TENDENCIES TO CHANGE IN THE COMPOSITIONS OF THE KARSTIC SOIL AND THE VEGETATION IN THE DOLINES IN THE HUNGARIAN BÜKK MOUNTAIN

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Résumé

Au cours des dernières décennies les conditions oecologiques des territoires carstiques ont subi des changements, par suite de l'intervention humaine.

Les changements des indicateurs les plus sensibles de l'environnement, ceux de la végétation et du sol, signalent les changements de la valeur oecologique.

En ce qui concerne les sols, notre évaluation a porté sur le teneur en humus, la réaction et la compacité du sol, le teneur en micro-éléments, et les cations et les anions hydrosolubles. Au cours de l'analyse, pour montrer les tendances des changements, nous avons comparé les données de trois ans (1978, 1984 et 1985).

Le teneur en substance organique du sol est élevé, en raison de la minéralisation lente. Les valeurs du phosphore sont moins importantes dans la subsurface que dans les couches situées plus bas. La réaction chimique est généralement indifférente ou légérement acide. La corrélation entre la quantité des anions et des cations hydrosolubles a été très étroite en 1978. En 1985 ce rapport est moins marquant.

Les valeurs de la réaction du sol, d'après l'indication d'espèce de plante étaient plus basses en 1985 que dans les années précédentes. La valeur des indices de l'economie thermique a diminué, tandis que celle des indices de l'hydro-économie a augmenté.

Zusammenfassung

In den letzten Jahrzehnten haben in den ökologischen Verhältnissen der Karstlandshaften durch den Einfluss des Menschen Änderungen stattgefunden. Die Wandlungen in der Zusammensetzung des Bodens un der Vegetation die die sensibelsten Indikatoren unserer natürlichen Unwelt sind, weisen auf die vor sich gegangenen Änderungen des ökologischen Wertes hin.

In Bezug auf die Böden hat unsere Bewertung die Angaben des Humusgehalts, der Bodenreaktion, der Bindigkeit, des Mikroelementsgehalts und die im Wasser Löslichen Anionen und Kationen erfasst.

Zur Darstellung der Tendenzen in den Veränderungen haben wir die Angaben von drei Jahren (1978, 1984, 1985) veglichen.

Der Humusgehalt der Böden war hoch infolge der langsamen Mineralisierung der organischen Stoffe. Die pH-Werte waren in den der Oberfläche nahen Schichten kleiner als in den tieferen Schichten. Die Reaktion war im allgenseinen neutral und schwachsauer. Zwischen der im Wasser löslichen Anionen- und Kationen-menge bestand im Jahre 1978 eine feste Korrelationsbeziehung. Im Jahre 1985 wurde diese Beziehung zwischen den Anionen und Kationen lockerer.

Nach der Indikation der Vegetation waren die Werte der Bodenreaktion kleiner im Jahre 1985 als in den vorangegangen Jahren. Die Verzeichniszahle des Wärmehaushalts haben sich vermindert, die Werte des Wasserhaushalts haben dagegen engenommen.

One of the most important tasks of environment management today is the study of ecological factors with a view to maintain the balance of ecosystems. This goes hand in hand with the development of the evaluation methods of ecological resources. Detailed ecological studies are carried on these days to find out, for example, about the causes of damages to the vegetation, primarily to forests. The deterioration of vegetation indicates the changes in the environmental factors that in the long run lead to the upsetting of the ecological balance. Forest damages are usually attributed to, and can also be proved to be the result of, the harmful effect of acidic precipitation. Researchers,

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however, seldom conduct detailed analysis of the processes that occur as the consequence of acidic precipitation, but also within the ecological system of the soil itself. W.D. Blümel (1986) points out four sources of soil acidification. The first he mentions is the natural atmospheric H deposition, a result of volcanic activity, nitrogen circulation, etc... He also regards as important anthropogenic atmospheric H deposition, the result of burning processes during industrial production, etc... The third source is particularly important for us, and that is the result of processes within the ecosystem of the soil, such as soil breathing, cation intake, and the H eduction of plants, and humus producing processes. The fourth, but not the least significant source of acidity according to him is the acidifying effect of the nutriment intake during the agricultural utilization of the soil.

