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PROPERTIES AND MORPHOLOGICAL FEATURES OF MUCK-PEAT SOILS STRONGLY DEWATERED IN YEARS 1972-1975

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A b s t r a c t. During the period of constructing the Dolna Odra Power Plant (1972-1975), the nearby muck-peat soils derived from low sedge and reed-sedge peat, were strongly dehydrated and over-dried. In years 1975-1976, on the over-dried terrain, the ground water level came back to the state from before the construction of the Power Plant. In 1998, those soils, as well as meadow flora covering them, was again put under research. Stated were the following: a relatively high loss of organic matter in the surface layer; vanishing of the spongy peat mass; an increase in the bulk density; and accumulation of macro- and microelements.

On the over-dried organic soils, associations of low quality plants are currently in majority. However, the chemical composition of organic soils and meadow plants does not show any excess contamination with heavy metals.

K e y w o r d s: muck-peat soils, soil properties, heavy metals.

INTRODUCTION

On the over-dried organic soils, associations of low quality plants are currently in majority. However, the chemical composition of organic soils and meadow plants does not show any excess contamination with heavy metals.

During the construction of the Dolna Odra Power Plant, the necessary hydrotechnical works caused a decrease in the ground water level in surrounding area, visible on the distance of 2 km from the construction site. The power plant is located in the place, where organic soils of the Odra river are in the contact with sandy mineral soils of older accumulation terraces of that river. Soils that were dried the most by dewatering were organic soils derived from low sedge and reed-sedge peat occurring in the neighborhood of the power plant. In years 1972-1975, no ground water was stated in them on the depth of 200 cm and higher. Dried were also the existing small water reservoirs, ponds, after-peat areas, previously created melioration ditches, and permanently waterlogged areas.

Peat mass under meadow flora shrunk; numerous, up to 40 cm wide and 100-200 cm deep cracks developed. The surface of soil, often stripped of its plant cover, was pulverized, and just under the sod, on the depth of 5-20 cm, hard and sharp-edged aggregates appeared. Deeper, at the depth of 20-30 cm, appeared over-dried muck with cloddy structure and with preserved signs of sedge, reed, and wood. A network of slots and cracks developed in that muck and underlying peat. In years 1975-1976, on the over-dried ground, the level of ground water came back to the state from before the construction of the Power Plant.

Changes in morphological features and some of the properties of those soils, caused by a significant decrease of the ground water level, are described in publications of Greinert *et al.* [4], Chudecki and Niedźwiecki [2], and Niedźwiecki *et al.* [11].

The aim of the research carried out in 1998 was to evaluate the morphological features and properties of those soils, 25 years after strong dewatering, including the accumulation of contaminants gathered in result of the activity of the nearby Dolna Odra Power Plant, in the upper (surface) part of the soil profile.

MATERIAL AND METHODS

In the grass land area over-dried in years 1972-1975, near villages of Krajnik and Krzypnica, included in research in 1998, located were research areas and seven soil pits were situated within them. Soil material from depths of: 0-5; 5-10; 10-20; 20-30; 30-50 cm was taken for laboratory research from those pits. Simultaneously, in the area surrounding the soil pits, the floristic composition was determined and samples of flora were taken in order to determine their chemical composition. Floristic characteristics of the greenness growth was carried out using the Braun-Blanquet method amended by Polakowski.

The following were measured in the taken soil material: reaction; content of organic matter and components soluble in HCl of the 0.5 $mol \cdot dm^{-3}$ concentration; general contents of macro-components (K, P, Mg) and trace elements (Cd, Pb, Zn, Cu, Co, Mn, Fe) soluble in concentrated HNO_3+$HClO_4$ acids. Measurements of the listed components in the soil and plant material were made using an atomic absorption spectrometer Solaar 929 (phosphorus was measured colorimetrically).

