SOME DATA ABOUT THE PHYSICAL AND CHEMICAL PROPERTIES OF THE SOIL OF KARST DOLINES

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Inside a doline the differencies of karst corrosion processes considering their dynamics can be associated with the microclimate, that is to say, the differencies of intensity in biogen processes as a function of the above. (JAKUCS, L. 1971.)

The disproportioned development of karst dolines is tightly connected with the processes based on the interconnection and expositional differencies of the soil temperature, its circumstances of humidity, the vegetation existing on the surface of the soil and the soil flora.

In our former studies we have tried to illustrate the local differencies of these processes according to the number of bacteria, humidity and temperature of soil on the bases of samples taken from dolines in the Bükk Mountains. (BÁRÁNY, 1975., BÁRÁNY—MEZŐSI, 1977., BÁRÁNY—MEZŐSI, 1978.)

The intensity of biogene processes in influenced by the physical and chemical properties of soils to an important degree, but the latter is also effected by biogene transformations. We would like to make our former researches on dolines in this respect more accurate and complete on the bases of the study of soil samples taken from different expositions. The analysis included in itself the study of the data of basic researches and those of aqueus samples showing the effect of infiltrating water. At the same time the values of soil humidity were measured and the numbers of bacteria determined. Soil-samples were taken at the end of September, thus, of course, there are deviations in respect of the number of bacteria between the data of the samples taken in summer and those of taken in autumn, but there are recognizable tendencies on the different slopes. The soil samples according to our former practice were taken in a doline in Bükk Mountains at the four cardinal points, on levels of 3, 6, 9, 12, 15 metres and in the depth of 5 and 30 centimetres. By denoting the places from where the samples should be taken we took into consideration then points of measurements in our former studies on microclimate that is the places where soil tests determining soil humidity were made. It was reasonable to denote the samples taking places according to the above points of view since the change in soil properties on the different parts of the slope could be very well studied in this way as the falling rain infiltrates into the ground in the direction which corresponds to the slope bend. This is to say that the infiltrating water enriched with the eroded soil constituents increases the intensity of corrosion on the basic stones up to a certain levele, then reduces it.

Layers of the soil are thick only in the deep parts of doline at the level of 3 metres is 80—100 centimetres, at the bottom of the doline is 150 centimetres and on the slope is generally 50 centimetres or even thinner. This arrangement of layers is

