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CHARACTERISTICS OF SOILS AND PLANTS ON TWO SELECTED RESEARCH AREAS IN THE SMOŁDZIŃSKI LAS DISTRICT WITHIN THE SŁOWIŃSKI NATIONAL PARK

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Abstract

The soils studied are situated in the northern part of Gardno-Łebsko Lowland, which is part of the Słupsk Plain. For laboratory research two parcels were chosen, with the area of 0.5 ha, situated in protected district of Smołdziński Las. The research of the selected parcels shows great differences in the construction of soil and flora profiles. What they have in common is the high level of groundwater, which is influenced by slight changes during the vegetation season. The investigated soils have the acid reaction in all parts of their profile. The lowest values observed in levels of moulder differed from 3.56 to 3.74 pH_{H20}.

Key words: forest ecosystem, soil, flora, ground water, organic carbon

INTRODUCTION

The Słowinski National Park (SPN) is located on the Gardno-Łebsko Lowland within the middle coast of southern Baltic. The park is characteristic for its exceptional – on a national scale – history of bedding, flora and soils. The SPN location, neighbouring large lakes and the Baltic Sea, influences the hydrologic ratio (Fig. 1). Its soils were created in various periods, forming the paedosphere on the old water-glacial formations of the last Vistula glaciation as well as on the geologically younger areas created as a result of waterside processes, Aeolian occurrences, and on different-age formations of biological origin (Tobolski et al. 1997). The SPN soils have been studied for a long time. In the twenties and thirties of the 21st century the matter of soil bedding on the Gardno-Łebsko Lowland was touched by Bülow, which is betoken in his works regarding the podsoil genesis (Bülow 1930, 1934).

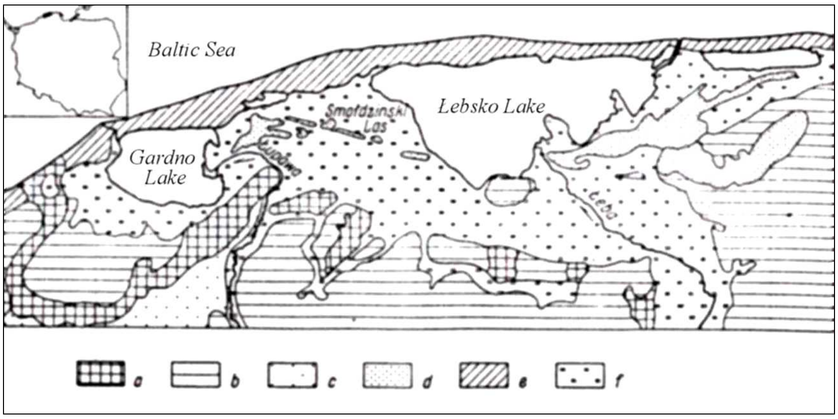

Fig. 1. Geo-morphologic sketch of Gardno-Łebsko Lowland: a) head moraine, b) ground moraine, c) outwashes, d) late-glacial Aeolian forms, e) holocene Aeolian form, f) forms of organogenic and mineral accumulation in valley bottoms, proglacial stream valleys and in depressions

Before the World War II the characteristics of soil bedding in the Łebska Spit was presented by Hueck (1932), claiming that mining soils existed on these areas too. A broad knowledge about soils, especially forested ones, was given in phytosociologic studies by Wojterski. Numerous of his works regarding the structure of phytocentoses and soil bedding in swamp and crowberry woods concern the Gardno-Łebsko Lowland (Wojterski 1963, 1964). For the pedological studies also the works by Piotrowska (1989, 1991) are of vital importance. They provide information on the action of shaping microforms of Aeolian accumulation and initial soil forms. At present the SPN soils are relatively well-known and described. The works by Dzięciołowski are of primary importance as he presented the diversity of SPN soil types, their distribution and genesis (Dzięciołowski 1973, 1974, 1975; Dzięciołowski and Tobolski 1975).

Since one of the most important qualities of the park nature is its exceptionally great dynamism of bedding, ground waters and flora, I made an attempt to investigate these relations. Therefore, this work is an introduction to a broad research aiming at defining and comparing the balance of biogenic substance circulation in two selected forest ecosystems.

