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Origin and properties of organic soils on the Soil Model Areas of the White Forest, NE Poland

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Abstract

The aim of the research was to determine the genesis and properties of organic soils in two Soil Model Areas (GPW) of the White Forest. The GPW are located in the Ostrów Mazowiecka Forest District with an area of 470.5 ha (52°73'68" N, 21°87'35" E) and in the Wyszków Forest District with an area of 325.7 ha (52°62'17" N, 21°42'26" E). The White Forest is a large, compact forest complex located in the lower basin of the Bug and Narew rivers, in the Masovian-Podlasie nature and forest region (IV) with an area of about 51 thousand ha. It is one of the poorest forest areas in the country in terms of habitat and species richness, and is only slightly transformed by humans. It is situated in the area of the Central Polish glaciation, covered mainly with plainly shaped fluvioglacial (sander) sands. In the 1970s, the State Forests National Forest Holding and the Soil Science Society of Poland established all over the country 139 GPW with an average area of 405.5 ha (minimum 300 ha) and a total area of 56529 ha. The aim of the GPWs was to preserve the typical (model) soils for a given region, which were to constitute a permanent comparative base for conducting scientific research and practical training of foresters. On small areas of both GPWs there are strongly decomposed murshic and murshic peat soils developed from sapric peat covered with alder forests (*Carici elongatae-Alnetum, Circaeo-Alnetum*), underlain with loose sand. They cover valleys that occupy 3.5% of the Ostrów Mazowiecka GPW area and 1.6% of the Wyszków GPW. According to the Classification of Forest Soils in Poland, they are classified as thin murshic soils and murshic peat soil (according to WRB 2022, as Histic Gleysols). In the murshic horizons of the tested soils, in addition to changes of morphological features and physical properties, a significant reduction in the exchangeable sorption capacity, carbon and nitrogen content and C:N values was observed. They can be classified as soils with a natural content of trace elements, with slightly enriched surface horizons. Maintaining the current low moisture level of these soils will probably lead to their progressive decomposition (mineralization) and, in further evolution, their transformation into mineral-murshic soils and then mineral soils. According to the soil trophic index (SIGo), 3 profiles of these soils were defined as eutrophic (SIGo >25) and 1 profile as mesotrophic (SIGo 20-25). Both the fertility and properties of these soils indicate suitable conditions for the growth and development of alder vegetation.

1. Introduction

The past and present interest of many soil scientists in organic soils results from their very important role in the environment and their significant influence on the climate. They demonstrate very high water retention capacity, carbon, nitrogen and macro- and micro-nutrient accumulation (Maciak and Gotkiewicz, 1983; Okruszko, 1988; Okołowicz and Sowa, 1997; Bogacz and Roszkowicz, 2010; Oleszczuk et al., 2022). Thanks to this, they reduce the intensity of increasingly frequent droughts and floods and limit global warming by binding large amounts of carbon. Unfortunately, numerous studies indicate an intensive process of mineralization of these soils as a result of excessive drainage and improper use (Maljanen et al., 2010; Frolking et al., 2011; Glina et al., 2016a; Kasimir et al., 2018; Tuohy et al., 2023). As a result, they lose their important functions, become emitters of CO_2 and other greenhouse gases, and significantly reduce their water retention capacity. A large part of them, especially the shallow ones, will be transformed into mineral soils due to the complete mineralization of organic matter (Łachacz, 2001; Łachacz et al., 2023). Hence, learning about their properties and monitoring their changes can help reduce the negative effects of their transformation. When strongly dry, organic soils may undergo intense mineralization, which leads to the disappearance of the vegetation covering them and their wind erosion. Organic soils are also important for agriculture (fodder production), as they cover about 30% of permanent grasslands in Poland (Liwski et al., 1981; Okruszko and Piaścik, 1993).

The aim of the research was to investigate the genesis and properties of organic soils in the Soil Model Areas of the White Forest in NE Poland.