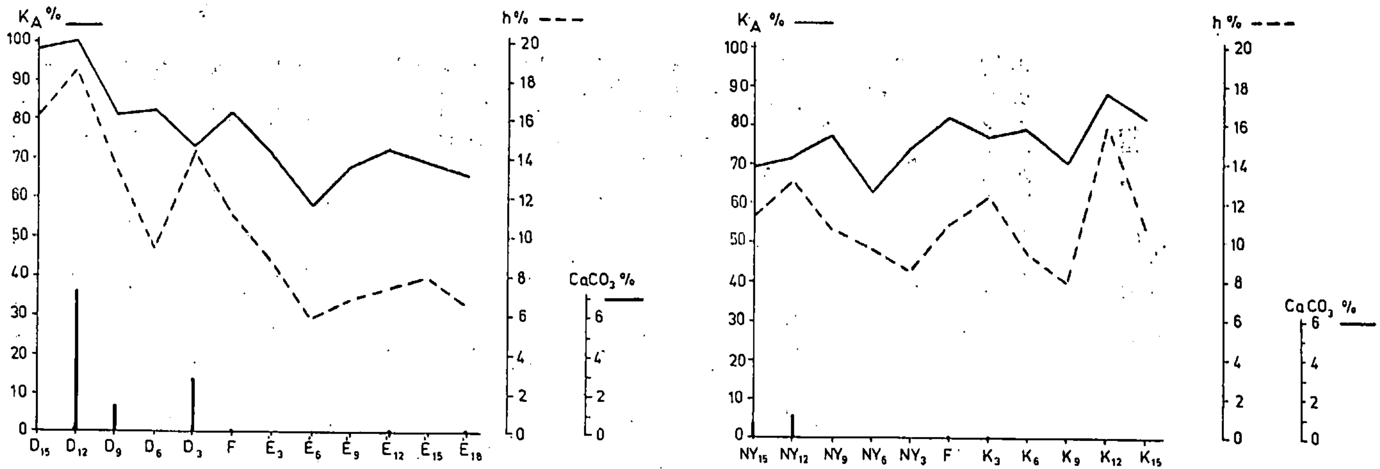

Fig. 1a. The humus and $CaCO_3$ content of the soil and the value of boundedness according toArany in the depth of 5 centimeter. K = boundedness according to Arany in %; h = content of humus in %. $CaCO_3$ = in %; F = the bottom of the doline; D_3, D_6 etc. = southern slope at the levels of 3, 6 metres; etc.; E_3, E_6 etc. = northern slope at the levels of 3,6 metres; Ny_3, Ny_6 = western slope at the levels of 3, 6 metres etc; K_3, K_6 = eastern slope at the levels of 3, 6 metres etc.

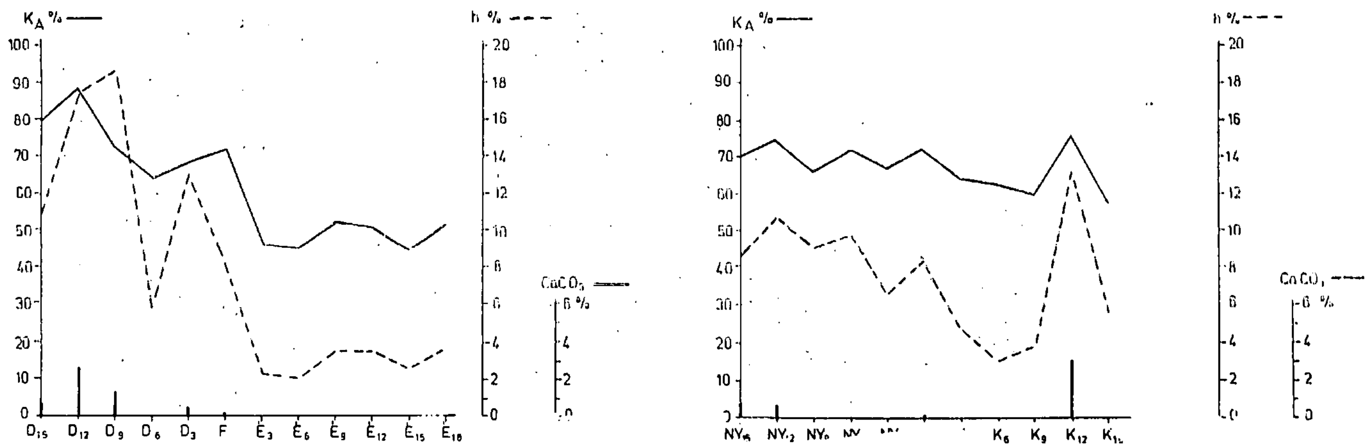

Fig. 1b. The content of humus and $CaCO_3$ of the soil and the value of soil boundedness in the depth of 30 centimeter. See explanation f d n i n n Fi u 1 .

predominantly a result of the surface-destroying activity of falling rain and that of the solifluctional motions. Summoning up our findings about the soils of the dolines we have found that the content of black soil, Ca^{++} and HCO_3^- is high compared to those of other soils. It is not unusual if we consider the lime-stone based clay soils since in the case of soils formed on a stone bases rich in Ca^{++}, as a result of moderate erosion the Ca^{++} content of the remaining debris is always higher. The erosion is reduced here by the high content of humus as well. This latter is closely connected with the extreme circumstances of microclimate in the microenvironment and its specific rock stepp vegetation. An intensiv rise in temperature and a strong cooling down result in extremities either in changes of the day temperature or that of the four seasons thus allowing only a slow and not complete change of the organic debris of the rather acidophyl vegetation.

