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Stefan Skiba, Marek Drewnik, Rafał Szmuc

THE SOIL COVER IN GAIK-BRZEZOWA (WIELICZKA FOOTHILLS)

1. Role of soils in the natural environment

The soil is a multi-functional, very important component of the natural environment. It forms a fundamental production base for farming. Depending on its fertility, the soil creates versatile habitats for meadow or forest vegetation that, in turn, result in characteristic landscapes.

The soil has different functions in the environment that are important for its biotic and abiotic parts, as the soil is a transitional link between an animate and inanimate nature. In the terrestrial ecosystems the soil forms natural habitats for plant life, and indirectly for animals and human beings.

A complex of micro-organisms (edaphone) living in the soil participates in the humification processes and in the mineralisation of decayed organic remnants that result in a soil humus formation. This way the soil plays a sanitary function. The soil humus and colloidal mineral soil particles (clay minerals) form specific complexes characterised by a high sorption capacity and ionic exchange potential, that are responsible for the storage of water and nutrients for the plants. This important soil property – the ability to absorb water and dissolved minerals (also toxic ones) – allows the soil to play another significant function in the environment – the function of the natural filter that stops and immobilises compounds which are harmful to the animate realm.

The soil is also characterised by a given porosity and, therefore, has a natural retentive capacity. A structure of the pore spaces and the sorption capacity of the soil control its ability to hold and store precipitation and meltwater. It is another, hydrologic function of the soil that regulates and controls water resources in the natural environment.

Participating in the matter and energy circulation throughout the ecosystems, the soil takes part in the accumulation of organic matter, in the circulation of biogenic elements, and in the storage and circulation of water.

The sorption capacity and ionic exchange potential of the soil affect also its self-regulating mechanism (buffering) and because of that the stability of the ecosystems is ensured, even if there is a high impact of external factors (Prusinkiewicz 1985). Thus, in the interdisciplinary studies dealing with the transformation and functioning of the natural environment a lot of attention is paid to the soil cover.

2. State of the studies on the soil cover of the Carpathian Foothills

There is a broad literature on the soils of the Carpathian Foothills. One of the first pedological issues – the work by Łoziński (1934) – presenting the peculiarities of the soils developed on the loess-like deposits of the Carpathian Foothills should be included amongst the important works describing the soil cover of this region. The origin of the aforementioned soils was presented by Uziak (1962), who emphasised that the stratification of such soil profiles is morphologically similar to that of the Podzols. He also stressed the role of morphodynamic processes in the development of the soil profiles. Zasoński (1981, 1983), based on micro-morphological studies, defined more precisely the genesis of these soils so confirming that the lessivage, i.e. through-wash, is a dominant mechanism in the soil forming process in this area. The formation of a compact and weakly permeable *argillic* horizon (Bt) occurring below the following top horizons: humus (A) and eluviation of colloids Eet (*luvic*) horizons, is a result of the lessivage process.

The illuvial horizon Bt (*argillic*) due to a higher content of colloids (swelling smectites as well), hinders the water circulation in the soil profile and in this way favours reduction-oxidation processes (gley formation). Thus, Haplic, Glossic or Stagnic Luvisols occur simultaneously. Uziak (1962) and Siuta (1961) paid attention to the dynamics of the gley process which assists the leaching of various compounds and favours the decomposition of the clay minerals if pH is acidic. Apart from the works dealing with the genesis of the Luvisols of the Carpathian Foothills, there are papers on the dynamics of water circulation and influence of the soil-forming process on the water properties of these soils (Firek 1977, Klimek 2000, Zaleski 2000, Zasoński 1989, 1992). For the Wieliczka Foothills, the characterisation of the soil cover at the margin of the foothills has been elaborated (Skiba 1992, Skiba *et al.* 1998) and the resistance of the Luvisols to chemical degradation has been described (Skiba, Drewnik 1995). Moreover, there are also the maps of land capability (IUNG) and other monographs (Skiba 1993).

In relation to the construction of the Dobczyce Reservoir the pedological issues referring to the water quality protection in the reservoir have been published (Adamczyk *et al.* 1980, Komornicki *et al.* 1982).

The purpose of this paper is to present the characteristics of the soil cover in the direct surroundings of the Dobczyce reservoir (Fig. 1) and to determine the influence of this water body on the soil cover.

3. Characteristics of the soil cover in the surroundings of the Dobczyce reservoir

The thick loess-like covers of silty deposits, mantling the flysch rocks of the Silesian nappe (Burtan 1994), are the substratum on which the soils of the area adjacent to the Dobczyce reservoir have developed. The flysch rocks (sandstones, conglomerates, clayey shales) occur on the ground surface mainly at the northern margin of the reservoir near Borzęta village and in the south – in the vicinity of the Droginiak Forest. The flysch deposits also appear as outcrops on the Jałowcowa Mt. close to the water dam.