2. Study area

The research was conducted on the Soil Model Areas (in Polish: Glebowe Powierzchnie Wzorcowe, GPW) in the Ostrów Mazowiecka Forest District with an area of 470.5 ha (N: 52°73'68", E: 21°87'35") and the GPW in the Wyszków Forest District with an area of 325.7 ha (N: 52°62'17", E: 21°42'26") located in the White Forest (Fig. 1). The White Forest is a large, compact forest complex located in the lower basin of the Bug and Narew rivers, in the Masovian-Podlasie nature and forest region (IV) (Zielony and Kliczkowska, 2012), with an area of about 51 thousand ha (Zaręba, 1986). It is one of the poorest forest areas in the country in terms of habitat and species richness, and it is subject to very small negative human influence (Kwasowski et al., 2000). It is situated in the area of the Central Polish glaciation, with outwash plains formed with glaciofluvial sands as the dominant form of the relief. At the request of the Soil Science Society of Poland, the Supreme Board of State Forests decided in 1975 to establish the GPW (Zarządzenie ..., 1975). The aim of the GPW, a joint concept of Polish foresters and soil scientists, was to "provide complete protection of soil patterns typical of a given region (district) against artificially induced changes in their morphology and physical, chemical and biological properties". Prusinkiewicz et al. (1977) defined the following functions and intended use for the GPW: "These areas are to constitute a permanent comparative (control) base enabling the natural and economic evaluation of the effectiveness of intensive forest management methods. GPW is also to serve scientific research and training purposes. The results of research and observations conducted on the basis of GPW will be used, among other things, to improve forest production methods in intensively managed forests." The appointed commissions, in accordance with specific principles, designated 139 GPW with an average area of 405.5 ha (minimum 300 ha) and a total area of 56529 ha, which constitutes almost 0.5% of the total forest area of the country. Despite the development of instructions for soil and habitat documentation for the GPW (Biały et al., 1988), the number of soil and habitat reports developed for the GPW is negligible.

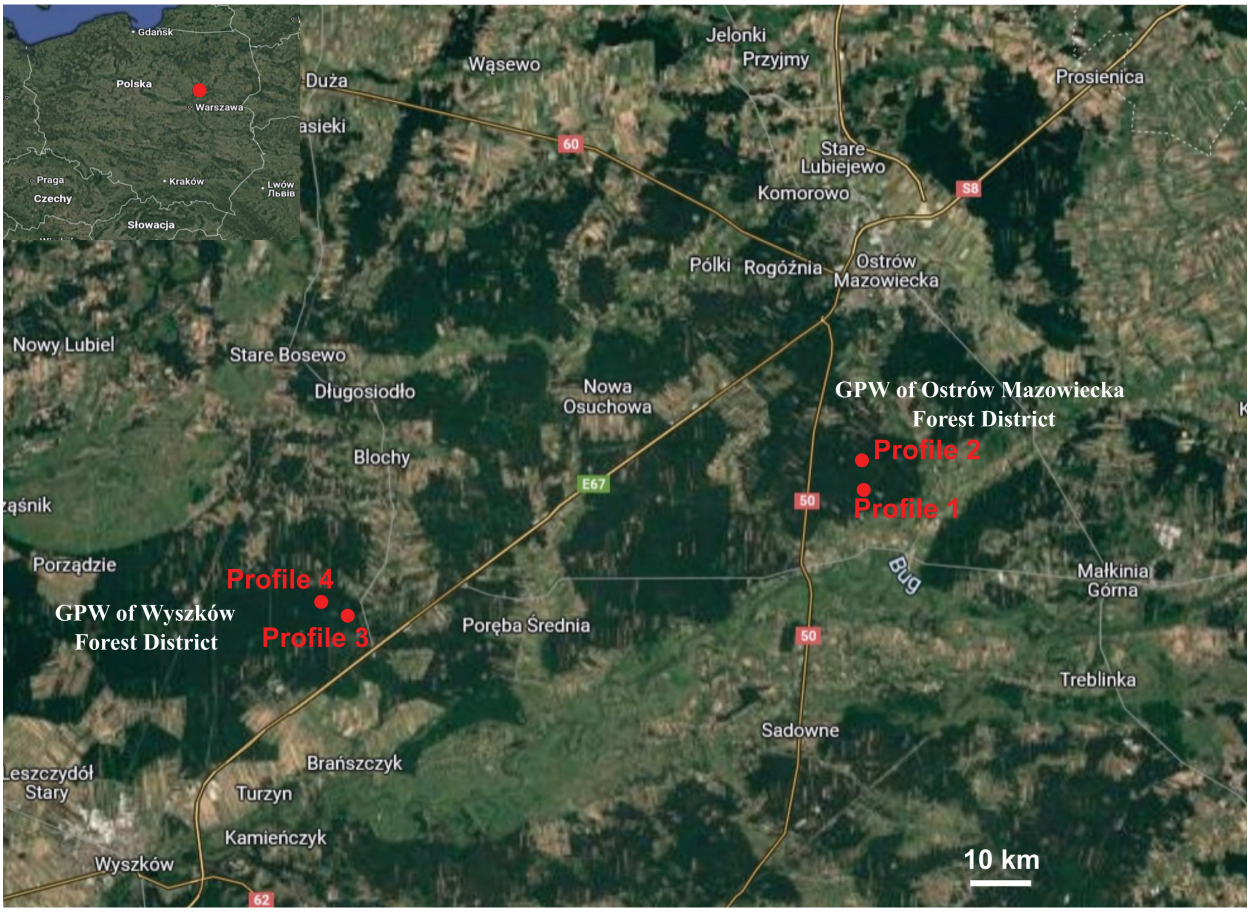

Fig. 1. Location of soil profiles and Soil Model Area (GPW)