Taking into consideration the individual slopes, the content of humus on the southern slope is relatively low. (See Fig. 1a, b.) Similarly to this at the level of 3, 6 and 5 metres of the eastern slope the content of humus is under 4% in the depth of 5 centimeter. There other places where the above value is much higher.

The soil of the doline can be determined as a clay soil taking into consideration the qualifying numbers according to Arany. There is clayish adobe soil only in the depth of 30 centimeter on the northern slope. The southern slope is a rather bound-soiled slope. Here, the value of soil-boundedness is generally higher than 60, but everywhere in the layer near the surface it is above 70. (See Fig. 1a, b.) Considering the fact of being bounded or not it can be assumed that erosion is slower on this slope but so is infiltration which obviously effects the intensity of corrosion of the ground stones and influences its reduction favourably. (The value of soil content is also very high besides the boundedness, especially in the soil layers of 5 centimeter near the surface). A similar boundedness can be found only on higher levels of the eastern slope. The slope angles are smaller on the eastern slope and on the less steeper side the erosion of soil constituents is of smaller degree than on the steeper slopes, therefore the soil is more bounded here.

In the case of humus content the western slope is rather similar to the southern one. The soil content is of the smallest value on the northern slope, here the soil is relatively the less bounded.

The smallest pH value on every level can be found on the northern slope in any depth. The soil, here, has slightly acid chemism: the values of pH are between 5—6. Whereas the reactions of soil on all the other slopes are near neutral (it can be seen especially on the southern slope): where the pH value is between 6 and 7.

The acid chemism does not have a favourable effect on the development of bacterium population (this medium influences more favourably the development of different sorts of mushrooms). Thus it is well understandable that high temperature, relatively humidity of soil and the values of pH between 5—6 altogether have the effect of the reduction of the number of bacteria. The content of $CaCO_3$ together with the degree of boundedness and the content of lime-stone in the soil are of the greatest value on the southern slope. Especially at the level of 6 metres the above content can be found only traces as well as the reduction in the humus content together with the boundedness. At higher levels of the western slope (at 12 and 15 metres) $CaCO_3$ has been found, although in smaller quantities.

Considering the percentage of all salts, there are no differencies between the content of salt on the individual slopes, because it is of 0.02% value everywhere.

Table 1. *Data of Basical Researches of Soil on the Four Main Slopes and at the Bottom of the Doline*

Denotation of soil samples	Depth	pH H_2O	$CaCO_3$ %	K_A	humus in %	Fe^{++} and Fe^{+++} mg/100 g
D_3	5	6.9	2.7	73	14.55	95.0
D_3	30	6.8	0.5	68	13.00	100.0
D_6	5	6.2	ny	82	9.40	145.0
D_6	30	6.3	ny	64	5.75	130.0
D_9	5	7.1	1.2	81	13.70	60.0
D_9	30	7.2	1.3	72	18.50	55.0
D_{12}	5	6.9	7.0	100	18.50	30.0
D_{12}	30	7.1	2.6	89	17.40	35.0
D_{15}	5	6.6	ny	98	16.20	65.0
D_{15}	30	7.1	0.6	79	10.70	80.0
$É_3$	5	5.6	ny	71	8.70	230.0
$É_3$	30	5.6	ny	46	2.38	230.0
$É_6$	5	5.4	ny	58	5.85	200.0
$É_6$	30	5.5	ny	45	2.10	180.0
$É_9$	5	5.8	ny	68	6.80	90.0
$É_9$	30	5.9	ny	52	3.50	90.0
$É_{12}$	5	5.8	O	72	7.40	80.0
$É_{12}$	30	5.5	ny	51	3.50	80.0
$É_{15}$	5	5.8	ny	69	8.00	85.0
$É_{15}$	30	5.8	ny	44	2.65	80.0
$É_{18}$	5	6.1	O	66	6.50	80.0
$É_{18}$	30	6.0	ny	51	3.75	80.0
F	5	5.6	ny	82	11.15	120.0
F	30	5.7	ny	72	8.35	120.0
K_3	5	6.0	ny	77	12.45	70.0
K_3	30	6.5	ny	64	4.75	80.0
K_6	5	5.7	ny	78	9.40	70.0
K_6	30	5.9	ny	63	3.05	65.0
K_9	5	5.8	ny	70	8.00	70.0
K_9	30	6,8	ny	60	3.90	80.0
K_{12}	5	6.5	ny	89	15.90	55.0
K_{12}	30	7.0	3.0	76	13.25	50.0
K_{15}	5	5.9	ny	82	10.50	60.0
K_{15}	30	6.4	ny	57	5.75	60.0
Ny_3	5	5.8	O	74	8.70	65.0
Ny_3	30	5.7	ny	67	6.50	70.0
Ny_6	5	6.1	ny	63	9.80	50.0
Ny_6	30	6.5	ny	72	9.80	45.0
Ny_9	5	6.4	ny	77	10.50	50.0
Ny_9	30	6.8	ny	66	9.05	60.0
Ny_{12}	5	6.6	1.2	72	13.25	45.0
Ny_{12}	30	6.9	0.8	75	10.90	45.0
Ny_{15}	5	6.8	0.7	69	11.65	35.0
Ny_{15}	30	7.0	0.8	70	8.55	35.0