STUDIED AREA

The soils studied are located in the northern part of the Gardno-Łebsko Lowland, within the Słupsk Plain. On the north they adjoin Łebska Spit, while on the south – over the zone of low peat – they abut on moraine heights (Fig. 2). For laboratory studies, two areas were chosen, each with the area of 0.5 ha, situated within the protected district of Smołdziński Las, adjoining the road from Smołdziński Las to Czołpino. One of them is located in the mixed forest with relatively high, changing

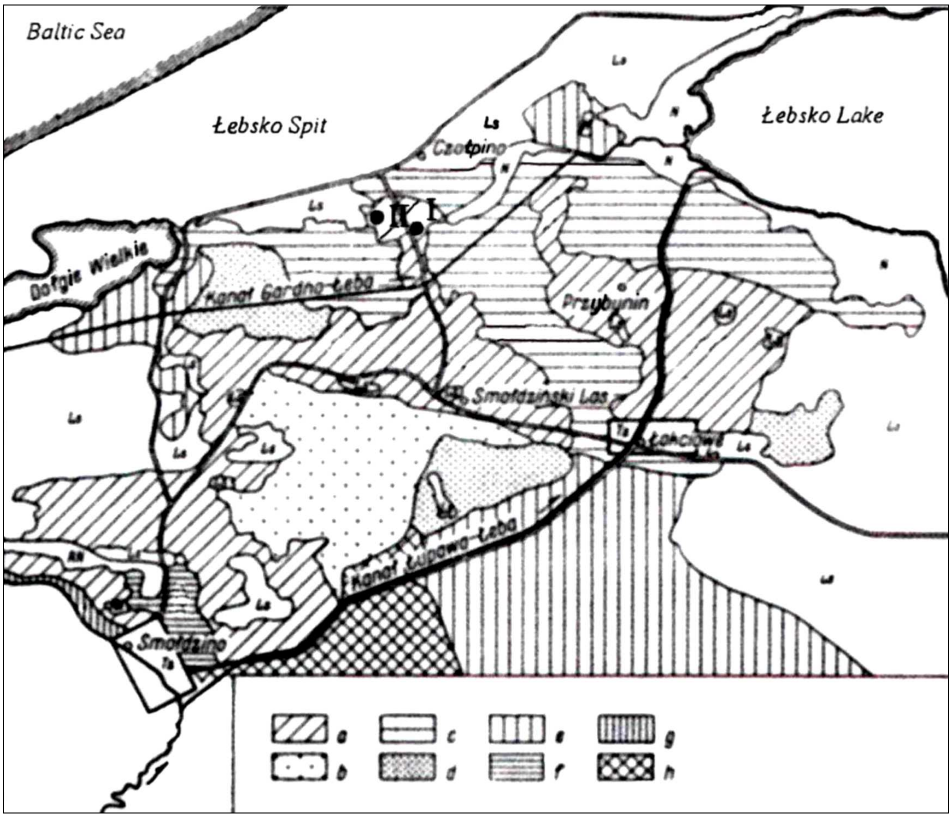

Fig. 2. Distribution of soils concerned: a) gley- podsol-decay soils, b) mineral-decay soils c) shallow peat-decay soils d) medium-depth peat-decay soils e) deep peat soils f) rigosol gley-podsols, g) proper fen soils h) complex of peat and mineral soils, Ls- forest, N- barren land, RN – waste land (farming), Tz – village premises, I – area I, II – area II

level of ground waters, about 1 500 m from the sea; the other one is located in a young wood with similar level of ground waters, about 900 m from the sea. The research, carried on from the early summer of 2002, aims at determining and comparing circulations of biogenic substance in the two forest ecosystems. Every six weeks in the vegetation period samples of soil, plants ground water and precipitation were collected and next they undertook adequate chemical analysis.

The presented work aims at:

– characteristics of soil and vegetation of the two areas,
– determining the actual humidity of the studied soil profiles,
– grain-size analysis,
– studying some physical proprieties of investigated soils,
– indication of acidity in the soils investigated,
– indication of organic carbon content.