RESULTS

Peat-muck soils that dried out during erection of the "Dolna Odra" power plant now can only be classified as strongly moorshed (Mt-III). In 1998, at the depth of 0-10 cm, strongly silted moorsh bound by plant root systems was observed in their M_1, i.e., the level of sodden moorsh. It is pulverized (70% of its weight is soil mass with the grain diameter below 1 mm), black in colour with brownish-reddish shade from 5 YR 2/2 to 10R2/1 (with visible light coloured grains of quartz). The under-sod level at the depth of 10-18 cm is differentiated. In the border part of the deposit, in the shallow organic soils, this level is distinguished by loose, grainy soil aggregates with the grain size of 1-4 cm. Whereas in the medium deep and very deep soils in its upper part (10-13 cm) permanent lamellar aggregates (discoidal) with the thickness of 1-4 mm and the length of 7-13 mm are predominant. They become symmetric polygons with sharp edges at the depth of 13-18 cm. These aggregates are very durable with the size of 2-8 mm and colour that is not uniform but close to 10R 2/1. In the transitional level, i.e., M-3 of these soils, at the depth of 18-35 cm, a chunky structure is observed (mainly with the size of 20-30 mm) that proves, according to Okruszko and Piaścik [13], deep soil drying.

The research carried out in 1998 proved in the upper part of the profile (0-20 cm) of those soils, that there was a relatively high loss of organic matter (average of 71.4% in 1973 to 48.4-64.1% in 1998). Moreover, in those soils, especially in the mineral-muck-peat ones, there was a significant decrease in the thickness of the organic horizon; it is now 43 cm in average, while in 1973 it was the average of 82 cm (Table 1). There is, however, a loss of spongy peat mass and an increase in the bulk density in their present organic horizon. This proves the presence of still intensive processes of mucking and mineralization of the peat mass. Shrinking of peat, their condensation and sedimentation of the dehydrated mass of organic soils, especially in a few first years after the dewatering, are indicated by many authors, i.e., Ilnicki [6], Krzywonos [9], Piaścik and Bieniek [14], Gawlik and Zawadzki [3], Okruszko and Piaścik [13], and Gotkiewicz *et al.* [5].

Szuniewicz and Chrzanowski [15] emphasize, basing on the research on Kuwasy Peatland, that in conditions of intensive dewatering, lowering of the surface of peatland, in a long run, caused mainly by mineralization of peat (77.2%), and in a smaller part by its compaction (22.8%).

Table 1. Changes in organic soil properties near the Dolna Odra Power Plant (average values)

Year	Depth	pH_{KCl}	Organic matter (%)	Depth of organic level (cm)	Bulk density ($g\ cm^{-3}$)
1973	0-10	4.1-6.1	72.2	82	0.38
	10-20	3.8-6.5	70.8		0.38
	20-30	4.0-5.7	82.6		0.26
1998	0-10	4.9-6.4	48.4	43	0.44
	10-20	5.4-6.1	64.1		0.42
	20-30	5.1-5.8	74.8		0.31

Data presented in Tables 1 and 2 prove that the reaction of the investigated soils is still acid or lightly acid.

T a b l e 2. Reaction; content of organic matter, C:N, and macro-elements (K, P, Mg) soluble in HCl of the concentration of 0.5 mol·dm^{-3} and soluble in concentrated acids HNO_3+$HClO_4$ in organic soils over-dried in years 1972-1975 near the Dolna Odra Power Plant in Nowe Czarnowo (average and extreme values)

Depth	pH_{KCl}	Ignition loss	C	N	C:N	mg 100 g^{-1} d.m. soil					
						Soluble in 0.5 HCl mol dm^{-3}			Soluble in HNO_3+$HClO_4$		
		(%)				K	P	Mg	K	P	Mg
0-5	4.9-6.4	47.6 33.6-75.6	23.3 16.6-27.7	2.16 1.54-2.56	10.76 10.11-11.64	15.5 10.4-21.2	16.1 3.7-33.1	92.1 54.5-132.6	69.9 20.8-149.0	108.9 39.5-226.5	184.5 122.2-307.9
5-10	5.2-6.1	49.4 34.6-70.7	23.1 17.2-28.1	2.10 1.64-2.49	11.00 10.22-12.95	17.3 8.2-31.4	11.4 6.0-17.4	72.7 60.4-100.7	94.0 51.6-175.1	74.3 25.7-129.5	187.4 95.5-436.0
10-20	5.4-6.1	64.1 46.3-72.4	24.8 17.7-29.8	2.21 1.75-2.48	11.22 10.08-13.05	18.1 7.3-34.1	7.4 4.3-12.0	55.8 31.2-90.3	51.7 21.8-100.2	51.1 21.0-73.0	95.4 58.3-155.0
20-30	5.1-5.8	74.8 64.6-85.3	30.2 26.3-34.9	2.45 2.28-2.60	12.33 10.89-14.68	14.6 6.1-21.1	5.6 2.7-8.5	35.5 23.6-52.5	24.7 18.2-31.4	48.8 22.7-106.3	57.1 34.0-97.0
30-50	5.0-5.6	85.7 83.5-87.8	28.1 17.7-40.2	2.00 1.30-2.76	14.05 11.01-16.21	11.4 6.2-18.2	3.0 2.5-3.9	44.3 17.4-99.1	28.4 10.8-67.8	36.3 27.7-41.0	59.2 29.8-119.8

