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SOIL COVER IN THE MARGINAL ZONE OF THE CARPATHIAN FOOTHILLS BETWEEN THE RABA AND USZWICA RIVERS

Abstract: The soils of the Carpathian Foothills formed of loess-like formations are described. In the soil cover *Haplic Luvisols* and *Stagnic Luvisols* prevail. Locally and only on the strongly weathered slopes *Cambic Luvisols* occur. At the foots of the slopes and in the valley bottoms *Eutric-Cambic Fluvisols* occur and locally in the hollows *Eutric Gleysols* can be found. The results of research on the heavy metal content and soil resistance to acidification and alkalisation are presented.

1. Introduction

The soil cover of the Carpathian Foothills between Raba and Uszwica rivers is weakly varied as it is in the whole Carpathian Foothill region (Siuta, Rejman, 1963; Uziak, 1962). The features of the silt loess-like formations together with the climatic conditions supported the formation of the 'pseudopodzolic soils' (Łoziński, 1934) or *Luvisols* (Firek, 1977, Zasoński, 1981, 1983).

The Research Field Centre of the Institute of Geography in Łazy where the research on the dynamics and the anthropogenic changes of the environment takes place (Kaszowski, 1991) is located in the Wieliczka Foothills which are part of the larger Carpathian Foothills region. The purpose of this paper is to characterize the soil cover and describe the most important features of the soils. Also the problems of the anthropogenic threats caused by agriculture and the neighbouring industry of Cracow, Bochnia and Tarnów are discussed. This paper summarises the results of pedological research carried up in 1990-1996 (Fig. 1), (Skiba, 1992; Klimek, 1995; Skiba, Drewnik, 1995; Skiba, Drewnik, Klimek, 1995).

2. Soil cover

The soils of the Carpathian Foothill were formed of the deep silt loess-like sediments that cover a major part of this area. Therefore the soil cover in terms of

Fig. 1. Location of sampling sites

Ryc. 1. Lokalizacja punktów badawczych.

typology is weakly differentiated. This is the result of the considerable genetic homogeneity of the silt formations and of the homogenous climatic conditions in the Carpathian Foothills. As it is in the whole area of the Carpathian Foothills *Haplic Luvisols* and *Stagnic Luvisols* prevail forming a mosaic of difficult-to-part complexes (Uziak, 1962; Zasoński, 1981, 1983; Skiba, 1995). They cover about 80% of the area. The remaining 20% is covered by the delluvial *Cambisols* and *Cambic Fluvisols*. *Eutric Gleysols* occur on the small inner-forest wet areas (Skiba, 1995).

Haplic Luvisols were formed as a result of the lessivage process, that is, the reduction of the coloidal fraction in the surface horizons. In the profile of these soils a clear regularity in the distribution of the clay particles (the diameter below 0.002 mm) takes place. Below the humus horizon (*A*) a white eluvial horizon (*luvic-Eet*) occurs while below the brown argillic-Bt can be found. The argillic horizon (*Bt*) is characterized by greater cohesion, which is a result of the illuviation of the colloids. The illuviation can be found deep in the soil (below 200 cm) where the gradual change into bedrock takes place (*C*). Stratification of the soil profile (*A-Eet-Bt-BtC-C*) typical for *Luvisols* is the result of the gravitational movement of the dispersed clay fraction (Fig. 2).

Fig. 2. Clay in the selected *Luvisol* profiles

Ryc. 2. Ił koloidalny w wybranych profilach gleb płowych.

The thick illuvial horizon (*Bt*) is weakly penetrable and limits the infiltration of the precipitation or thaw water. The periodically stagnant precipitation water in the argillic horizon (*Bt*) causes the oxidation-reduction processes (gley) in the surface layers of the soil profile. It can be characterized with more distinct whitening of the soil mass in the luvic horizon and with the characteristic patches in the oxidation-reduction process zone (*Eetg, Btg*). Such soils are classified as *Stagnic Luvisols*. *Haplic Luvisols* and *Stagnic Luvisols* form mosaic complexes in the Foothill area and the separation of the two types is possible only with the use of micromorphological methods (Zasoński, 1983).