STUDY METHODS

The material for chemical analysis was collected every six weeks from June to November 2002 from five chosen at random positions in the area of parcels I and II. After taking the material to the laboratory, the samples undertook adequate analysis. The actual humidity (WA) was determined with dry-gravimetric method (available for plants), and next the grain-size analysis with the Casagrade's mesh method. Basing on these analysis the elementary grain-size distribution indicators were established with the program "Granulom", i.e. standard deviation, graphic curtosis, grain obliqueness and diameter. Density (Mw) was determined with measuring flask method, volumetric instantaneous density (Mo') and volumetric actual density (Mo) was determined in samples collecting with Kopecki glass cylinder. These samples had intact structure. General porosity (Po) was calculated applying the following equation:

$$Po = (Mw - Mo) : Mw$$

Index porosity (e) was calkulated according to equation:

$$e = (Mw - Mo) : Mo$$

and store of water in soil (Q) was callculated according to Myśliwska (2001) applying the equation:

$$Q = WA * h$$

h – thickness of investigation soil.
pH was determined with the potentiometric method using a glass electrode. The active acidity was indicated in water solutions, while the exchange acidity – in the 0.1 KCl solution. Organic carbon was indicated with Tiurin's method (Myślińska 2001).

CHARACTERISTICS OF SELECTED FOREST ECOSYSTEM

The areas investigated are located within the villages Smołdziński Las and Łokciowe, on a sandy plain 0.2-0.5 m above the sea level (Fig. 2). Despite the two areas location in a protected district, their soil profiles are not identical. On the studied area of Smołdziński Las District predominant soil subtype is the underdeveloped podsol.

Soils of mixed forest

The soils in the mixed forest (area I) were classified glejopodsol, decay soils. They cover the area 0.1-0.5 m above the sea level and compose 49.3% of the land studied

(Tobolski 1997), being mostly the habitat for humid mixed forests. The studies conducted determined the morphological soil structure, which is illustrated in the following sequence of genetic levels: Ol-Ah-Ees-B_1fe-B_2fe-C_m-C

Ol – duff sublevel, humus type mor (about 1 cm),
Ah – decay-humified sublevel, strongly acidic (about 5 cm),
Ees – loose sand, grayish, new, clear passage, eluvial level (about 15 cm),
B_1fe – rusty-brown colour, dense structure (about 15 cm), illuvial level,
B_2fe – rusty-orange, dense structure, sometimes rusty coloured, illuvial level (about 40 cm),
C_m – mother rock level with a thin layer of organic mud (about 5 cm),
C – light yellow sand, fine grained, mother rock level, below 80 cm.

The ground water level is established at 1.1-1.3 m.

Soils of young wood

The studied young wood occurs on forest soils, very poor, mainly on proper podsols created from loose sand, which is connected with high and hardly active level of ground water (Dzięciołowski 1973, 1975). The type of bedding can be assumed to be of a decisive importance, since in the places where sands of different origin approach the coastline, the black crowberry does not occur. The morphological structure of podsol proper soils is characterized in the following sequence of genetic levels <u>O-A-Ees-Bfe-B/C-C.</u> The Ao level composes well-developed layer of 2 cm thick duff, under which there is a layer of overlaid humus, type mor A, consisting of slightly decomposed plant parts, mostly pine needles and other plants from the bedding with a 10 cm thickness. Deeper, there appears a well-developed eluvial level Ees, grey-coloured with 30 cm thickness. Under the eluvial layer there is an easily noticeable illuvial level Bfe, coloured rusty yellow, thick approx. 22 cm, which transforms into the yellow mother rock (C) already at the depth of 70 cm. The ground water level is established at 1-1.2 m.

Flora of mixed forest (area I)

The flora covering the studied area I is relatively varied and characteristic of the areas with high and changing levels of ground water. The predominant tree species is the *Betula pendula* along with the *Pinus silvestris*. In the intermediate forest frequently occurs: *Fagus silvatica, Quercus robur, Rubus plihatus*, whereas in the undergrowth covering almost 95% of the forest area is dominated by the *Molinia coerulea*, the grass of the genus *Deschomposia caespitosa*, there also occurs the *Vaccinium myrtilus*, and the *Vaccinium vitis ideae*. In the land depressions there can be seen the fern: *Athyrium filix-femina* and the *Phragmites communis*. The considerable percent of the undergrowth is covered with the moss: *Pleurozium schreberi*, *Hypnum cupressiforme, Dicranum scoparium*.