Acidification occurs, if less forcefully (due to the stronger buffer effect of the soils on calcic rockbed), in karstic soils as well. In the soil this process goes hand in hand with the increase of H ions and cation-acids (Al^{3+}, Fe^{3+}, and Mn^{2+}) on the sorption carrier. This process, in the long run, leads to the structural deterioration of karstic soils and an increased danger of erosion. At the same time, the intensity of the karstic corrosion also changes, which may cause changes in the superficial and sub-superficial processes.

Photo 1. One of the examined dolines of the Hungarian Bükk Mountain. Typical solution doline. Deep: 18 m. Diameter: 50 m.

The phenomena outlined above have been triggered off on a larger scale in the last decades, by human activity. The present paper attempts to show the changes in the ecological value of karstic areas by examining in detail the soil and the vegetation as the most important ecological indicators.

Those karstic areas are adequate for microarea ecological studies that have been formed as the result of the interaction of external and internal environmental factors, but still represent autonomous dynamic units. The dolines of karstic areas satisfy these requirements since in respect of the microclimate determining the microarea ecofactors, they are considered as third-rate microclimate areas with independent heat ecologies.

Of the ecological components, the soil and the vegetation were minutely examined, but the peculiarities and change trends of the soil microclimate and of the biogenic processes in the soil will also be referred to, when necessary.

Tendencies to change in karstic soils

The properties of karstic soils are influenced by the fact that these soils are thick in karstic valleys and sink holes, while they form thinner or thicker layers on slope surfaces, depending on the angle of the slope.

On the surfaces with relatively little relief energy, the processes of redeposition go on vertically, while on sloping surfaces these processes are vertical and horizontal, depending on the inclination. On the slopes the processes of leaching and redeposition intensify, the aggresivity of the solvent water increases, which adds up in the depressions.

In the dolines of the Hungarian Bükk mountain clay soils, usually indicative of the dynamics of brown forest soils are the rule, with dark, often black, rendzina soils on the rock-extrusions and the northern exposures. Owing to the horizontally layered soil profile, the little soil depths, and horizontal (sloping) redepositional processes, in addition to elluvial and illuvial processes, good soil could not form here.

As regards its physical qualities, this soil consists of less classified sediment in terms of the finer soil components (warp, clay), and better classified sediment in respect of the larger components. This indicates that the soils are immature and unconsolidated, made up of solution residue to a larger, and of loess-like sediment to a smaller extent. The unconsolidated state allows a smaller degree of protection from erosional damages. Fine silt sand (0,1 mm - 0,02 mm ∅) makes up 50-60 per cent of the soil, with a great proportion of larger sand in it.

The organic matter content of the soils is generally high, but this is not utilised by the vegetation as a consequence of the slow mineralization of organic matter. Differences were detected in the humus contents of the northern and southern exposure slopes. On the northern exposure slopes the decomposition of organic matter is slowed down by a lower temperature and a higher soil humidity, while it is sped up by higher temperature and lower soil humidity on the south exposure slopes.

The soil pH, an important ecological indicator of the range of plant species, changes in direct proportion with the number of bacteria in the soil, and in an inverse ration with the humus content.

The pH was lower in the layers close to the surface than in the deeper levels; it was generally neutral or weakly acidic. The impermeability was high, which resulted in a good retention of water (Table 1 and 2).

An examination of the water-soluble anions and cations showed that the soil is well supplied with Ca^{2+}, K^{+}, and N ions, the quantity of Mg^{2+} ions being medium. Of the anions, the levels of HCO_3^- were high, but the Cl^- and SO_4^{2-} ion content was also significant.

It was observed that the Ca^{2+} and HCO_3^- contents were higher in the higher parts of the dolines than in the lower parts. This is the result of the ad-

Photo 2. The characteristic association of Hungarian karst dolines is the Nardo-Festucetosum ovinae, Nardetum strictae, association type of sub-alpine pastures.