3. Materials and methods

Field studies were conducted in July 1997 and included 4 soil profiles, prof. 1 and 2 from GPW Ostrów Mazowiecka Forest District and 3 and 4 from GPW Wyszków Forest District (Fig. 1). In the profiles a morphological description was determined according to the Classification of Forest Soils in Poland (2000) and degree of peat decomposition was estimated by the field method proposed by von Post (Polish Soil Classification, 2019). Soil samples were taken from the distinguished genetic horizons for physicochemical and chemical analyses and studies of the ground cover vegetation and tree stands were carried out. The following basic soil analyses were determined: soil texture by Bouyoucos-Casagrande method modified by Prószyński, total organic carbon (TOC) using the automatic carbon analyser Shimadzu TOC 5000 A, pH in distilled water and 1 mol·dm^{-3} KCl, using the potentiometer method at a soil:liquid ratio of 1:2.5 (v/v), total potential acidity (Hh) using the Kappen method (extraction using 1 mol·dm^{-3} calcium acetate and titration using 0.1 mol·dm^{-3} NaOH), total exchangeable base cations (Ca^{2+}, Mg^{2+}, K^+, Na^+) using 1 mol·dm^{-3} ammonium acetate at pH = 7 and analysed by an atomic absorption spectrometer (Thermoelemental SOLAAR M6). Trace elements and iron content were determined using the ASA technique in 20% hydrochloric acid after ashing of the organic matter at a temperature of 500°C. The bulk density of soils (D) was determined based on the total organic matter content (TOC) using the formula $D=1,3773 \cdot e^{-0,0547 \cdot TOC}$ (Brożek and Zwydak, 2003). The values of the soil trophic index (SIG) were calculated according to the Brożek et al. (2011b) methodology.

For soils with an organic horizon thicker than 20 cm, according to the formula:

$$SIGo = (WSo + WYo + WNo) \cdot 1,333$$

where:
WSo – indicator of soil alkaline cation content,
WYo – converted acidity index,
WNo – converted nitrogen index,
1.333 – coefficient for organic soils.

Forest habitats were diagnosed according to soil using the soil trophic index and the key to assessing the habitat type based on the SIG value, taking into account partial diagnoses according to the ground cover and tree stand (Brożek et al., 2011a; Instrukcja …, 2012). The SIG used as a numerical indicator enables a more accurate assessment of the production potential of the soil and habitats and significantly reduces the subjective assessment of forest habitat type evaluators based on soil (Siedliskowe podstawy …., 2004). The soils were classified according to the Classification of Forest Soils of Poland (2000), SGP (2019) and World Reference Base for Soil Resources (IUSS Working Group WRB, 2022).

4. Results

According to the Classification of Forest Soils of Poland (2000), profile 1 of the tested soils was classified as murshic peat soils developed from sapric peat and as sapric murshic soil by SGP (2019). The remaining profiles (2–4) were classified as thin murshic soils by the Classification of Forest Soils of Poland (2000) and as sapric thin murshic soils by SGP (2019). According to WRB (IUSS Working Group WRB, 2022) all the studied soil profiles were classified as Histic Gleysols. The soils were underlain by loose sand and covered with alder forests (*Carici elongatae-Alnetum, Circaeo-Alnetum*) (Table 1). They occur in the marshy, narrow, long valleys of both GPWs and cover their small areas, respectively: Ostrów Mazowiecka Forest District 3.5% and GPW Wyszków Forest District 1.6%, surrounded by Brunic Arenosols covered with mixed coniferous forest. In thin murshic soils (profiles 2–4) the total thickness of the organic layer (mursh) ranged from 36 to 40 cm, while in profile 1 the thickness of the organic layer was 52 cm (total mursh and peat) (Table 2). Under the thin raw sub-horizon of the litter (Ol) in profiles 1 and 3 there was a murshic horizon (Mt1) with a thickness of about 20 cm. In profiles 2 and 4, Mtbi surface horizons with a thickness of 10 cm were distinguished, in which, in addition to a large amount of roots of forest floor vegetation, high activity of soil fauna (animal burrows, earthworms) was found. These horizons were of colour, depending on moisture, from very dark grey (10YR 3/1) to black (10YR 2/1). The mursh was heavily overgrown with roots of forest floor vegetation and had a granular structure. Granular aggregates of mursh were strongly associated with plant roots. The deeper murshic horizons (Mt2), also about 20 cm thick, showed a similar colour, loose arrangement and granular structure, but they contained significantly less plant roots. In profile 1, the mursh was underlain by well decomposed sapric peat (H7) with recognizable fragments of alder wood, very dark brown in color when moist (5YR 2/2) and with a fibrous structure. During field studies, the Otni peat layers were fully saturated with water, which was caused by the presence of groundwater at a depth of 80 cm and its capillary rise. In the remaining profiles the depth of the groundwater table ranged from 36 to 50 cm.