ny = in traces
K_A = Qualifying numbers according to Arany

Studying the content of Fe^{++} and Fe^{+++} ions (See Table I.) it can be well seen that the Fe content is eroded to the bottom of the slope with the filtrating water on every slope. At the lower levels of the southern and northern slopes and at the bottom its value is over 100 mg/100 g and, what is more, at same levels of the northern slope it reaches the value of 200 mg/100 g as well. So, an accuumulation area can be found at the level of 6 metres where Fe^{++} and Fe^{+++} ions are accumulated. This tendency is also recognizable in the eastern and western cross-sections with a difference in the iron content which of smaller value at every level on the western slope. The iron accumulation is of greater value on the deeper bits as well.

Examining the number of anions and cations, which are soluble in water, it is noticeable that their quantity on the eastern slope is relatively small (See Fig. 2a, b, c, d.), similarly to that of observed at the bottom of the doline. There is a slight resemblance between the above ion content and the ion supply of the lower parts of the eastern slope (at the levels of 3, 6 and 9 metres). This slight resemblance can be a consequence of the intensive erosion here. The erosion of the already solved ions is of smaller degree at higher levels (12 and 15 metres) of the eastern slope, owing to the smaller slope angle.

The number of anions and cations is generally higher on the southern and western slopes, which fact can be associated with the higher content of black soil and $CaCO_3$. From among the cations, Ca^{++} and from among the anions, HCO_3^- are present in greater number. The occurance of Ca^{++} ions is connected with the basic stones and rocks. But in the case of HCO_3^- it is also of importance that the penetrability of clay soils is worse than that of loose soils, thus the escape of carbonic acid takes place slower. But while on the eastern and northern slopes and at the bottom of the doline the content of Ca^{++} and HCO_3^- is nearly the same compared to other ionic constituents, the above two ionic constituents are dominant on the western and southern slopes. The outstanding differencies can refer to differencies of dynamism in the biogene processes of the soil.

On the western slope the ionic content changes considerably from the level of 6 metres on downwards and at higher levels the content of Ca^{++} and HCO_3^- is of greater value than in the deep parts of the doline. This quantitative change can be noticed only at the level of 12 metres on the eastern slope. This important fact cannot be left out of consideration when studying the assimetric development of the dolines. The content of ionic constituents reduces considerably at the level of 9 metres, but this does not influence the content of Ca^{++} and HCO_3^-. Thus the infiltrating water does not erode the constituents so intensively on this unfavourably exposed part of the slope (due to lower temperature and higher content of humidity) thus the corrosive abilities of deep infiltrating water are also reduced. But nevertheless the rain water that returns to the surface has an indirect erosive effect at the higher levels of the slopes, while the infiltrating water at lower levels of the doline has already become much more erosive and can erode the soluble constituents more easily. Consiquently, here, the number of Ca^{++} and HCO_3^- ions is less, since they penetrated into deeper layers.

