300	<300	-170
W-15	80	<300	<300	<300	<300	<300	<300	<300	-220
W-16	72	<300	<300	280	270	<300	<300	<300	-240
W-20	85	180	150	130	140	160	140	150	-65
W-23	110	170	140	90	110	110	100	103	+7
village – Koźmin									
W-9	170	<300	<300	<300	<300	<300	<300	<300	-130
W-19	138	<300	<300	<300	<300	<300	<300	<300	-170
W-22	140	<300	<300	<300	<300	<300	<300	<300	-160
wieś, village – Dąbrowa									
P-6	120	280	250	220	240	260	280	<300	-135
P-9	83	300	280	240	280	<300	<300	<300	-220
W-19	73	270	240	<300	<300	<300	<300	<300	-230
W-33	45	280	260	<300	<300	<300	<300	<300	-250
village - Kuźnica Janiszewska									
W-2	160	<300	<300	<300	<300	<300	<300	<300	-140
W-3	260	<300	<300	<300	<300	<300	<300	<300	-40
W-8	110	<300	<300	<300	<300	<300	<300	<300	-190
W-12	70	<300	<300	<300	<300	<300	<300	<300	-230
W-17	130	<300	<300	<300	<300	<300	<300	<300	-170

The analysis of the grassland floristic composition revealed the progressing degradation process of the sward flora as shown by the disappearance from it of economically valuable species and increased proportions of wild-growing plants, such as: tufted hairgrass, common sorrel, soft brome grass and velvet grass [MOCEK et al. 2008]. The above changes were the result of both reduced site moisture content in the course of the entire vegetation season in relation to the meadow plant requirements and the distribution of atmospheric precipitation during vegetation. In addition, those changes were intensified by utilization mistakes involving insufficient fertilization and, in particular, lack of appropriate care [KRYSZAK, GRYNIA 2001].

RECAPITULATION

The principal objective of all soil science investigations carried out so far in the neighbourhood of exploitation hollows of “Adamów” and “Konin” opencast mines was to find answers to such basic questions as: “Does lignite opencast mining deprives adjacent areas of water and if so, to what extent? and does this have a negative impact on crop plant production on soils surrounding exploitation hollows?”

In the past, partial objectives of individual projects were achieved to various extent depending on the adopted program of research. However, the main objective was always to reveal and confirm a possible extent of soil drainage degradation caused both by natural as well as anthropogenic factors, including other than man’s mining activities (melioration drainage, incorrect agronomy etc.).

Specific hydrological conditions prevailing in Brudzew commune are closely associated with the geological structure, climatic conditions, position in relation to the Warta River, landform features as well as with the network of water courses, ditches, old river-beds, boggy depressions, etc. [MOCEK, OWCZARAK 2006]. The key issue from the point of view of the considered dispute between farmers and “Adamów” opencast mine is Area I shown on the enclosed map in 1 : 25000 scale which is situated within the floodplain terrace. In the past, this region was waterlogged much more frequently and, locally, was even swampy. The construction of the embankment against flooding, regulation of the Teleszyna River and Struga Janiszewska, construction of the Jeziorsko water reservoir which regulates and stabilizes flows in the Warta, the destruction of melioration devices (weirs, gates) all contributed to progressing and systematic drainage of this region significant for the soil productivity in this area. Drainage of the discussed area as well as other extensive patches of land in the Warta River valley is perceived as a spontaneous hydrogeological phenomenon taking place in the entire Central Polish Lowland which manifests itself as a general lowering of ground waters as well as disappearance of many water courses and smaller water reservoirs. Large areas of swampy or excessively waterlogged soils underwent gradual drying which resulted in various degrees of degradation of their surface layers. On areas of former grasslands, a gradual transfer of various types of ground-water management regimes into alternate or even precipitation-water regimes was observed. For that reason, many areas of permanent grasslands changed into arable land. This situation also took place in Brudzew commune, especially in the above-mentioned Area I, where the above-described natural drainage was further intensified by the opencast mining drainage. However, the impact of the latter on productivity reductions of adjacent soils is either barely visible or much smaller than the results of the earlier natural drainage aided in recent decades by unfavourable atmospheric conditions.

Therefore, the performed comprehensive and complex analysis and synthesis of the obtained research results and observations, the review of numerous scientific reports supported by clear evidence from phytosociological investigations made it possible to arrive at the conclusion that the observed low deposition of ground waters in Brudzew commune, especially in the indicated areas II and III, is the outcome or consequence of overlapping of a number of unfavourable natural conditions resulting, first and foremost, from a general trend – in a long-term perspective – towards lowering of ground water levels caused by unfavourable changes in atmospheric conditions. Similar trends were also observed to occur in Area I but in this area, additionally, the above-described natural drainage phenomena were intensified by the activity of Koźmin brown coal opencast mine, or to be more precise, its drainage barrier.

Therefore, in the case of Brudzew commune, it is not only the activity of the opencast mine that leads to the degradation of soil productivity but the naturally degraded grassland sward is further intensified by the activity of opencast mining.

Hence, it was recommended that appropriate compensations should be calculated for the total area of about 700 ha of all grasslands situated in the determined zone (range) of the anticipated opencast mining drainage. The value of a lump sum compensation was calculated on the basis of the elaborated new cost evaluation procedure of grassland restoration assuming the reclamation variant in which complete reconstruction of the turf takes place, together with chemical treatment of the damaged old sward.

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