The values of the chemical properties of the mursh were similar in profiles 1, 3 and 4: pH in KCl slightly above 5, exchangeable sorption capacity from 66.79 to 129.53 cmol(+) kg^{-1}, saturation of the sorption complex with basic cations from 59.34 to 75.83%, organic carbon content from 12.09 to 26.15% and C:N value from 8.3 to 11.2 (Table 2). In the mursh of profile 2, lower pH values in KCl (approximately 4.5) and the share of basic cations in the sorption complex (47.62–59.5%) as well as higher C:N values (15.7–18.3) were found. In the mursh horizon of profile 1, a slightly higher content of organic carbon, nitrogen, and a lower C:N value was found compared to the peat directly underneath. The percentage share of base cations and hydrogen in the sorption complex of organic horizons of profile 1, 3 and 4, in decreasing order, was as follows: $Ca^{2+} > H^+ > Mg^{2+} > Na^+ > K^+$ (Fig. 2). In profile 2, hydrogen was quantitatively dominant and potassium had a larger share than sodium ($H^+ > Ca^{2+} > Mg^{2+} > K^+ > Na^+$), except for the deepest layer of the murshic horizon. Increased contents of manganese, zinc, copper, lead and cadmium were found in the surface layers of the murshic horizons of the tested soils (Table 3).

Table 1
Location and morphological properties of the tested soils

Profile No. Coordinates (WGS 84)	Horizon	Depth [cm]	Texture	Biological activity Peat degree decomposition*	Colour in state**		Structure	Forest seat type (TSL) and ground water level	Plant associations
					Dry	Moist			
Murshic peat soil (GPW of Ostrów Mazowiecka Forest District); SGP (2019): sapric murshic peat soil									
1	Ol	0–1	–	–				Alder	*Carici elongatae-Alnetum*
N: 52°72'33",	Mt1	1–18	–	many roots of ground cover plants	5YR 7/1	5YR 6/1	granular	80 cm	
E: 21°88'31"	Mt2	18–35	–	significantly less roots of ground cover plants	5YR 7/2	5YR 6/2	granular		
	Otni	35–52	–	H7	5YR 2/3	5YR 2/2	fibrous		
	OtD	52–80	–	H7	5YR 3/2	5YR 3/1	fibrous		
	D	80–100	loose sand	–	5YR 7/1	5YR 6/1	n.a.s.		
Thin murshic soils (profiles 2 – GPW of Ostrów Mazowiecka Forest District; profiles 3–4 – GPW of Wyszków Forest District); SGP (2019): sapric thin murshic soils murshic soils									
2	Mtbi	0–10	–	many roots of ground cover plants and soil fauna	10YR 3/2	10YR 2/2	granular	Alder	*Carici elongatae-Alnetum*
N: 52°73'32",	Mt1	10–20	–	many roots of ground cover plants	10YR 3/1	10YR 2/1	granular	50 cm	
E: 21°87'23"	Mt2	20–40	–	significantly less roots of ground cover plants	10YR 3/3	10YR 2/3	granular		
	D1	40–50	loose sand	–	10YR 6/2	10YR 6/1	n.a.s.		
	D2	50–60	loose sand	–	5YR 6/1	5YR 5/1	n.a.s.		
3	Ol	0–1	–	–				Alder	*Circaeo-Alnetum*
N: 52°67'87",	Mt1	1–16	–	many roots of ground cover plants	10YR 3/1	10YR 2/1	granular	36 cm	
E: 21°57'17"	Mt2	16–36	–	significantly less roots of ground cover plants	10YR 3/2	10YR 2/2	granular		
	D	< 36	loose sand	–	10YR 8/1	10YR 7/1	n.a.s.		
4	Mtbi	0–10	–	many roots of ground cover plants and soil fauna	10YR 3/2	10YR 2/2	granular	Alder	*Circaeo-Alnetum*
N: 52°68'13",	Mt1	10–20	–	many roots of ground cover plants	10YR 3/1	10YR 2/1	granular	37 cm	
E: 21°56'88"	Mt2	20–37	–	significantly less roots of ground cover plants	10 YR 3/3	10YR 2/3	granular		
	D	<37	loose sand	–	7.5Y 7/1	7.5Y 6/1	n.a.s.		