Geological diversity is reflected in the terrain relief. Steep sections of the slopes and some summit parts usually coincide with the flysch rocks outcropping on the surface. Broad interfluves and gentle, mainly convex-concave slopes match the extent of the loess-like covers.

The land use pattern (Fig. 2) corresponds well with this lithologic-geomorphic layout. The steep slopes are occupied by the forests, whereas the gentle slopes and summit areas as well as the valley floors have been under cultivation since the Middle Ages. Earlier they were settled by neolithic cultures (Pietrzak 1995).

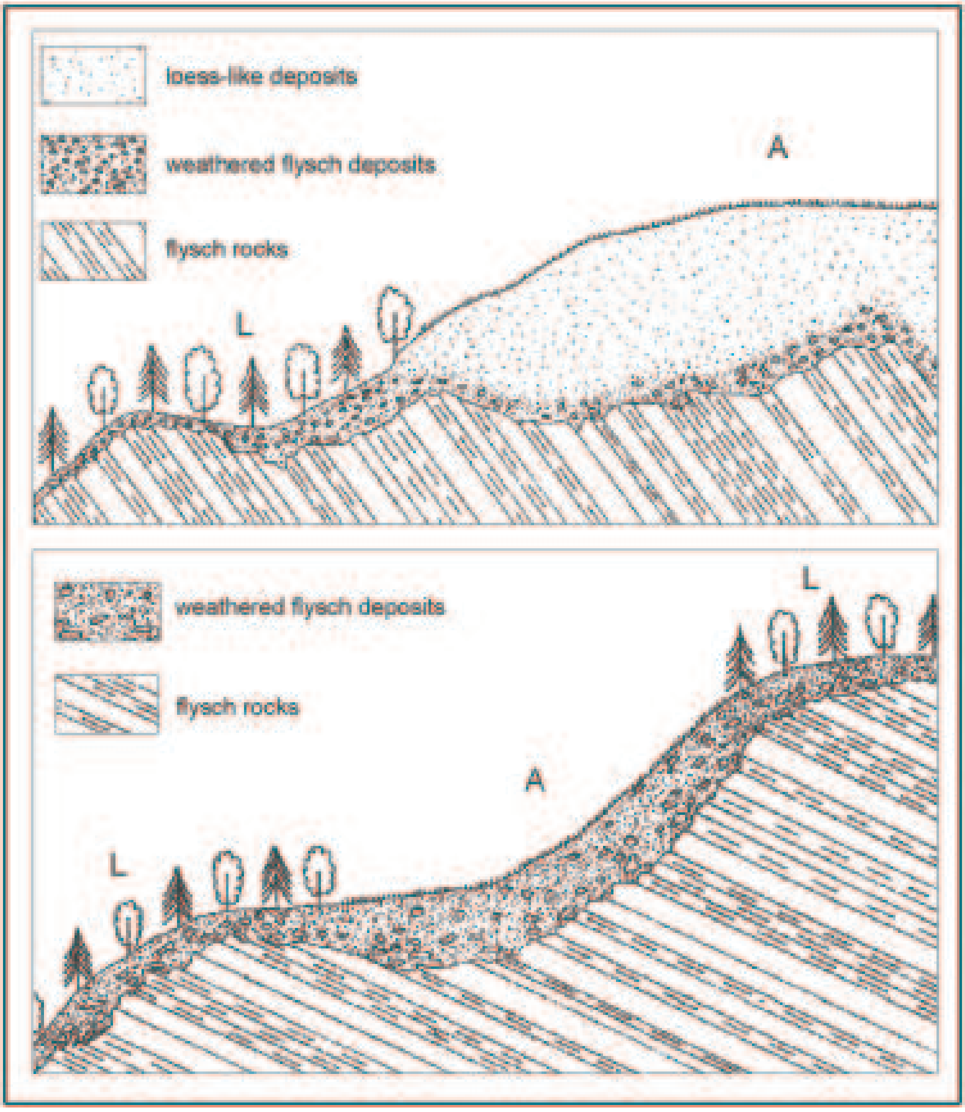
Dystric and Eutric Cambisols predominate on the weathered flysch deposits. When considering the texture these are light, medium and heavy loams. The Dystric Cambisols have pH below 7 in the whole profile (pH 3.5-4.5) while the Eutric Cambisols are acidic only in the top horizons (pH 3.5-4.5); in the deeper horizons – Bbr, Bbr/C – pH increases and exceeds the value of 5 (Tab.1,2). The thickness of the Cambisols amounts to 1 m, although shallow soils happen to occur on the steep slopes. Locally, on sandy and sandy-loamy weathering covers the Orthic Podzols are developed which form dystrophic habitats for the forest communities. The pH rarely exceeds 4.0 in the whole soil profile (Adamaczyk *et al.* 1980).