On the steeper slopes in the agricultural complexes formations similar to *Cambisols* occur. These soils seem to have been formed as a result of weathering and anthropogenic processes. In such places the eroded and shallow humus layer is regenerated by agricultural activities. The ploughed surface horizons and sub-humus ones (*Eet and Bt*) are being mixed and enriched with the organic matter. Thus a new (agricultural) humus layer is formed (*Aagr*) together with a new soil profile: (*Aagr/Bt-Bt-BtC-C*) similar to *Cambisols*. Such processes of 'rejuvenation' of the soil can be found in the areas subject to erosion and the soils are then called secondary *Cambisols* (Uziak, 1962). At the bottom of the river valley well-formed *Cambic Fluvisols* occur. On the mid-field wet areas *Eutric Gleysols* can be found and they are probably formed under the influence of the surface (usually on the argillic horizon) precipitation water. These soils cover small areas with hydrophyllic vegetation.

2. Properties of the soils

The loess-like formations that are the bedrock for soils condition their silt texture (Tab. 1). These formations have a small amount of sand (5-10%); a large amount of silt (50-60%) and a lot of clay (10-20%). The distribution of clay in the soil profile is characteristic for the lessivage process; in the surface horizons it is between 5-10% and in the argillic horizons respectively more – 10-20%. In the mineral composition quartz prevails and among the clay minerals – illites and mixed forms of montmoryllonite-illite. Kaollinites occur vestigally (Fig. 3).

The content of humus in the described soils is about 1.5-2.5%. Only in the meadow soils is it 3.0%. In the forest soils, because of the constant supply of leaf organic matter, the humus horizons are shallow (5-10 cm) but the content of humus is about 3-4%.

The reaction of the described soils is generally acidic in the forest soils – pH 4.0-5.0; or weakly acidic in the agricultural soils – pH 5.0-6.0. The generally low pH values in the silt soils of the Carpathian Foothills are the result of the lack of the calcium carbonate in the loess-like formations. The base saturation is also smaller in the forest soils (below 50%) and greater in the agricultural soils. These differences are caused by the fertilization and liming processes (Tab. 1).

3. Buffering capability

Soil buffering, i.e. resistance to acidification or alkalization, depends very much on texture and mineral composition together with the content of humus. As a measure of the soil buffering the gradient of the buffering curve has been drawn against the axis drawn on the so-called 'theoretical curve' traced for distilled water. The small gradient means greater buffering capacity while a picture close to the theoretical curve means smaller degree of buffering. Analysed buffering diagrams (Fig. 4) show small gradients of the buffering curves of the surface horizons of the forest soils against the axes. The meadow soils have a more pronounced gradient with the agricultural soils having the steepest. This means, therefore, that the surface horizons of the forest soils have the strongest resistance to the reaction changes, grass horizons of the meadow

Fig. 3. X-ray diffraction patterns of fine earth of the soil in the genetic horizons.

Ryc. 3. Dyfraktogramy rentgenowskie części ziemistych gleby z poziomów genetycznych.

soils – weaker and the agricultural soils – the weakest. This regularity is the result of the varied organic matter in the soils. In case of decalcified soils such as the silt soils, the buffering depends mainly on the amount of the organic matter and clay minerals composition (Pokojska, 1992, Ulrich, 1987). The greater acidification and alkalization capacity is caused by the mineral composition of the soil. A slight weakening of the self-regulatory properties in the mineral horizons of the soil can cause a greater amount of illites than minerals of the montmoryllonite group (smectites). The presented curves seem to show good buffering in the silt soils of the region.

4. Heavy metal content

Heavy metals were marked in the soils of the research area. This research was undertaken to gain pilot information about the possible pollution of soils due to emission from the neighbouring steel industry of Bochnia (Skiba, Drewnik, 1995).

Tab. 1. Soil profiles and some chemical properties of the soils.

Tab. 1. Profile glebowe oraz niektóre właściwości chemiczne gleb.