* according to von Post method, ** after Munsell colours atlas, structure, n.a.s. - non-aggregate structure (separated grain)

Table 2
Selected physico-chemical properties of the tested soils

Profile No.	Horizon	Depth (cm)	pH		cmol(+)·kg^{-1} of soil							%			C : N
			H_2O	KCl	Ca^{+2}	Mg^{+2}	K^+	Na^+	SB	Hh	CEC	BS	C	N	
Murshic peat soil (GPW of Ostrów Mazowiecka Forest District)															
1	Ol	0–1	5.8	5.3	72.71	2.06	0.52	0.34	75.63	52.50	128.13	59.02	37.45	2.92	12.8
	Mt1	1–18	6.3	5.3	88.40	5.35	0.29	1.49	95.53	34.00	129.53	73.75	26.15	2.43	10.8
	Mt2	18–35	6.8	5.3	49.49	2.06	0.11	0.84	52.50	20.50	73.00	71.92	13.30	1.19	11.2
	Otni	35–52	5.4	4.8	71.39	2.47	0.12	1.19	75.17	32.50	107.67	69.81	21.39	1.27	16.8
	OtD	52–80	5.8	5.2	79.15	2.67	0.17	0.42	82.41	31.00	113.41	82.41	9.85	0.78	12.6
	D	80–100	5.1	4.8	1.26	0.08	0.02	0.07	1.43	1.43	2.86	50.00	0.42	0.03	14.0
Thin murshic soils (profile 2 – GPW of Ostrów Mazowiecka Forest District; profiles 3–4 – GPW of Wyszków Forest District)															
2	Mtbi	0–10	5.1	4.6	25.00	9.46	16.82	0.96	52.24	54.00	106.24	49.17	36.50	2.09	17.5
	Mt1	10–20	5.0	4.6	20.00	2.26	2.62	0.67	25.55	28.10	53.65	47.62	18.00	1.18	15.8
	Mt2	20–40	5.2	4.9	23.00	6.99	1.23	0.67	31.89	21.70	53.59	59.50	17.40	0.95	18.3
	D1	40–50	5.9	5.4	7.32	0.24	0.23	0.20	7.99	2.50	10.49	76.16	2.60	0.17	15.3
	D2	50–60	6.3	5.8	2.35	0.26	0.15	0.08	2.84	0.90	3.74	75.93	1.10	0.07	15.7
3	Ol	0–1	5.1	4.7	59.67	10.08	1.92	1.85	73.52	29.00	102.52	71.71	26.66	1.12	23.8
	Mt1	1–16	5.3	4.8	49.73	3.74	0.17	2.19	55.83	38.25	94.08	59.34	12.84	1.23	10.4
	Mt2	16–36	5.9	5.4	55.20	3.71	0.17	2.46	61.54	31.00	92.54	66.50	25.55	2.29	11.2
	D	< 36	7.6	6.3	1.41	0.17	0.03	0.12	1.73	0.30	2.03	85.22	0.15	n.t.	
4	Mtbi	0–10	5.9	5.3	59.49	4.32	0.31	0.97	65.09	20.75	85.54	75.83	15.51	1.68	9.2
	Mt1	10–20	5.7	5.1	49.37	2.67	0.12	0.83	52.99	20.50	73.49	72.10	13.92	1.67	8.3
	Mt2	20–37	6.2	5.3	45.29	2.06	0.10	0.84	48.29	18.50	66.79	72.30	12.09	1.36	8.9
	D	<37	6.8	5.7	2.21	0.24	0.04	0.12	2.61	0.60	3.21	81.30	0.35	0.03	12.5

Explanation: SB – sum of bases, Hh – hydrolytic acidity, CEC – cation exchange capacity (CEC = SB + Hh), BS – base saturation, n.t. – not tested