Denotation of soil samples	Depth	pH (KCl)	Total salt %	$CaCO_3$ %	K_A	Tot. humus %	Zn	Cu	ppm Mn	Na	Mg	NO_3 NO_2	P_2O_2	K_2O	SO_2 SO_4
N_3	5 cm	6,08	0,02	0,1	71	5,04	4,9	3,1	273,8	36	144	9,3	15	128	12,8
N_3	30 cm	5,96	0,02	0,0	77	3,49	1,2	3,7	170,5	32	46	3,4	6	60	8,4
N_6	5 cm	5,51	0,02	0,0	68	5,02	4,9	2,7	297,2	31	133	9,2	14	133	13,7
N_6	30 cm	4,90	0,02	0,0	53	2,95	1,2	1,5	153,8	70	60	2,8	3	60	22,0
N_9	5 cm	5,30	0,02	0,0	66	4,99	4,4	1,7	208,3	37	209	5,1	13	238	16,2
N_9	30 cm	4,80	0,02	0,0	52	2,79	4,1	2,0	120,9	45	106	2,4	4	103	9,2
S_3	5 cm	5,80	0,06	3,6	62	6,24	14,4	2,6	143,4	45	212	28,5	270	317	37,4
S_3	30 cm	6,81	0,03	8,8	54	5,99	16,8	5,1	95,6	60	134	23,0	221	181	15,0
S_6	5 cm	6,84	0,02	2,9	81	6,12	16,3	5,7	143,4	42	196	19,6	122	270	27,8
S_6	30 cm	6,97	0,05	5,8	71	5,98	17,0	6,6	95,6	99	168	21,6	86	194	39,7
S_9	5 cm	6,78	0,04	3,3	75	6,20	18,1	6,2	224,5	39	196	25,8	89	216	19,3
S_9	30 cm	6,98	0,05	4,0	74	5,98	16,7	5,8	197,5	52	156	22,3	75	220	18,4
S_{12}	5 cm	6,73	0,04	2,0	80	6,37	17,4	5,5	197,7	47	302	32,8	69	279	28,4
S_{12}	30 cm	6,84	0,06	1,9	71	5,99	14,5	5,0	192,3	41	166	27,3	66	204	11,7
F_1	5 cm	5,18	0,02	0,0	81	5,47	14,9	3,7	296,3	42	288	37,3	97	607	20,7
F_2	30 cm	5,24	0,02	0,0	68	5,49	8,7	2,1	221,6	51	264	9,3	242	288	17,3

K_A = Qualifying numbers according to Arany S.
N_3, N_6 etc. = northern slope at the levels of 3, 6 etc. metres.
S_3, S_6 etc. = southern slope at the levels of 3, 6 etc. metres.
F_1 and F_2 = the bottom of the doline.

Table 1. Data of Basical Researches of Soil on the Northern (N) and Southern (S) Slopes and at the Bottom of Doline (Bükk Mountain, Hungary 1985)

Denotation of soil samples	Depth	pH (KCl)	Total salt %	$CaCO_3$ %	K_A	Tot. humus %	Zn	Cu	ppm Mn	Na	Mg	NO_3 NO_2	P_2O_2	K_2O	SO_2 SO_4
E_3	5 cm	5,54	0,02	0,0	73	5,08	6,2	3,1	303,6	54	198	11,8	16	187	16,6
E_3	30 cm	5,41	0,02	0,0	52	2,46	1,0	1,4	138,5	25	62	3,4	3	64	7,3
E_6	5 cm	5,55	0,02	0,0	66	5,16	11,0	7,3	361,8	29	199	11,4	13	151	10,1
E_6	30 cm	6,16	0,02	0,0	62	5,19	6,2	7,1	358,2	47	83	6,8	11	131	9,1
E_9	5 cm	6,25	0,03	0,5	81	5,69	16,4	8,1	360,9	31	189	23,9	33	177	21,3
E_9	30 cm	6,56	0,02	0,9	71	5,45	12,9	7,2	341,1	21	125	13,2	24	159	17,5
E_{12}	5 cm	6,39	0,03	0,5	74	6,07	17,4	6,2	356,6	54	218	31,3	51	227	32,2
E_{12}	30 cm	6,75	0,02	2,2	80	5,82	13,0	5,1	221,0	37	139	19,3	40	160	17,7
W_3	5 cm	5,66	0,02	0,0	70	5,07	9,5	3,4	347,9	25	230	18,3	15	159	15,9
W_3	30 cm	5,55	0,02	0,0	52	3,44	3,2	2,2	286,9	18	124	3,3	7	74	7,7
W_6	5 cm	6,32	0,02	0,5	68	5,24	15,6	8,2	369,6	27	200	9,9	19	261	13,3
W_6	30 cm	6,90	0,03	1,5	56	4,86	9,3	7,5	346,5	41	93	4,0	12	180	12,6
W_9	5 cm	6,85	0,03	3,6	66	5,29	15,9	8,0	291,7	36	180	23,1	33	439	26,6
W_9	30 cm	6,94	0,05	5,1	63	5,20	12,9	7,2	225,7	72	121	8,1	24	243	42,2
W_{12}	5 cm	6,99	0,03	5,5	78	5,53	15,5	6,5	221,4	46	197	27,4	45	357	22,6
W_{12}	30 cm	7,04	0,03	5,8	79	5,25	13,2	5,2	107,3	58	134	10,4	35	250	15,0