Luvisols predominate on the loess-like covers. These are the soils with a characteristic stratification of the soil profile which is morphologically similar to that of the Podzols. This morphological similarity between the Luvisols and Podzols caused the Luvisols to be assigned to podzolic soils on the older maps while they are classified as pseudo-podzols on the maps of land capability.

The Luvisols are either slightly acidic (pH 5.0-5.5) or sometimes acid (pH 4.5-5.0) but from the ecological point of view these are mesotrophic soils.

The Luvisols were formed due to the gravitational movement of the dispersed colloids deep into the soil profile. The colloids that are moved are deposited in cracks and pores, forming the characteristic plasma structures of the *vosepic* type, and more rarely of the *skellatisepic* type (Zasoński 1979, 1983). This way a horizon enriched in colloidal clay (Bt-*argillic*) is formed, which is dark brown in colour with a mosaic over-colouring. The overlying eluvial horizons (Eet-*luvic*) contain less fraction below 0.002 mm (Fig. 3) and are lighter in colour as certain ion compounds have been eluviated together with the colloids.

The transitions from the eluvial (Eet-*luvic*) to the lower-lying illuvial (Bt-*argillic)* horizons are clearly visible or stained, and on the basis of that Haplic Luvisols or Glossic Luvisols are distinguished.



A – arable land, L – forest

Fig. 2. Lithological conditions of relief, soil cover and land use pattern
(after Adamczyk *et al.* 1980, with changes)

The occurrence of the horizons with a larger amount of colloids, sometimes the swelling ones (smectites), under the eluvial horizons, results in reduced water infiltration down the soil profile. That brings about an intermittent stagnation of the water originating from thawing or high precipitation in the upper horizons of the soil profile. Because of the water stagnation reduction-oxidation processes are triggered (gley-forming) and the scattered, spherical concretions are formed together with the further bleaching of the horizons where the water is periodically logged. Thus, Stagnic Luvisols are formed. It should be emphasised that in the discussed terrain, as throughout the Carpathian Foothills, almost all the Luvisols are subjected to gley forming processes from the top (Skiba 1992, Zasoński 1983, Uziak 1962). The colloids' enrichment horizon (Bt-*argillic* horizon) also hinders the development of the plant root system.

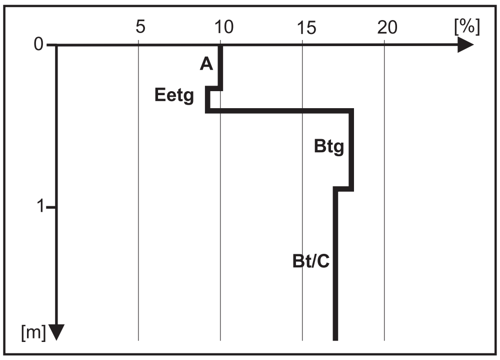


Fig. 3. Colloid fraction (ř < 0.002 mm) content in a Stagnic Luvisol profile (profile No. 1 – Gaik-Brzezowa)

The Luvisols are often shallowed due to erosion. Horizons A and Eet have been removed while a new ploughing-humus horizon is already developed as horizon Bt. Such "decapitated" soils usually occur on steep sections of the slopes.

The profile of the Luvisols characteristic of the surrounding of the Dobczyce reservoir is represented by the soil from Gaik-Brzezowa.

Profile:

A – 0-25 cm, grey (10YR 5/3), clayey silt, moderately moist, moderately firm, granular structure, numerous roots, pH - 5.9, organic matter – 1.91%, visible transition.

Eetg – 25-32 cm, light beige, (10YR 4/6), clayey silt, moist, moderately firm, subangular structure, singular roots, singular reddish (7.5 YR 5/6) iron concretions, pH - 5.2, visible transition of the *glossic* type.

Btg – 32-28 cm, bright brown (7.5YR 5/6), clayey silt with tongue-like whitish (10YR 7/3) stains, moist, pH - 5.0.

Btg/C – 88-160 cm, bright brown (7.5YR 5/5), clayey silt with whitish stains, moist, pH – 5.0.