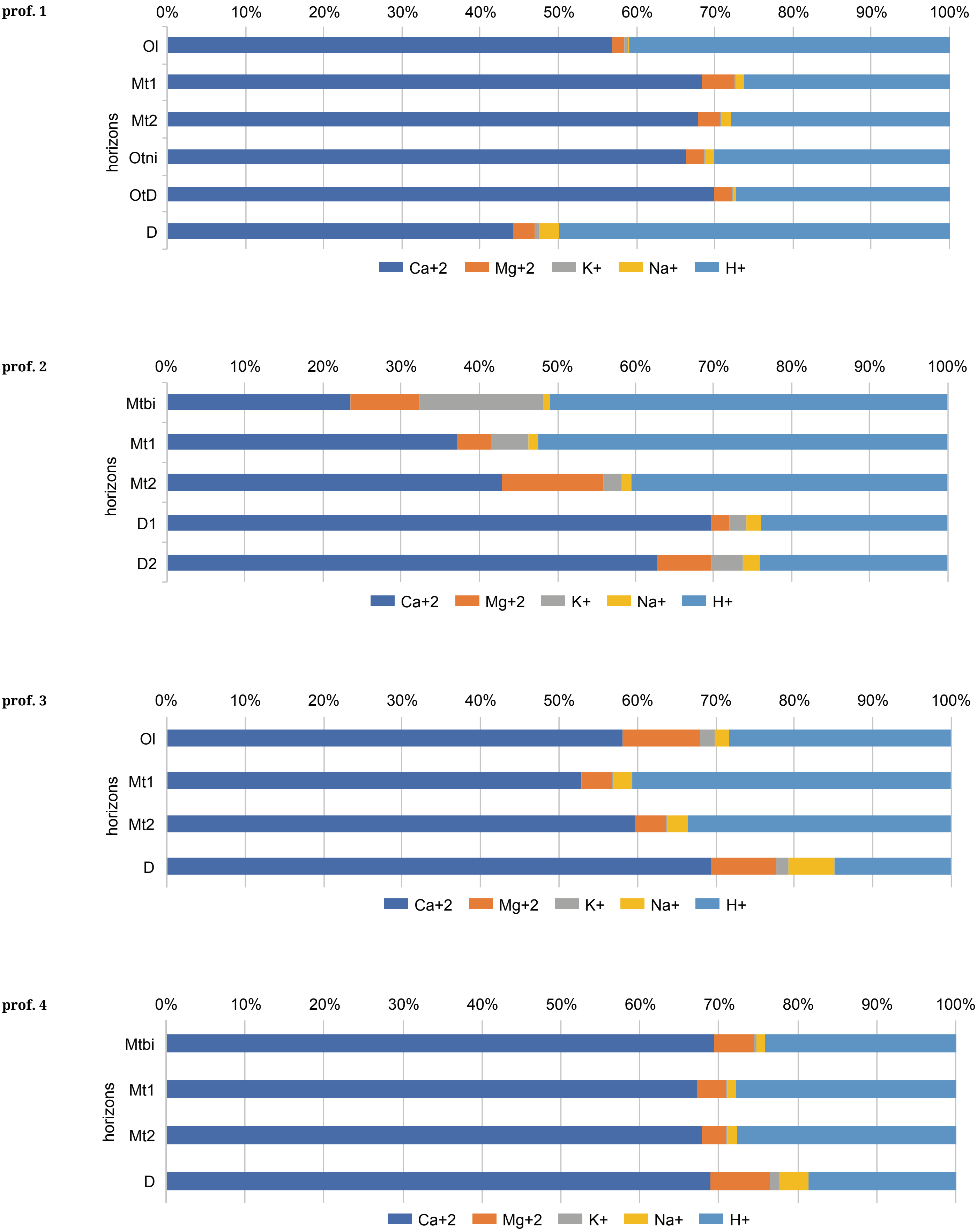

Fig. 2. Percentage of exchangeable cations in investigated soils (profile 1–4)

Table 3
Content of iron and trace elements in the tested soils

Profile No.*	Horizon	Depth [cm]	Fe [g.kg^{-1}]	Mn	Zn	Cu	Cr	Pb	Cd
				mg.kg^{-1}					
Murshic peat soil (GPW of Ostrów Mazowiecka Forest District)									
1	Mt1	1–18	1.5	455	69	10.2	8	31	2.8
	Mt2	18–35	6.8	205	31	8.0	20	17	1.5
	Otni	35–52	10.8	80	13	9.8	20	10	1.5
	OtD	52–80	4.9	50	9	4.6	8	10	0.5
	D	80–100	2.3	321	119	1.7	3	7	0.2
Thin murshic soil (GPW of Wyszków Forest District)									
4	Mtbi	0–10	1.6	394	70	9.8	10	44	2.4
	Mt1	10–20	4.6	282	41	7.9	14	12	1.6
	Mt2	20–37	9.7	199	32	7.6	13	12	1.4
	D	<37	2.8	269	84	4.2	4	8	0.4

*Soil profile numbers as in Table 1

The trophic assessment of the tested soils showed that profiles 1, 3 and 4 were eutrophic soils with a SIGo value of 29 to 32, while profile 2 was a mesotrophic soil with a SIGo value of 24 (Table 4). Both the fertility and properties of these soils created suitable conditions for the growth and development of alder vegetation. This was confirmed by the consistency of all partial diagnoses based on SIGo values, including partial diagnoses according to ground cover and stand (Table 5).