Profile No. Profil nr	Depth Głębokość [cm]	Horizon Poziom	Color (moist) Barwa (wilg.)	Fraction content in % Zawartość frakcji w % mm						pH		C org	Humus Próchnica	H Exch. acidity	S CEC	T ECEC	V BS
				1.0-0.1	0.1-0.05	0.05-0.02	0.02-0.006	0.006-0.002	<0.002	H_2O	KCl	[%]		cmol(+)kg^{-1}			[%]
HAPLIC LUVISOL - GLEBA PŁOWA TYPOWA - **ŁAZY**																	
1	0-20	A	10YR4/4	5	11	48	18	7	11	5.9	5.0	1.35	2.32	4.48	3.17	8.05	39
	20-43	Eet	10YR5/2	5	12	48	17	8	10	5.5	4.1			5.02	2.52	7.57	29
	43-90	Bt	7.5YR4/6	6	12	42	17	8	15	5.3	3.8			5.22	3.48	9.08	42
	90-120	Bt/C	10YR6/5	4	12	38	22	11	10	5.4	4.0			4.18	4.12	8.30	49
STAGNIC LUVISOL - GLEBA PŁOWA OPADOWO-GLEJOWA - **GAIK BRZEZOWA ON ' DOBCZYCE' RESERVOIR**																	
2	0-25	Ap	10YR5/3	14	8	41	19	8	10	5.9	4.7	1.11	1.91	0.23	7.5	7.73	97
	25-32	AEetg	10YR5/3	12	7	42	20	8	11	6.2	5.2	1.36	2.34	0.88	8.1	8.98	90
	32-88	Btg	7.5YR5/6	11	8	37	18	8	18	5.8	4.4			0.18	10.7	10.88	98
	88-160	Bt/C	7.5YR5/6	8	9	40	20	6	17	5.0	3.6			2.28	6.7	8.98	74
SAMPLES FROM THE SURFACE HORIZONS - **ŁAZY** PRÓBKI POZIOMÓW POWIERZCHNIOWYCH - **ŁAZY**																	
1	280-300	C		11	15	47	13	3	11	5.6	4.0	-	-	1.75	7.03	8.78	80
2	0-5	Ah		18	18	40	13	3	8	4.1	3.3	3.50	6.03	17.63	1.31	18.94	7
3	0-20	Ap		12	11	45	18	5	9	5.2	4.1	0.97	1.63	4.62	3.73	8.35	44
4	0-5	Ah		17	11	46	14	3	9	4.5	3.6	6.28	10.83	17.91	9.07	26.98	34
5	0-20	Ap		13	11	45	17	5	9	6.0	5.4	0.70	1.21	2.80	6.60	9.40	70
6	0-5	Ad		10	6	42	25	6	11	6.1	5.3	2.20	3.79	4.44	13.19	17.63	75
7	0-5	Ad		10	10	44	17	7	12	6.0	5.3	1.86	3.21	3.56	13.39	16.95	79
8	0-5	Ad		10	8	44	21	6	11	6.5	5.4	1.01	1.74	2.25	11.59	13.84	84
9	0-20	Ap								7.4	6.8	1.20	2.07	0.75	37.15	37.90	98
10	0-20	Ap		45	10	19	12	6	8	6.1	4.9	2.23	2.23	2.66	5.34	8.00	67

Fig. 4. Buffering curves vs. theorethical curve (KT): A - for surface horizons of forest soils, B - for surface horizons of grassland soils, C - for surface horizons of agricultural soils, D - for the genetic horizons of Luvisols.

Ryc. 4. Krzywe zbuforowania gleb na tle krzywej teoretycznej (KT): A - dla poziomów powierzchniowych gleb leśnych, B - dla poziomów powierzchniowych gleb użytków zielonych, C - dla poziomów ornych gleb uprawnych, D - dla poziomów genetycznych gleby płowej.

The soil samples were taken from the surface horizons, from the depth of 0-5 cm and only in the agricultural soils were so-called 'mixed samples' taken from the depth of 0-20 cm. The location of the sampling sites (Fig. 1) included the distance from the possible pollution emitters: Samples 1, 2, 3 and 4 were taken in the north-western part of Łazy, Sample 1 was taken from a depth of 280 - 300 cm i.e. bedrock formation for the researched soils, Samples 5, 6 and 7 were taken in the Dworski Stream catchment area, Samples 8 and 9 – close to the local road from Brzeźnica to Rzezawa (c.10 m). Site 10 was placed about 10 m away from the intersection of the road mentioned above with the international road E-4 in Rzezawa.