Soil Unit: Stagnic-Glossic Luvisol

Gleysols also occur in the area adjacent to the Dobczyce reservoir. Their arrangement corresponds to the layout of the ravine floors and of the concavities at the lower parts of the slopes. These soils are often accreted due to deluvial processes. They are characterised by a high moisture content and are subjected to the processes of ground gley-forming, that starts just from the humus horizon A below which the gley horizons G occur.

In the pattern of the soil cover in the direct surroundings of the Dobczyce reservoir Haplic and Stagnic Luvisols as well as Dystric and Eutric Cambisols prevail. In places where the flysch rocks outcrop, i.e. in the region of the Droginiak Forest and close to

Tab. 1. Basic properties of soils characteristic for the surroundings of the Dobczyce reservoir

Profile No.	Depth cm	Horizon	Colour Munsella (moist)	ø≪ 1mm	%% of earth fractions				pH	
					1.0-0.1	0.1-0.02	<0.02	<0.002	H_2O	KCl
Podzol – Ratanica catchment *)										
21	3-9	Of		-	raw humus				4.1	2.9
	10-12	Ofh		-	raw humus				3.7	2.6
	13-18	Ees		-	62	22	16	5	3.7	2.6
	19-44	Bs1		8	74	12	14	5	4.3	3.7
	45-60	Bs2		12	82	11	7	4	4.0	3.7
	61-100	Bs/C1		27	85	8	7	4	4.1	3.6
	101-150	Bs/C2		20	80	11	9	5	4.3	3.6
Eutric Cambisol – Dębnik catchment *)										
34	0-19	Ap		20	37	29	24	7	5.2	4.3
	20-43	Bbr		10	33	30	30	8	5.6	4.5
	44-82	Bbr/C1		20	56	20	16	8	5.5	4.3
	83-110	Bbr/C2		80	56	21	8	5	5.5	4.3
Stagnic Luvisol – Gaik-Brzezowa**)										
1	0-25	Ap	10YR5/3	0	14	49	37	10	5.9	4.7
	25-32	AEetg	10YR5/3	0	12	49	39	11	6.2	5.2
	32-88	Btg	7,5YR5/6	0	11	45	44	18	5.8	4.4
	88-160	Bt/Cg	7,5YR5/6	0	8	49	43	17	5.0	3.6
Eutric Gleysol – Gaik-Brzezowa**)										
6	0-2	Ah	10YR2/2	0	-	-	-	-	5.8	4.8
	2-9	Agg	10YR3/3	0	17	54	29	8	5.8	4.8
	9-30	ACgg	5Y4/1	0	9	54	39	10	4.6	3.9
	30-110	G	5Y3/1	0	9	52	39	12	4.4	3.8

*) after Adamczyk *et al.* (1980)
**) original

the village of Borzęta, small areas are occupied by Orthic Podzols. In the map (Fig. 1) compiled according to the land-capability maps, the large area of Cambisols is the result of assigning the "decapitated" Luvisols to Cambisols group.

4. Influence of the Dobczyce reservoir on the soil cover

The construction of the Dobczyce reservoir caused the forest and farmland amounting to a total area of c. 1000 ha to be excluded from management. Besides the forests and waste land, the soils assigned to the mountain wheat complex (10.), the mountain cereal complex (11.) and, to a lesser degree, the strong cereal-root plant complex (8.), the moderate grassland complex (2z) and the poor and very poor grassland complexes (3z), are now under the water. The terrain occupied by the Dobczyce reservoir corresponds to the extent of the alluvial soils (Fluvisols) of various subtypes (Fig. 2) and in smaller areas to the Luvisols or Cambisols and Gleysols.

The present-day influence of the Dobczyce reservoir on the soil cover is limited to two aspects. These are: abrasion which affects the shores and secondary triggering of

Tab. 2. Selected chemical properties of soils characterstics for the surroundings of the Dobczyce reservoir

Profile No.	Depth cm	Horizon	C org.	Exchangeable acidity (Hh)	Cation exchange capacity (CEC)	Total of exchange capacity (T=H+S)	Base saturation (BS=S*100/T)
			%	cmol kg^{-1}			%
Podzol –Ratanica catchment *)							
42	2-8	Ofh	-	65.10	9.79	74.89	13
	8-16	AEes	-	8.31	1.12	9.93	11
	16-47	Bs		7.05	0.83	7.88	11
	47-74	Bs/C		4.25	0.77	5.02	15
Eutric Cambisol –Dębnik catchment *)							
34	0-19	Ap	-	2.88	2.17	5.03	43
	20-43	Bbr		1.94	2.36	4.39	55
	44-82	Bbr/C1		1.80	3.09	4.89	63
	83-110	Bbr/C2		n.o.	n.o.	n.o.	n.o.
Stagnic Luvisol – Gaik-Brzezowa**)							
1	0-25	Ap	1.11	0.23	7.50	7.73	97
	25-32	AEetg	1.36	0.88	8.10	8.98	90
	32-88	Btg		0.18	10.70	10.88	98
	88-160	Bt/Cg		2.28	6.70	8.98	75
Eutric Gleysol – Gaik-Brzezowa**)							
6	0-2	Ah	9.35				
	2-9	Agg	1.96	0.18	9.40	9.58	98
	9-30	ACgg	1.33	0.88	3.10	3.98	78
	30-110	G	0.65	2.01	2.70	4.71	57