Flora of young wood (area II)

The seaside young wood occurs in acidic and very poor soils (oligotrophic), mostly in proper podsols associated with high and hardly active level of ground water (Dzięciołowski 1973, 1975). Ground water levels depend mainly on the precipitation amount and, to some extent, on the water level in the neighboring lakes and sea. The coastal location and the seaside climate result in the seaside forests considerably differing from the inland forests in soil types and flora composition. In forming forest sites and accumulations, the role of strong winds is of vital importance, as well as a relatively low average annual temperature, low annual amplitude, relatively short and usually cool summer, long autumn, relatively low precipitation level (approx. 700 mm) and high air humidity (Matuszkiewicz 2002).
The selected research area is covered with loose pine stand, coming from self-seeding and previus plantings, quite low (approx. 20 m) with misshaped tree heads and tilted trunks. The undergrowth covers 75% of the area and its cover consists of bushes of *Vaccinium myrtilus*, *Vaccinium vitis ideae*, *Empetrum mignum*, *Calluna vulgaris*, as well as well-developed moss layer: *Pleurozium schreberi*, *Dicranum scoparium*, *Hylocomium splendens*, *Luecobrum galucum.* The cup-moss happens to be found there too.

RESULTS

The grain-size content of the two soil types presented here is relatively monotonous (Tab. 1). It is dominated by intermediate sand (0.5-0.25 mm), the contribution of

Table 1

Mechanical composition of soils studied at parcels I and II

Area Number	Depth of sampling [cm]	Percentage content of earth-part fractions [%]				
		1.0-0.5 mm	0.5-0.25 mm	0.25-0.10 mm	0.10-0.02 mm	lower 0.02 mm
I	0-5	5.43	60.60	32.57	0.94	0.33
	5-20	1.39	66.85	30.89	0.42	0.23
	20-40	1.11	68.96	30.28	0.34	0.09
	40-60	1.14	66.08	32.47	0.23	0.08
	60-80	3.19	61.25	34.63	0.59	0.32
	80-100	1.67	55.68	36.19	0.46	0.17
II	0-5	5.31	35.41	50.09	3.02	0.28
	5-20	2.76	49.03	47.73	0.42	0.06
	20-40	1.47	51.03	47.04	0.37	0.06
	40-60	0.47	47.04	48.08	0.36	0.04
	60-80	0.25	54.91	44.44	0.35	0.04
	80-100	0.18	52.02	47.37	0.37	0.05

which is between 55.68% and 68.96% in the first parcel profile, and in the profile of the other – 35.41 to 54.91%. Small-granular sand (0.25-0.12 mm) occupied the second place with regard composition of soil, the content of which on the parcel I is 30.28-36.19%, and on the other – 47.04-50.09%. The coarse sand content is relatively low and established on the average at 1.11-5.43% (area I) and 0.18-5.31% (area II). Dust occurs in the smallest amount, i.e. 0.08-0.33% (area I) and 0.04-0.28% (area II). The sands investigated from the areas I and II are the Aeolian ones representing mainly the intermediate fraction. Basing on the grain-size analysis the grain-size distribution indicators were determined (Tab. 2). The average grain diameter in samples of the areas I and II are very similar. The standard deviation GSO from the average grain diameter is within the range 0.38-0.58; which indicates either a good material selection or the uniform dynamics of drift deposition. It is further confirmed by values of obliqueness factor, which meet the symetric distribution.

Table 2

Average values of grain-size indicators for soils of areas I and II

Area Number	Depth of sampling [cm]	Mz	GSO	GSP	GSK
I	0-5	1.81	0.49	1.82	0.07
	5-20	1.85	0.41	1.87	0.12
	20-40	1.84	0.38	1.85	0.10
	40-60	1.83	0.38	1.86	0.07
	60-80	1.86	0.43	1.86	0.06
	80-100	1.92	0.42	1.93	0.10
II	0-5	2.01	0.58	1.99	-0.06
	5-20	1.94	0.45	1.93	-0.07
	20-40	1.96	0.42	1.96	-0.02
	40-60	1.99	0.38	1.99	0.04
	60-80	1.97	0.36	1.98	0.08
	80-100	2.00	0.26	2.01	0.09

