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GEOMORPHOLOGICAL CONDITIONS OF WATER-AIR PROPERTIES IN THE SILT SOILS FROM THE EDGE ZONE OF THE CARPATHIAN FOOTHILLS*

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A b s t r a c t. In this paper an attempt to estimate the influence of the relief on the selected physical soil properties from the edge zone of the Carpathian Foothills has been presented. Differentiation of water-air properties related to the location on the slope was evaluated. It results from, both, the main soil forming process – lessivage, erosion and accumulative changes in the morphology of the soil profile. Soils lessivés situated on tops and slopes less prone to erosion are characterised by deeper eluvial horizons - luvic with a higher total porosity and water retention in comparison to illuvial horizons - argillic. Eroded lessivé soils occur on the slopes prone to erosion with the argillic horizon outcropped to the surface which determins their properties in the whole soil profile. First of all, their porosity is low and they have a limited capacity for water retention. Gley soils occur in the valley bottoms and synclines of slopes. They are characterised by higher total porosity and retention in the whole profile in comparison to the lessivé soils.

K e y w o r d s: the Carpathian Foothills, lessivés, relief, retention, pF.

INTRODUCTION

The area of the Carpathian Foothills is formed from the folds of Carpathian flysh covered by a deep layer of silt deposits – loess-like silts with genesis difficult to establish. Different soil forming processes such as: lessivage, pseudo-gleying and browning, as well as the influence of erosion and accumulative changes enveloping soil top horizons have taken part in the formation of the soil cover at the edge zone of the Carpathian Foothills [10]. These processes occur simultaneously with browning process at a clearly lower level. It has been estimated that well developed lessivés soil predominate among the soils covering the Carpathian

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Foothills [4,5,8,9]. Water-air properties of the soils in the Carpathian Foothills have been described in a few earlier papers [1-3,6]. In some of them authors stressed the importance of the influence of relief on the soil water conditions [6,7]. Therefore the aim of the present work was to estimate the effect of relief on the water-air properties of silty soils from the edge zone of the Carpathian Foothills.

MATERIALS AND METHODS

The present investigations were carried out in the watershed of the Dworski Potok located in the edge part of the Wieliczka Foothills, which belong to the Carpathian Foothills. The watershed of the Dworski Potok with a surface of 0.29 km^2 belongs to small watersheds from the area of foothills which has been agriculturally utilised. Three characteristic patches of soils situated in different parts of the slope and representing different taxonomic units, i.e. soils lessivé pseudo-gley *Stagnic Luvisol* (profile 1) on the top, soils lessivé eroded *Cambic Luvisol* on the protuberant slope (profile 2), soils lessivé pseudo-gley *Eutric Gleysol* – in the syncline of the slope (profile 3) have been selected for the present investigations. In the soil samples representing selected genetic horizons the following analysis were made: granulometric composition by the densimetric method by Cassagrande as modified by Prószyński, density of the solid phase by the pycnometric method. In soil samples of 100 cm^3 and intact texture, density and characteristics of soil water potential in the moisture function (h-Θ) was determined. From the sorption curves of water pF, differential porosity was determined. Total porosity was calculated. on the basis of the solid phase density and soil density.

RESULTS

Soils selected for profile investigations were characterised by the granulation typical for silts and clay silts. They contain up to 9% of sand fraction, 54-66% silt fraction and 31-43% clay fraction. Differentiation in the colloidal clay content, characteristic of the lessivage process, occurred in the profiles of soils lessivé. The A, Eet, C horizons had a lower content of colloidal clay (7-11%) than illuvial horizons Bt (12-16%). Colloidal clay content of the gley soil was uniform and amounted from 11 to 15%. In the investigated mineral horizons, a solid phase density of the soil was from 2.62 to 2.70 Mg m^{-3}, and in the humus horizons from 2.50 to 2.64 Mg m^{-3}. Soil density increased together with depth and amounted 1.14 to 1.66 Mg m^{-3}. The highest level of soil density (1.60 - 1.66 Mg m^{-3}) was