The content of lead for Sample 1 is about 9.77-10.62 mg kg^{-1}; zinc – 24.50-26.00 mg kg^{-1}; cadmium – 0.55-0.70 mg kg^{-1}; copper – 17.85-18.22 mg kg^{-1}; chromium – 13.30-18.55 mg kg^{-1}; manganese – 182.0-189.0 mg kg^{-1}. Assuming that those values are standard for the loess-like formations of the Foothills the content of some elements in the surface horizons can be interpreted as slightly raised. The content of such elements as lead, cadmium and manganese in some sites is several times larger than in the bedrock (Tab. 2, Fig. 5). The highest level of lead was marked in Samples 2 and 4. More zinc occurs in Samples 4, 6 and 9; cadmium and manganese in samples no 4, 6 and 10. At all

Tab. 2. Content of the heavy metals in surface horizons of investigated soils.

Tab. 2. Zawartość metali ciężkich w powierzchniowych poziomach badanych gleb.

Profile No. Profil nr	Depth Głębokość [cm]	Pb	Zn	Cd	Cu	Cr	Mn
ŁAZY							
1	280-300	10.62	26.00	0.70	18.22	18.55	189.0
1'	280-300	9.77	24.50	0.55	17.85	13.30	182.5
2	0-5	48.07	40.50	0.05	11.70	26.68	154.0
3	0-20	18.72	53.25	0.42	20.15	22.53	282.0
4	0-5	85.72	96.00	1.67	25.12	34.23	546.5
5	0-20	15.32	37.00	0.32	16.30	22.88	153.5
6	0-5	28.72	83.00	1.05	22.82	17.73	428.0
7	0-5	19.37	58.75	0.87	23.40	17.38	193.5
8	0-5	18.30	58.25	0.92	21.47	23.95	269.5
9	0-20	31.47	69.75	0.57	19.50	18.63	130.5
10	0-20	20.62	44.50	1.27	16.70	12.50	151.5
10'	0-20	21.05	45.00	1.20	17.65	7.63	339.0
Catchment area of Ratanica and Dębnik rivers near DOBCZYCE (Niemyska-Łukaszuk, 1993)							
10	0-23	27.50	57.50	0.40			
11	0-18	21.11	53.50	0.30			
13	0-17	40.00	85.10	0.77			

Fig. 5. Content of heavy metals in soils of the marginal zone of the Carpathian Foothills.

Ryc. 5. Zawartość metali ciężkich w glebach progu Pogórza Karpackiego.

sampling points large amounts of copper and chromium has not been observed. Similar results for lead, cadmium and zinc for the surface horizons of the silt soils of the southern part of the Carpathian Foothills in the Dobczyce river reservoir surroundings (Tabs 1 and 2) were described by Niemyska-Łukaszuk (1993). Higher values for the heavy metal content occur mainly in the agricultural soils. This is probably the result of fertilizing.

The presented values of the heavy metal content in the soils are, despite a slight increase in the agricultural soils, distinctly lower than the standards for the polluted soils presented in literature (Kabata-Pendias, Pendias, 1993).

5. Conclusion

The soil cover of the Carpathian Foothills is weakly typologically varied, which is the result of the homogeneity of the loess-like bedrock.

Haplic Luvisols and *Stagnic Luvisols* prevail in the soil cover. Well-formed *Eutric Fluvisols* occur at the foot of the slopes and in the river valley bottoms.

The texture, mineral composition, content of humus and large exchange capacity prove substantial buffering capabilityof the soils, which results in classifying these soils as resistant to acidification and alkalization.

The results of pilot research upon the heavy metal content in the soils do not show the pollution of soil with these elements.

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Pokrywa glebowa progu Pogórza Karpackiego między Rabą a Uszwicą

Streszczenie

Opisano gleby progu Pogórza Karpackiego wytworzone z utworów lessopodobnych (ryc. 1). Pokrywa glebowa jest mało zróżnicowana typologicznie, co wynika ze względnej jednorodności podłoża. Wśród jednostek glebowych przeważają gleby płowe typowe (*Haplic Luvisols*) i gleby płowe opadowo-glejowe (*Stagnic Luvisols*). U podnóży stoków i w dnach dolin rzecznych występują brunatne gleby deluwialne i aluwialne (*Eutric-Cambic Fluvisols*). Skład mineralny (ryc. 3), uziarnienie (ryc. 2), zawartość próchnicy i duża pojemność sorpcyjna (tab. 1) określają dobre zbuforowanie tych gleb (ryc. 4). Wyniki pilotowych badań nad zawartością metali ciężkich w glebach okolic Stacji Naukowej Instytutu Geografii UJ (tab. 2, ryc. 5) nie wskazują na zanieczyszczenie gleb tymi pierwiastkami.