Mz – average grain diameter (phi), GSO – graphic standard deviation, GSP – graphic curtosis (oblateness), GSK – graphic obliqueness

The density of studied soils was least in decay level: Ah i A (Tab. 3). Its value was increased gradually together with deep to magnitude 2.71 g/cm^3 in B_2fe level. The density in mother rock level of area I (1.99 g/cm^3) expressive differed from analogous density of area II (2.84 g/cm^3). Values of instantaneous volumetric density and actual volumetric density was increased along with the profile depths in both areas. The soil of area I was characterised considerable higher values of these parameters than the soil of area II, only in mother rock level was similar. The actual volumetric density of area I soil changed irregularly. It amounted 1.14 g/cm^3 in surface (Ah),

Table 3

Some physical proprieties of investigated soils

Area Number	Soils genetic level	Thickness of the soil layer [cm]	Density [g/cm^3]	Density volumetric momentary [g/cm^3]	Density volumetric actual [g/cm^3]	Overall porosity [%]	Index of porosity	Water reserve [t/ha]	Water reserve [mm]	Mean reserve of water in the profil [mm]
I	**Ol**	1	-	-	-	-	-	-	-	171.92
	Ah	5	1.95	1.17	1.14	47.72	0.72	17.1	1.71	
	Ees	15	2.61	1.27	1.22	53.39	1.14	63.6	6.36	
	B_1fe	14	2.65	1.42	1.25	52.82	1.12	165.34	16.53	
	B_2fe	40	2.71	1.33	1.15	57.51	1.35	528.4	52.84	
	C_m	5	1.99	1.12	0.64	67.65	2.09	846.01	84.6	
	C	20	2.54	1.51	1.21	52.61	1.11	98.75	9.88	
II	O	2	-	-	-	-	-	-	-	135.00
	A	10	1.75	0.83	0.77	56.04	1.27	89.64	8.96	
	Ees	29	2.54	0.97	0.91	64.61	1.83	216.05	21.61	
	Bfe	22	2.64	1.15	0.99	62.45	1.66	406.21	40.62	
	B/C	8	2.71	1.37	1.17	56.84	1.32	446.71	44.67	
	C	30	2.84	1.42	1.16	58.82	1.45	551.41	55.14	

1.15-1.25 g/cm^3 in enrichment levels (Bfe) and 1.20g/cm^3 in mother rock level. That density had least value (0.64 g/cm^3) in mother rock level with a layer of organic mud (C_m). The actual volumetric density in soil of area II changed within the 0.77-1.77 range.

The soil of area I was characterised by smaller porosity (average 52.8%) than the soil of area II (60.0%), it is inverse only in mother rock level (area I – 67.6%, area II – 58.8%). The surface levels of both areas showed least the index porosity (I – 0.72, II – 1.27).

Average reserve of water accessible for plants in soil profile of area I amounted to 171.92 mm and was higher than on area II – 135.00 mm. The mother rock levels had the highiest reserve of water (I – 84.60 mm, II – 55.14 mm) the surface layers had the smallest (I – 1.71 mm, II – 8.96 mm).

The soils of profiles studied show the acid and strong acid reaction in the water environment as in the KCl solution. The lowest pH value was recorded in the upper, hu-