*) after Adamczyk *et al.* (1980)
**) original

the mass movements that modify the soil cover. Then, accumulation of the weathered material takes place and leads to an accretion of the profiles of the alluvial soils. However, the water-logging of the soils due to the damming of the reservoir has not been noticed.

The abrasion is observed almost along the entire shoreline. Its intensity and pattern is differentiated depending on the variation in the geological substratum and relief.

The most significant changes in the soil cover are observed in the sites where the abrasion adds up to the formation of the landslides, slumps and falls. Such phenomena are most common along the northern shore of the Dobczyce reservoir from Nadrabie to Ostra Mt. and in the region of Jałowcowa Mt. In the aforementioned belt there are outcrops of the sandstones and shales of the Godula beds as well as the sandstones and conglomerates of the Lower Istebna beds to which the steep forested slopes correspond.

In the remaining terrain where the thick loess-like covers occur the abrasion predominates together with phenomena of creeping. These shores are being degraded very slowly. The influence of the reservoir on the soil cover is not observed there.

In the wind-protected, deeply incised bays of the reservoir there is accumulation of the alluvial material. This phenomenon takes place in the backwater zone, at the mouths of the streams, mainly in the region of Zakliczyn on the northern side of the Dobczyce reservoir. The accumulated material becomes the parent rock for the alluvial soils (Fluvisols). These soils are characterised by the large amount of poorly decomposed plant material present in the profile. The phenomenon of accumulation of the alluvial-deluvial material also takes place on the floors of the ravines which now descend directly to the reservoir. Such properties are also typical for the Gleysols mentioned earlier (Tab.1).

Because of the reservoir's construction – probably per an analogy to the lowland reservoirs – the formation of bogged soils due to the rise of the groundwater table was expected (Ziętara 1992).

In the region of the Dobczyce reservoir the larger water-logged areas associated with the rise of the groundwater table have not been stated. The inspection of the outcropping of the soil profiles along the shores did not show the changes in the morphology of these soil profiles, i.e. there was no increase in the mottling of the soils on the slopes descending to the reservoir. It might be the result of the presence of a poorly permeable, textural horizon Bt-*argic*.

In the zone of the backwater where protective embankments are made in the region of Droginia-Osieczany, the water-logging of the soils occurring on the former terraces of the Raba river has also not been stated. It confirms the efficiency of the protective facilities, i.e. the drainage system, reservoirs and pumping-station.

5. Conclusions

1. The soil cover of the surroundings of the Dobczyce reservoir is characteristic of the Wieliczka Foothills region. The soil cover is dominated by Haplic Luvisols or Stagnic Luvisols often shallow through erosion ("decapitated") prevail. Smaller areas are occupied by Cambisols, Podzols, Gleysols and Fluvisols. The Luvisols are the best farming soils throughout the Carpathians.
2. The construction of the Dobczyce reservoir caused the fertile soils belonging to the mountain wheat and cereal complexes or to the grassland complexes of the lower land capability classes (complexes 2z and 3z) to be excluded from management.
3. The present-day influence of the Dobczyce reservoir on the soil cover is insignificant. It manifests mainly in the triggering of the mass movements on the slopes that, in turn, modifies (erodes most often) the soil cover on the slopes adjacent to the reservoir. The slopes are usually modelled by the abrasion which favours and supports the slow mass movements (creeping). The accumulation of material at the surface only takes place in tiny sections in the streams' outlets to the reservoir, in protected bays and on the floors of the ravines descending directly to the reservoir.
4. The changes in the soil cover due to the damming up of the ground water table have not been observed. The above results from the upland relief of the area in question as well as from the properties of the soils themselves. A slight water-logging is only observed on the floors of the ravines descending now directly to the reservoir.

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Stefan Skiba, Marek Drewnik, Rafał Szmuc
Department of Pedology and Soil Geography
Institute of Geography and Spatial Management
Jagiellonian University
Cracow
Poland