However, the degree of acidity decreased because during research carried out in 1973, the surface layer of soil often had strongly acid reaction (Table 1). The significant improvement of the reaction is probably a result of the influence of furnace ashes of the power plant, which are located in the nearby storage places, the area of which had not been sodded and was subject to aeolian erosion for many years.

Contents of total nitrogen in the surface 0-20 cm layer of those soils ba-lanced between 1.54 and 2.56% (average of 2.16%). Especially worth attention is the profitable ratio of C:N, which stays between 10.1:1 and 13.0:1 (average of 11:1) in this layer, and this ratio shows tendencies to extent along with the depth of the profile (Table 2). Similar values of C:N in organic soils are given by Okruszko and Piaścik [13], who emphasize that the mass with greater C:N ratio is more susceptible to biological transformations.

The surface part of the profile contains the most macro-elements (K, P, Mg), both those soluble in HCl of the concentration of 0.5 mol dm^{-3} and those soluble in concentrated acids HNO_3+$HClO_4$ (Table 2). Such a state is mainly an outcome of the intensity of mineralization and humification processes in peat and the activity of the power plant. The factor that could have also had some effect here, especially in less over-dried soils, was the capillary rise of water, occurring after the elimination of the depression funnel, as pointed out by Bieniek [1].

The content of potassium soluble in HCl of the concentration of 0.5 mol dm^{-3}, according to the recommendations of the IUNG [7], is very low in the investigated soils. Only sporadically it exceeds 30 mg of K 100 g^{-1}s.m. of soil (Table 2). Despite potassium, those soils also lack phosphorus assimilable by plants. The content of that element in deeper parts of the profile is sometimes a trace content; in the surface level it is lower that a very low content. On this background, relatively well is the richness of the investigated soils in magnesium soluble in HCl of the concentration of 0.5 mol dm^{-3}. Its content in the surface layer (0-20 cm) reaches an average of 92.1 mg 100 g^{-1} s.m., which indicates high contents of that element. Total contents of macro-elements (Table 2) proves low contents of potassium in the investigated soils, as well as high contents of magnesium. It also shows the accumulation of phosphorus mainly in the surface (0-20 cm) layer of soil. Accumulation of phosphorus mainly in the surface horizon, as well as very weak transportation of that element deeper into the peat mass has been pointed out by many authors.

The sod-muck horizon of the investigated soils, especially at the depth of 0-20 cm, stood out also in terms of a significant accumulation of trace elements (Table 3). Below that depth, contents of Cd, Pb, and Zn was rapidly decreasing. It should be, however, stressed that the showed concentration, considering the limit contents of heavy metals in the surface layer of soil elaborated by Kabata-Pendias *et* al. [8], is a natural state for most of the investigated metals (degree of pollution

T a b l e 3. Contents of trace elements in organic soils over-dried in years 1972-1975 near the "Dolna Odra" Power Plant in Nowe Czarnowo (average and extreme values, mg kg^{-1} s.m. of soil)