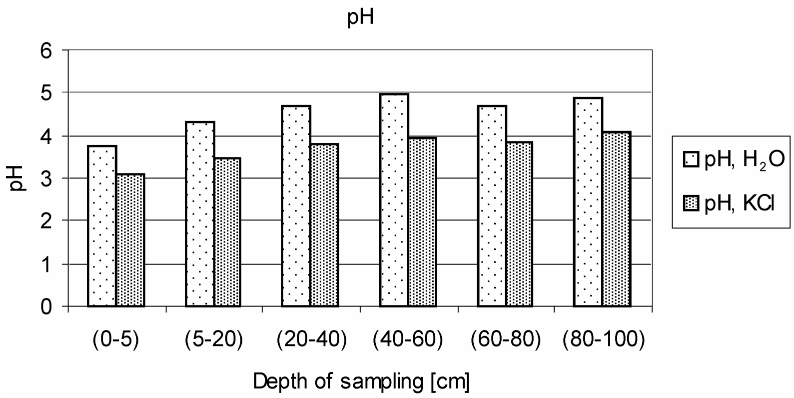

Fig. 3 Active (pH_{H2O}) and exchange (pH_{KCl}) in profile of area I

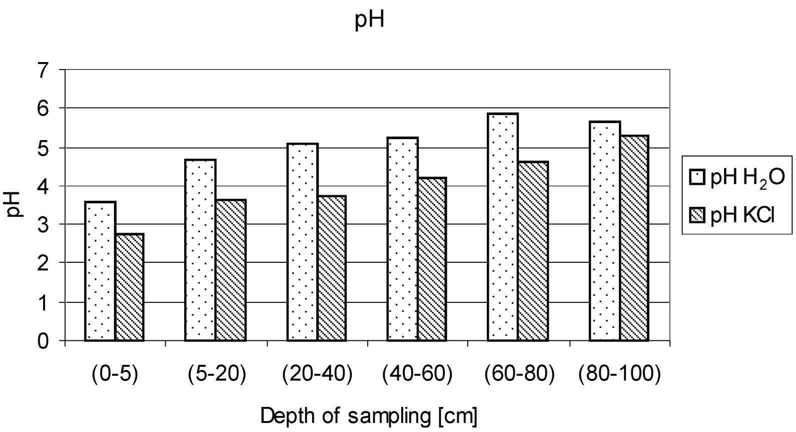

Fig. 4. Active (pH_{H2O}) and exchange (pH_{KCl}) in profile of area II

mus layers of the soil profiles, in the water environment. Their values were estimated at between 3.56 (area II) and 3.74 (area I), whereas in the KCl solution – from 2.75 (area II) to 3.11 (area I) (Fig. 3, 4). 60 cm farther in the profile depth its active acidity is on average from 4.96 (area I) to 5.26 (area II), and the exchange acidity – from 3.96 (area I) to 4.20 (area II).

The actual humidity changes as well depending on the depth of profiles investigated (Fig. 5). The highest one is in the upper layer in the both profiles and is established at 23% for area I and 44% for area II. In the deeper layers (5-20 cm) the humidity decreases to approximately 5.46-7.02% and increases steadily along with the profile depths, which is connected with the capillary ground water rise. The actual humidity and acidity of the profiles studied fluctuate slightly in vegetation season, which is related to precipitation and changing levels of ground water. The depth of ground water deposition influences to a great extent humidity at each genetic level. The highest humidity is at area II, where the ground water level occurs on average at the 100-120 cm depth. The humidity of soils studied is highest at the levels of overlaid humus.