Table 4
Base cations sum (Sv [mol/l.5 m^3]), converted acidity (Yv/Czsv [mol/l,5 m^3]), converted nitrogen (N^2/C) and their corresponding soil trophic index SIGo partial indicators (WSo, WYo, WNo)

Profile No.*	Sv	Yv/Czsv	[N^2/C]	WSo	WYo	WNo	SIGo
Alder (Eutrophic organic soil; SIGo >25)							
1	368,8	1,49	0,023	10	2	10	29
3	125,5	0,65	0,012	9	5	8	29
4	173,6	0,58	0,018	9	6	9	32
Alder (Mesotrophic organic soil; SIGo 20–25)							
2	102,9	0,62	0,004	9	5	4	24

*Soil profile numbers as in Table 1

Table 5
Synthetic diagnosis of the forest site types (TSL) based on the SIGo with taking into account partial diagnoses according to ground cover and stand

Profile No.*	SIGo	Stand	Ground cover	Diagnosis TSL
Alder (Eutrophic organic soil; SIGo >25)				
1	29	Ol	Lw	Ol
3	29	Ol	Ol	Ol
4	32	LMb/Ol	LMb/Lw	Ol
Alder (Mesotrophic organic soil; SIGo 20–25)				
2	24	Ol	Lw	Ol

Explanation: *soil profile numbers as in table 1, Ol – alder forest, Lw – moist broadleaved forest, LMb – mixed swamp broadleaved forest

5. Discussion

The formation of mainly thin murshic and murshic peat soils was determined by the terrain relief, i.e. the occurrence of narrow (up to 100 m wide), elongated and boggy depressions in the area of both GPWs of the White Forest, which provided adequate moisture for the peat-forming process in the Holocene. Anaerobic conditions were created by shallow groundwater levels and surface water runoff from the surrounding higher terrain. As a result of reduced moisture content of the tested soils (lowering of the groundwater level), the peat-forming process ended and the mursh-forming process began. In order to understand the change in the direction of evolution of these soils, it is necessary to answer the question of what factors and phenomena caused the change in water conditions of the tested soils. Field studies did not indicate any drainage works in the area of both GPWs as a direct cause of changes in water conditions. However numerous studies indicate that the phenomenon of reduced soil moisture in large areas along with the lowering of groundwater levels is caused by negative human activity. Such activities include land improvement of agricultural soils, fulfilling mainly drainage functions, not drainage and irrigation functions (Bykowski et al., 2001; Kiryluk, 2008). This makes it impossible to continuously control soil moisture, irrigate soils during droughts, and retain water when there is an excess. Climate warming is another global factor that reduces soil moisture due to the increased frequency of droughts. This intensifies the mursh-forming process of organic soils and releases greenhouse gases into the atmosphere, nutrients to the surface and groundwaters as well as reduces the water storage capacity of these soils (Berglund and Berglund, 2010; Oleszczuk et al., 2022). The above anthropogenic factors probably caused a reduction in the moisture content of the tested soils, creating conditions for their intensive decay process. This phenomenon is also confirmed by significant decreases in groundwater levels in forest habitats in other areas of Poland (Korytowski et al., 2017; Liberacki and Szafrański, 2013).

The soils of both GPWs showed, much more advanced mursh-forming process than the organic soils of the Bialskie Mountains (Bogacz et al., 2008), Stołowe Mountains National Park (Bogacz and Roszkowicz, 2010), surroundings of the Legnica Copper Smelter (Bogacz and Sebzda, 2009), Kampinos National Park (Okołowicz and Sowa, 1997) and Sudety Mountains (Glina et al., 2016b) area. This was confirmed in most of the tested soils by the complete transformation of peat into mursh and its morphological and physical properties (structure) and lower exchangeable sorption capacity, carbon and nitrogen content and a significantly lower C:N value. Following many researchers, assuming a C:N value of less than 20 as the initiation mursh-forming process of the organic matter (Liwski et al., 1981; Maciak and Gotkiewicz, 1983; Okruszko and Piaścik, 1993; Maciak, 1995), its average value in the murshic horizons of the tested soils 12.1 indicates their intensive mineralization. Such conditions ensure high biological activity and, consequently, a significant intensification of the mursh-forming process. The tested soils can be classified as soils with a natural content of heavy metals, with slightly enriched of topsoil horizons. Similar contents and distribution of heavy metals in profiles were also found in organic soils of the Kampinos National Park (Czarnowska et al., 1983; Okołowicz and Sowa, 1997). Maintaining the current low moisture level of the tested soils will lead to their progressive decomposition (mineralization) and, in further evolution, their transformation into mineral- murshic soils and then mineral soils.

The renewed interest of Polish foresters and soil scientists in the GPW concept seems justified due to the growing negative impact of humans on forests and the entire environment. Among other things, the process of global warming is constantly intensifying due to the increase in CO_2 concentration in the atmospheric air, which is associated with an increase in the frequency and intensity of extreme weather phenomena (droughts, floods). Forests play a very important role in minimizing these phenomena by accumulating significant amounts of CO_2 (Jabłoński and Stempski, 2017; Łabęda and Kondras, 2020), as well as water retention.