T a b l e 1. Selected physical properties of investigated soils

Depth (cm)	Horizon	% of fraction diameter in (mm)				Solid phase density (Mg m^{-3})	Soil density (Mg m^{-3})	Total porosity (cm^{3} 100 cm^{-3})	Content of pores (cm^{3} 100 cm^{-3})			
		1.0-0.1	0.1-0.02	<0.02	<0.002				>30 µm	30-1.9 µm	1.9-0.2 µm	<0.2 µm
Soil lessivé pseudogley (*Stagnic Luvisol*)												
0-30	Ap	9	59	32	8	2.61	1.51	42.1	2.3	12.1	13.6	14.4
30-47	Eetg	8	59	33	8	2.62	1.41	46.2	5.2	17.5	12.8	10.4
47-90	Bt	6	55	39	15	2.67	1.60	40.1	1.5	6.8	10.4	23.3
90-150	C	4	65	31	7	2.68	1.60	40.3	2.1	11.0	12.8	15.2
Eroded soil lessivé (*Cambic Luvisol*)												
0-30	Ap	6	63	31	11	2.64	1.54	41.7	2.8	10.6	11.7	16.9
30-65	Btg1	8	56	36	12	2.68	1.62	39.6	1.7	7.8	11.0	19.7
65-94	Btg2	4	59	37	16	2.68	1.66	38.1	2.2	10.7	12.1	13.5
94-145	C	3	66	31	12	2.68	1.66	38.1	2.3	11.3	12.2	12.4
Gley soil (*Eutric Gleysol*)												
0-5	Ah	2	64	34	11	2.50	1.14	54.4	7.9	19.6	13.0	12.0
5-29	Ahgg	3	54	43	15	2.70	1.45	46.3	8.7	13.6	9.5	12.4
29-90	Gox	6	54	40	12	2.60	1.44	44.6	8.6	14.2	9.9	12.3
90-120	G1	3	57	40	13	2.60	1.43	44.9	8.1	12.6	14.6	9.8
120-145	G2	3	57	40	13	2.66	1.46	45.1	7.7	12.6	10.3	14.5
145-170	CG	4	54	42	13	2.65	1.49	43.7	6.4	12.2	10.6	15.0

found in the illuvial and parent rock horizons of the soils lessivé. In the humus horizons, soil density amounted to 1.14 to 1.54 Mg m^{-3}. Whereas the mineral horizons of the gley soil and eluvial horizons of soil lessivé were characterised by lower soil density level (1.41 – 1.49 Mg m^{-3}) than in the illuvial horizons (Table 1).

Soil lessivé pseudogley *Stagnic Luvisol* (profile 1) which occurred in the investigated area, was situated on the tops and slopes that were less prone to erosion. They are characterised by a deep eluvial horizon Eet – luvic, changing at the depth of about 50 cm to a compact illuvial horizon argillic Bt. In these soils, total porosity decreases within the soil profile. Its highest amount was observed in the eluvial horizon Eet (46%), which probably was the result of low soil density that, in turn, resulted form gravitational translocation of colloids within the soil profile. The amount of aerial pores (>30 μm) ranged from 1.5% in a strongly condensed illuvial horizon Bt to 5.2% in horizon Eet. The content of mesopores (30 – 0.2 μm) was the lowest in Bt horizon (17.2%), and the highest in Eet horizon (30.3%) (Fig. 1). These amounts indicate a considerable potential retention of water accessible for plants in the eluvial horizon, and the majority of it (17.5%) constitutes water easily accessible for plants. In Bt horizon, however, the majority of accessible water constituted the water not easily accessible for plants (10.4%).

The content of micropores (<0.2 μm) in the humus and parent rock horizons showed little differentiation and amounted to, respectively, 14.4% and 15.2%. Whereas, in the eluvial horizon, the amount of this group of pores was the lowest (10.4%), and in the illuvial horizon it was the highest (23.3%) (Fig.1). The present results showed that the amount of water inaccessible for plants occurring in the Bt horizon was higher than the retention of water accessible for plants.