K_A = Qualifying numbers according to Arany S.
E_3, E_6 etc. = eastern slope at the levels of 3, 6 etc. metres.
W_3, W_6 etc. = western slope at the levels of 3, 6 etc. metres.

Table 2. Data of Basical Researches of Soil on the East (E) and West (W) Slopes of Doline (Bükk Mountain, Hungary 1985)

ded up effects at deeper levels of the water filtering in. The K^+ and Na^+, as the most frequently moving ions, remain at the bottom of the dolines in smaller quantities, naturally, which results in the acidification of the soil, while the Fe^{3+} and Fe^{2+} ions are abundant in the deeper parts, this also being an acidifying factor.

In the case of water-soluble anions and cations, we have compared the data for 1979 and 1984 from 38 places.

Of the cations, the amount of K^+ ions decreased in most places, but in several instances the quantity of Mg^{2+} ions also decreased. The amount of Na^+ ions increased, on the other hand, which impairs the physical and chemical properties of the soil. The increase of Ca^{2+} ions can be the result of the solution of $CaCO_3$ in the presence of SO_4^{2-} ions ($CaSO_4 \cdot 2H_2O$ being the result), and a simultaneous increase of Ca^{2+} ions. An increase of the SO_4^{2-} anions suggests the effects of acidic precipitation. At most places, however, the amount of HCO_3^- and Cl^- ions decreased.

The changes of the correlation between anions and cations were also examined in three years (1978, 1984, and 1985) (Table 3).

With the exception of Mg^{2+}, in 1978 there was a close correlation (R = 0,5 or more) between the amounts of the cations and the anions. It may be food for thought that this correlation could no longer be detected everywhere in 1984 and 1985. This was particularly true for the northern and western slopes (i.e. the southern and eastern exposures) of the dolines in 1984, where close correlation could be detected only in 2 or 3 places. In 1985 the correlation between the amounts of anions and cations was stronger on the northern slope (southern exposure). At the same places on the other slopes the correlation was loose between the Cl^- and SO_4^{2-} ions and the total cation content. The cause of the weakening of the correlation may have been the change in the soil composition as a consequence of the acidic precipitation, but this proposal needs further proving.

No earlier data concerning of microelements (Zn, Mn, Mg) being available for comparisons, the examination of these remains a task of the years to come.

Besides, and taken as a function of, the soils, we also examined the changes in the composition of the vegetation. Naturally, a few years are not sufficient for an examination like that, but still, with a knowledge of the tendencies of soil changes, the modifications in the indications of plant species, together with soil processes can indicate the changes to be expected in ecological values.

The characteristic association of Hungarian karstic dolines is the Nardo-Festucetosum ovinae, Nardetum strictae, which is the association of subalpine pastures.

We have compared the data from 1979 and 1985, with special regard to the species composition, domination, and plant ecological indication. In the examination of plant ecological indication we used indicators for heat balance (T), water balance