Depth cm	Soluble in 0.5 HCl mol dm^{-3}				Soluble in HNO_3+$HClO_4$						
	Cd	Pb	Zn	Cu	Cd	Pb	Cu	Zn	Ni	Co	Mn
0-5	0.40 0.10-0.66	23.3 13.4-33.9	42.1 12.3-69.3	2.3 1.3-3.8	0.67 0.45-0.82	39.6 23.3-56.1	10.8 3.4-17.4	114.4 69.9-165.2	11.0 6.9-20.9	3.8 1.9-4.7	886.0 273.0-1675.6
5-10	0.44 0.34-0.63	22.5 17.0-33.9	49.2 27.1-104.7	2.1 1.5-2.8	0.80 0.48-1.51	46.3 28.7-64.4	13.0 7.6-26.3	114.7 44.9-218.4	8.2 4.5-16.5	3.9 1.7-9.1	1147.8 285.1-2856.7
10-20	0.27 0.19-0.36	17.3 14.4-19.0	21.7 12.9-37.6	1.4 1.1-2.0	0.49 0.22-0.86	28.7 26.5-34.2	8.3 5.8-14.4	77.3 21.1-117.5	5.6 3.7-9.1	2.5 1.2-5.2	702.8 296.6-1358.2
20-30	0.11 0.00-0.22	3.2 1.1-6.1	12.6 5.9-27.9	0.8 0.6-0.9	0.20 0.10-0.30	6.6 1.3-12.1	4.4 1.4-5.7	19.6 12.0-29.3	2.3 0.7-3.1	1.6 0.7-3.8	221.1 114.3-407.2
30-50	0.04 0.00-0.08	2.0 0.4-4.0	8.1 1.3-13.7	0.7 0.4-0.8	0.22 0.07-0.41	2.6 0.5-4.6	3.4 3.0-4.4	11.5 4.6-18.9	2.8 1.3-4.3	1.2 0.7-1.5	340.2 107.8-864.5

0). An increased content (degree of pollution 1) was only sporadically observed in cases of zinc and cadmium. Despite the increased contents, the amount of heavy metals presented in Table 3, fits within the limits of admissible contents of those elements in cultivated soils [10]. However, the analysis of availability of investigated heavy metals for plants, considering the limit values for evaluating the contents of micro-elements soluble in HCl of the concentration of 0.5 mol dm^{-3} in soils, shows that those soils are poor in terms of copper and medium rich in zinc.

Currently, there are no areas without any plants on the organic soils over-dried in years 1972-1975. However, there was a radical decrease in contents of high and medium value plant associations: meadow fescue (*Festuca pratensis*); meadow-grass (*Poa pratensis*); and red fescue (*Festuca rubra*). In majority are associations of small value plants: reed grass (*Calamagrostis canescens*); wool soft-grass (*Ho*lcus lanatus); grass of genus Deschampsia (*Deschampsia caespitosa*); and soft brome grass (*Bromus mollis*). Dicotyledonous weeds were: goose five-leaf (*Potentilla anserina*); common yarrow (*Achillea millefolium*); creeping crowfoot *(Ranunculus repens*); dandilion (*Taraxacum officinale*); and field thistle (*Cirisium arvense*).

Chemical composition of the flora is presented in Table 4. This table indicates that there is a shortage of potassium in the analyzed flora, and it usually shows high contents of calcium and magnesium. From among the trace elements, taking into consideration the so called norms of hay richness, according to Nowak [12], which equal 5.1-8.0 mg of Cu kg^{-1} s.m.; 31-50 mg of Zn kg^{-1} s.m.; 31-50 mg of Mn kg^{-1} s.m.; and 51-100 mg of Fe kg^{-1} s.m.; zinc and copper occurred in shortage in the investigated flora. Other microelements, including cadmium and lead, stay within the limits of contents considered natural [8].

CONCLUSIONS

Research carried out in 1998 proved that 20 years from a deep dehydration and over-drying of muck peat soils, those soils still did not regain their natural crop production capability, despite of the rise of the ground water level in 1976 back to the state from before the construction of the power plant. Meadow plant crops

T a b l e 4. Contents of macro- and microelements in plants from over-dried (in years 1972-1975) organic soils near the Dolna Odra Power Plant (average values)

Habitat	%			m kg^{-1} d.m.						
	K	Mg	Ca	Cd	Pb	Zn	Cu	Co	Mn	Fe
Dry habitat temporary moist	0.78	0.48	0.71	0.152	1.66	22.44	3.55	0.61	79.8	130.4
Fresh habitat moist	0.79	0.43	0.73	0.133	2.31	24.42	4.44	0.48	65.2	103.8

collected on those soils is of low quality and is 50-70% smaller that the crop collected before the dehydration of the area.

Chemical composition of the organic soils and meadow plants does not show any excess pollution with heavy metals. This state is a result of pro-ecological activity systematically carried out by the Board of the Power Plant.

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