Patches of eroded soil lessivé of *Cambic Luvisol* (profile 2) occurring on the slopes had been formed as a result of shallow erosion of soil lessivé used as the arable soils. Intensive agricultural treatment as well as water erosion resulted from the washing off of their upper horizons and the upheaval of the illuvial horizon Bt. Therefore these soils are characterised by a uniform and low total porosity in the whole soil profile. It was from 38.2 to 42.0% and was similar to the total porosity of the Bt horizon of the soils lessivé. In the whole soil profile, contribution of respective pore groups was also only slightly differentiated (Table 1). Only the top Ap and Bt1 horizons were exceptions due to their higher content of micropores than in deeper horizons. It made the bigger part of water inaccessible for plants in the floor part of these soil. In the investigated profiles, retention of water not-easily accessible and inaccessible for plants was about 2.5 to 3 times higher than the retention of water easily accessible (Fig. 1). In these soils, a small part (1.7-2.8%) of

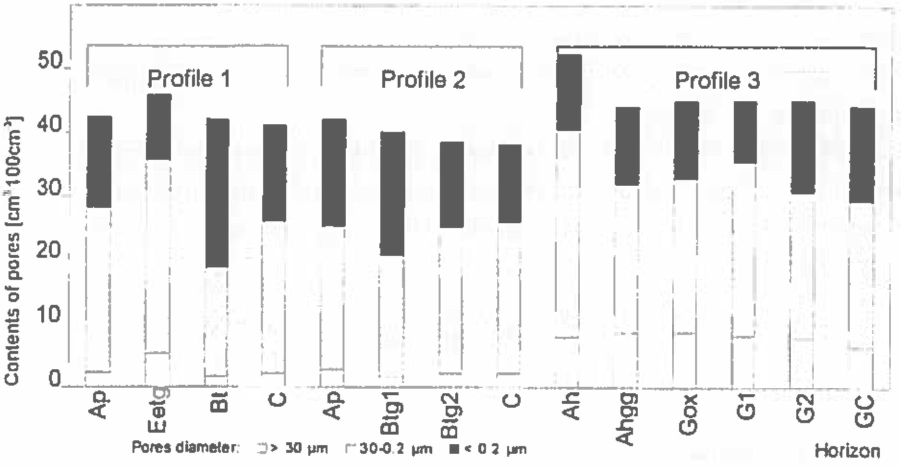

Fig. 1. Contents of pores in genetic horizons selected for profile investigations.

macropores from the very top of the soil, limited permeability and velocity of the percolating of rainfall water.

Gley soils *Eutric Gleysol* (profile 3) occurred in the valley bottoms and synclines of the slopes as the soils accompanying soils lessivé. They had a blue-ferruginous colour through almost the whole of the profile. It proved their changeable water–air conditions due to the periodical bogging of these soils by the water coming from the surface and subsurface flows. These soils are characterised by higher total porosity in the whole profile, i.e. from 44 to 54%, as well as a considerably higher contribution of aerial pores (6.4 to 8.7%) (Fig. 1) in comparison to the investigated soil lessivé. In the gley soils, the content of mesopores was about 1.5 to 2.7 times higher than the content of micropores which increased retention of water accessible for plants, in the situation where water easily accessible for plant predominated.

CONCLUSIONS

The influence of relief on water-air properties of loess-like deposits was observed as a differentiation in porosity and retention of the soil cover at the edge zone of the Carpathian Foothills:

1. Soil lessivé *Stagnic Luvisol* located on the tops and slopes less prone to erosion had deep eluvial horizons, with higher total porosity and increased contribution of macro- and mesopores when compared to the illuvial horizons. Such a porosity structure influenced higher retention in the eluvial than in illuvial horizons of these soils.

2. Eroded soil lessivés *Cambic Luvisol* located on the slopes prone to erosion are characterised by the porosity and retention in the whole profile similar to those of the illuvial horizons, due to their erosion shallowness and the illuvial horizon outcropped to the surface.

3. Gley soils *Eutric Gleysol* occurring in valley bottoms and synclines of the slopes are distinguished by the higher total porosity (with large contribution of macropores) and higher retention in the whole soil profile in comparison to the soil lessivés.

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