The effects of well-functioning GPWs can also constitute a significant contribution to the management and development of the preferred, proecological model of forest management in Poland (Zielony and Chojnicki, 1996; Zarządzenie nr 11A ...., 1999).

6. Conclusions

1. The surface of both GPWs is covered with thin, strongly decomposed murshic and murshic peat soils formed from sapric peats covered with alder forests (*Carici elongatae-Alnetum, Circaeo-Alnetum*), underlain with sand.
2. In the murshic horizons of the tested soils, in addition to changes in morphological and physical properties, a significant reduction in the exchangeable sorption capacity, carbon and nitrogen content and C:N values was observed.
3. They can be classified as soils with a natural content of trace elements, with slightly enriched surface horizons.
4. The advanced mush-forming process in the tested soils and observed reduction of soil moisture in Poland indicates that they will probably be further transformed into mineral-murshic soils and then into mineral soils.
5. According to the soil trophic index (SIGo), 3 profiles of these soils were defined as eutrophic (SIGo >25) and profile 1 as mesotrophic (SIGo 20–25). Both the fertility and properties of these soils created suitable conditions for the growth and development of alder vegetation.

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Geneza i właściwości gleb organicznych na glebowych powierzchniach wzorcowych (GPW) Puszczy Białej, północno-wschodnia Polska

Słowa kluczowe

Proces murszenia
Olsy
Trofizm gleb
Glebowe powierzchnie wzorcowe

Streszczenie

Celem przeprowadzonych badań było określenie genezy i właściwości gleb organicznych w dwóch Glebowych powierzchniach wzorcowych (GPW) Puszczy Białej. GPW położone są w nadleśnictwie Ostrów Mazowiecka o powierzchni 470,5 ha (52°73'68" N, 21°87'35" E) i w nadleśnictwie Wyszków o powierzchni 325,7 ha (52°62'17" N, 21°42'26" E). Puszcza Biała jest dużym, zwartym kompleksem leśnym leżącym w dolnym dorzeczu Bugu i Narwi, w Krainie przyrodniczo-leśnej Mazowiecko-Podlaskiej (IV) o powierzchni około 51 tys. ha. Jest jednym z uboższych w kraju obszarów leśnych pod względem siedliskowym i bogactwa gatunkowego oraz w małym stopniu jest przekształcona przez człowieka. Położona jest na obszarze zlodowacenia środkowopolskiego, pokrytego przede wszystkim równinnie ukształtowanymi piaskami fluwioglacjalnymi (sandrowymi). Lasy Państwowe i Polskie Towarzystwo Gleboznawcze w latach siedemdziesiątych XX wieku utworzyły 139 GPW o przeciętnej powierzchni 405.5 ha (minimum 300 ha) oraz łącznej powierzchni 56529 ha. Celem GPW było zachowanie typowych gleb (wzorcowych) dla danego regionu (dzielnicy), które miały stanowić trwałą bazę porównawczą do prowadzenia badań naukowych i praktycznego szkolenia leśników. Na małych powierzchniach obu GPW występują płytkie silnie zmurszałe gleby murszowe i torfowo-murszowe wytworzone z torfów niskich porośniętych olsami (Ol) (*Carici elongatae-Alnetum, Circaeo-Alnetum*), podścielone piaskiem luźnym. Pokrywają doliny, które zajmują 3.5% powierzchni GPW Ostrów Mazowiecka i 1.6% GPW Wyszków. Według Klasyfikacji gleb leśnych Polski zostały zaklasyfikowane do płytkich gleb murszowych oraz torfowo-murszowych (Histic Gleysols według WRB 2022). W poziomach murszenia badanych glebach, oprócz zmian cech morfologicznych i właściwości fizycznych stwierdzono znaczne zmniejszenie wymiennej pojemności sorpcyjnej, zawartości węgla, azotu oraz wartości C:N. Można je zaliczyć do gleb o naturalnej zawartości pierwiastków śladowych i nieznacznie wzbogaconych poziomach powierzchniowych. Zachowanie obecnego niskiego poziomu uwilgotnienia tych gleb będzie prawdopodobnie prowadzić do postępującego ich murszenia (mineralizacji), a w dalszej ewolucji ich przekształcenie w gleby mineralno-murszowe, a następnie mineralne. Według siedliskowego indeksu glebowego (SIGo) 3 profile tych gleb zostały określone jako eutroficzne (SIGo >25) oraz 1 profil jako mezotroficzny (SIGo 20-25). Zarówno żyzność, jak i właściwości tych gleb wskazują na odpowiednie warunki do wzrostu i rozwoju roślinności olsu.