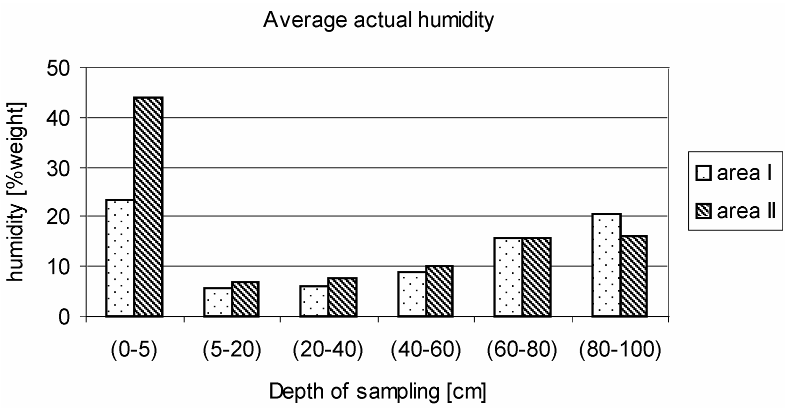

Fig. 5. Average actual humidity in soil profiles of areas I and II

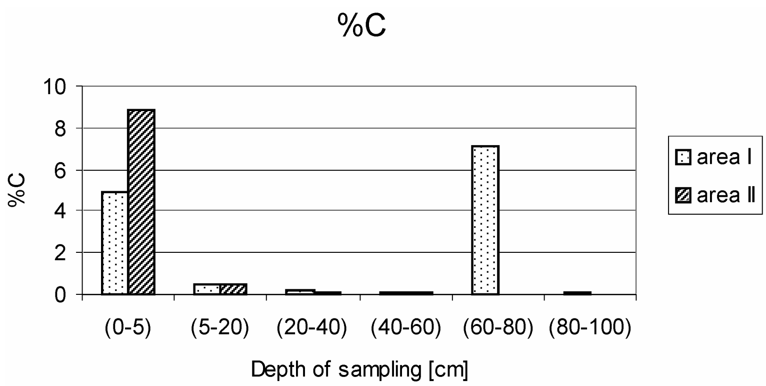

Fig. 6. Content of organic carbon in soil profiles of areas I and II

The organic matter is accumulated mainly in the humus levels of the soils. The highest content of organic carbon was detected in the upper levels of the profiles (0-5 cm). In area I the content C_{org} = 4.92, whereas in the area II – C_{org} = 8.88%. The organic carbon content, however, decreases considerably along with the depth of the both profiles reaching the value 0.01-0.06% at the depth of 100 cm (Fig. 6). Only in case of area at the depth of 80 cm there occurs a thin layer of organic sludge, which is easily noticeable in the enlarged content of organic carbon (7.14% C_{org}).

DISCUSSION

The obtained results concerning the studied physical and chemical characterictics, reflect previous works conducted on the area of Słowiński National Park. The investigated soil profiles show acid and strong acid reactions, especially in the humus layers, which is confirmed by Tobolski's research (Tobolski et al. 1997) on the SPN podsols. The values increase slightly with a profile depth, reaching value of 4.96-5.84 pH at the depth of approx. 60-80 cm.

The researches concerning the grain size content of the parcels are comparable to those obtained by Mocek (1978). Loose podsols formed at the sand drift areas are dominated by intermediate sand (0.5-0.25 mm). Due to its monofractional sandy substrate, the ground water level is fluctuating considerably during the vegetation season, which influences plant-living conditions significantly.

The actual humidity depends to a great extend on the precipitation amount as well as ground water levels. Similarly to Reinmann's conclusions (Reinmann et al. 1965) the actual humidity decreases with the soil profile depth, reaching its minimal values at approx. 20 cm depth. However, deeper, the humidity increases again, which is connected with the capillary ground water rise. The determined humidity plays an important role in indicating the balance of biogenic substances in the selected forest ecosystems, since water is the basic carrier of the determined nutrient is soil, water and plants.

The low content of organic carbon is also typical for podsols. Only in the humus layer (0-5 cm) the content is significant and fluctuates between 4.92 to 8.88%. Deeper down the content is getting lower. Similar values were presented by Tobolski (Tobolski et al. 1997). Only at approx. 80 cm depth (soil of area I), in the thin layer of organic sludge, the content of organic carbon is estimated at 7.14%, which results from the deposition of organic matter banked with a thick sand drift.

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CHARAKTERYSTYKA GLEB ORAZ SZATY ROŚLINNEJ NA DWÓCH WYBRANYCH DZIAŁKACH BADAWCZYCH W OBWODZIE SMOŁDZIŃSKI LAS W OBRĘBIE SŁOWIŃSKIEGO PARKU NARODOWEGO

Streszczenie

Badane gleby występują w północnej części Niziny Gardnieńsko-Łebskiej, wchodzącej w skład Równiny Słupskiej. Do badań laboratoryjnych wybrano dwie działki o powierzchni 0,5 ha każda, znajdujące się na terenie Obwodu Ochronnego Smołdziński Las.

Na podstawie dokonanych badań obu analizowanych działek stwierdzono, że różnią się one znacznie budową profili glebowych oraz szatą roślinną. Ich wspólną cechą jest dość wysoki poziom wód gruntowych, ulegający niewielkim zmianom w okresie sezonu wegetacyjnego. Badane gleby charakteryzują się odczynem kwaśnym w całym profilu. Najniższe wartości pH obserwuje się w poziomach próchnicy nakładowej i poziomach próchnicznych, gdzie wahają się od 3,56 do 3,74 pH_{H2O}.