	HCO_3 1978	HCO_3 1984	HCO_3 1985	Cl 1978	Cl 1984	Cl 1985	SO_4 1978	SO_4 1984	SO_4 1985	
Ca	0,83	0,47	0,58	0,61	0,35	−0,66	0,73	0,17	0,83	NORTHERN SLOPE
Mg	0,31	0,37	0,78	0,16	0,35	−0,87	0,41	0,06	0,62	
K	0,53	−0,11	0,70	0,55	0,49	−0,70	0,58	0,64	0,72	
Na	0,72	−0,48	0,84	0,67	0,42	−0,60	0,73	0,89	0,48	
Ca	0,91	0,47	0,70	0,71	0,74	−0,28	0,60	0,75	0,29	SOUTHERN SLOPE
Mg	0,38	0,86	0,71	0,77	0,01	−0,41	0,83	0,31	−0,43	
K	0.94	0,91	0,28	0,71	0,11	0,37	0,94	0,22	−0,90	
Na	0,07	0,27	−0,47	0,74	0,71	0,88	0,81	0,75	−0,55	
Ca	0,94	—	0,99	0,46	0,54	—	0,22	0,75	0,31	EASTERN SLOPE
Mg	0,53	−0,56	0,84	0,63	−0,50	−0,20	0,56	−0,05	0,38	
K	0,81	0,29	0,72	0,46	0,49	0,47	0,20	—	−0,19	
Na	0,09	−0,85	0,92	0,68	0,10	0,01	0,73	0,88	0,46	
Ca	0,05	0,41	0,30	0,33	−0,35	−0,66	0,91	−0,07	−0,23	WESTERN SLOPE
Mg	0,15	−0,07	0,20	0,35	0,82	0,12	0,50	0,67	−0,57	
K	0,13	0,17	0,49	0,50	0,16	−0,16	0,85	0,40	−0,32	
Na	—	−0,14	0,63	0,18	0,96	−0,13	0,03	0,85	−0,31	

Table 3. Correlation coefficients between in water soluble anions and cations

(W), soil reaction (R), and nitrogen demand (N) (ZÓLYOMI, B. 1966), then ecological average numbers were calculated:

$$Tá = \frac{x_i \cdot y_i}{i \cdot n}, \text{ where}$$

Tá = the number of the average heat balance value for the found species,

x_i = the given ecological value,

y_i = the species number of the given ecological value,

n =the number of the found species.

The average value of the heat balance numbers calculated according to the relationship above is higher (5,5) than it was in 1985 (5,17), which means that in addition to the species characteristic of temperate zone deciduous forest climate, a few of the species of the submediterranean forest and the warm steppe climate could still be found in 1979, mostly on the northern and western slopes. The water balance indicator numbers ranged between 3,67 and 3,77 in 1979, and between 3,62 and 4,89 in 1985. In the latter year several species favouring higher moisture contents could be found in the dolines.

The average values of the soil reaction indicators range between 2 and 3, indicative of weakly acidic and nearly neutral soil reaction. This average

Photo 3. Afforested doline in the Hungarian Bükk Mountain. The age of the pine saplings are the same. The growing of pines is slowly in deeper part of doline because of the cold-airlake (Kaltluftsee).

value, however, on one hand, hides the presence of lime-favouring plant species, occurring with great frequency while, on the other, several plant species are neutral as regards the soil reaction. These two extreme values impair the chances of assessing the real situation. In both years the species that favour lime could be found in the greatest numbers in the dolines. During the seven years in question the average number indicating the value of soil reaction decreased a little, indicating, it is inferred, a shift of the soil pH in the acidic direction. The soil reaction average values of the occurring plant species indicate the tendencies of the soil change detailed earlier. Today the karstic sink holes contain more plant species, compared with 1979, which favour a neutral or weakly acidic soil pH.

The indicator number of the nitrogen demand (N) ranges between 0 and 3 in the area. Its value was 2-3 or 1-2 most of the time, which means medium nitrogen requirements.

On the basis of earlier data we also examined the association of a dolines planted with pine saplings, and it was possible to analyse the differences and similarities in the association compositions of an open, grass-grown, and an afforested dolines.

The planted dolines contained associations richer in species than the open dolines. The difference in composition is the consequence of the presence of the forest, which is closely related to soil ecological conditions.

We can sum up with the conclusion that even minor anthropogenic interventions (e.g. periodical mowing or pasturing) on the karstic surfaces with their restricted ecological features may lead to changes in the soil and the natural vegetation, and these changes, if coupled with the increasing effects of acidic precipitation, may have appreciable effects on the nature (character) of the processes of karstic corrosion proceeding through the soil.

All this should focus our attention on the future importance of microarea ecological research.

Literature

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