In the 5 and 30 centimeter depths of the doline's bottom the erosion is rather intensive and it is supposed to be more moderate indeeper layers of soil due partly to the erosion on both sides of the slopes and partly to the increasing boundedness of the soil. Most probably the intensity of corrosion on basic stones decreases because of the saturated solution.

The quantity of Cl^- and SO_4^{--} ions seems to be more or less similar on every xteeesop is noticeable that Mg^{++} ions are present among the ions to an important Ittnl..

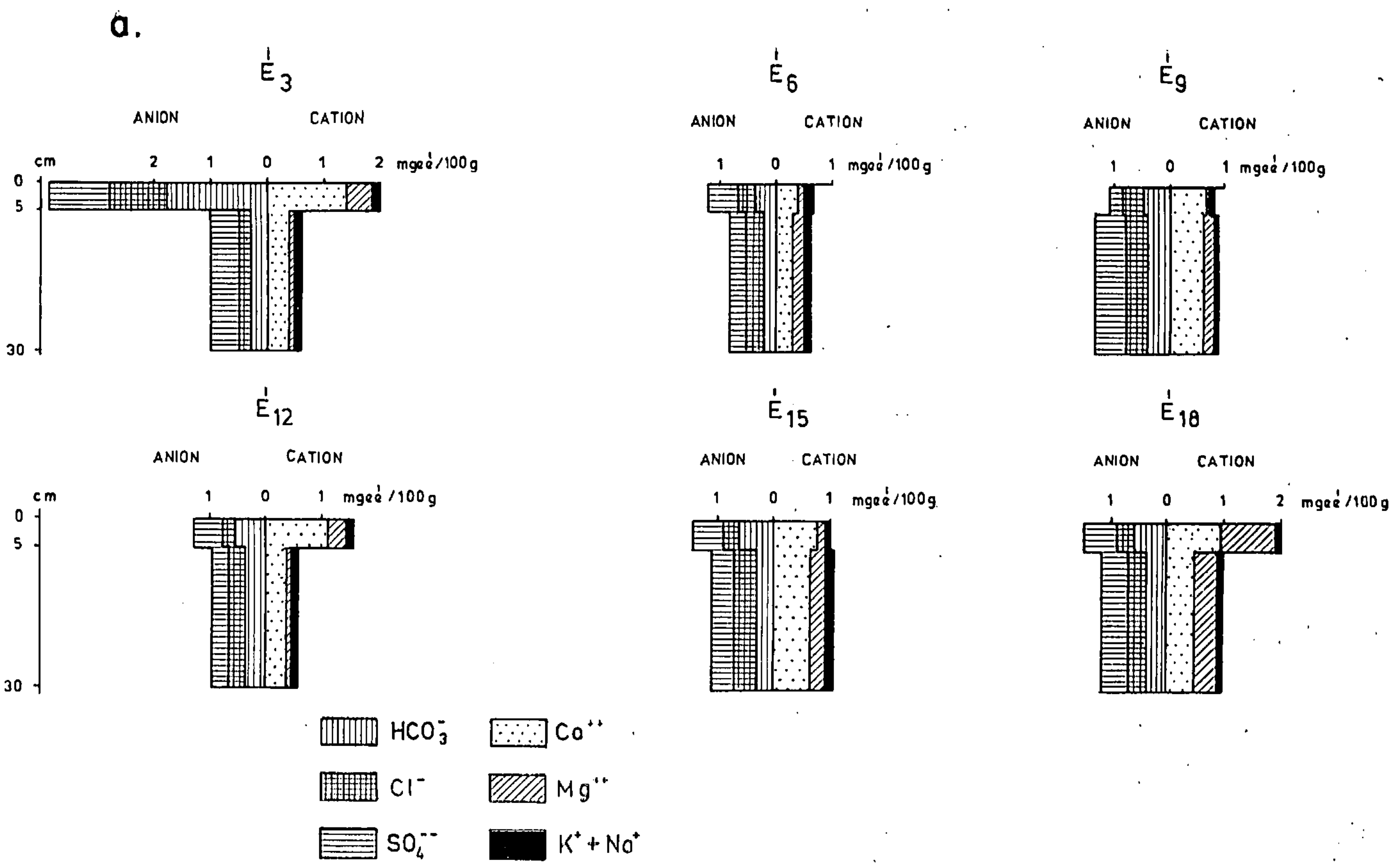

Fig. 2a. The number of anions and cations which are soluble in water on the northern slope. $É_3$, $É_6$ etc. = northern slope at the levels of 3, 6 metres.

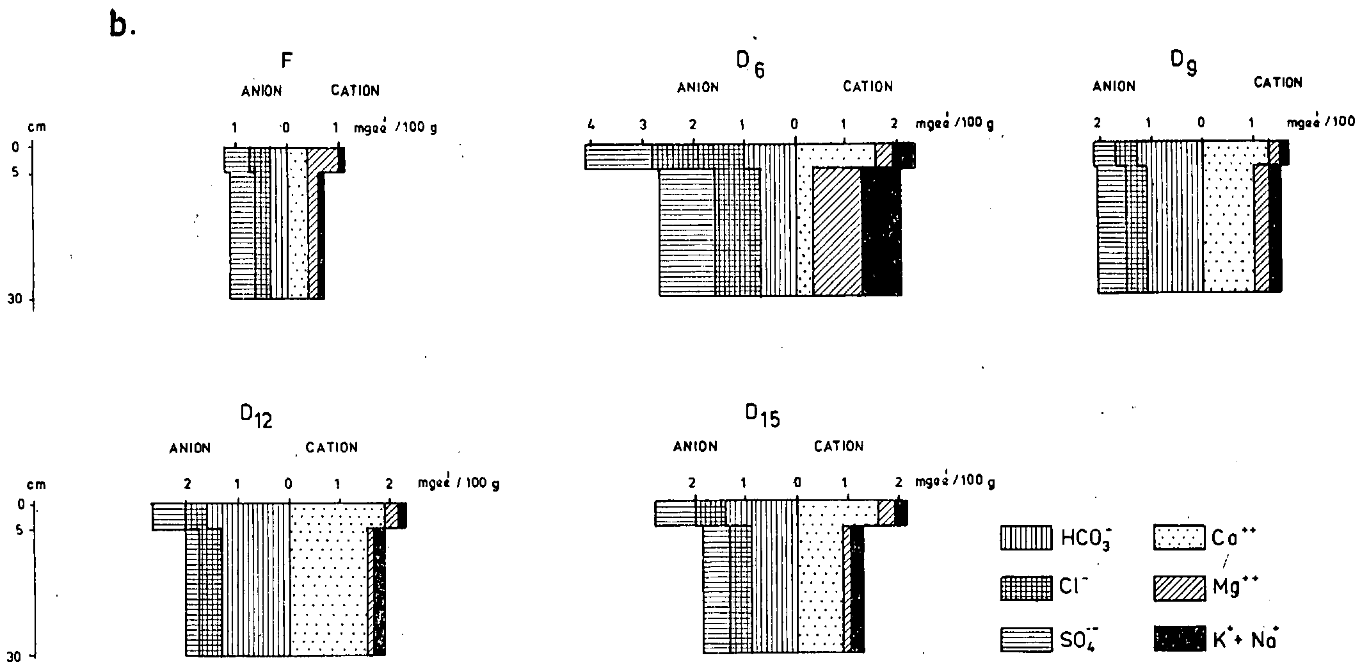

Fig. 2b. The number anions and cations which are soluble in water at the bottom of the doline and on the southern slope. F = the bottom of the doline; D_3, D_9 etc. = the southern slope at the levels of 6, 9 etc. metres.

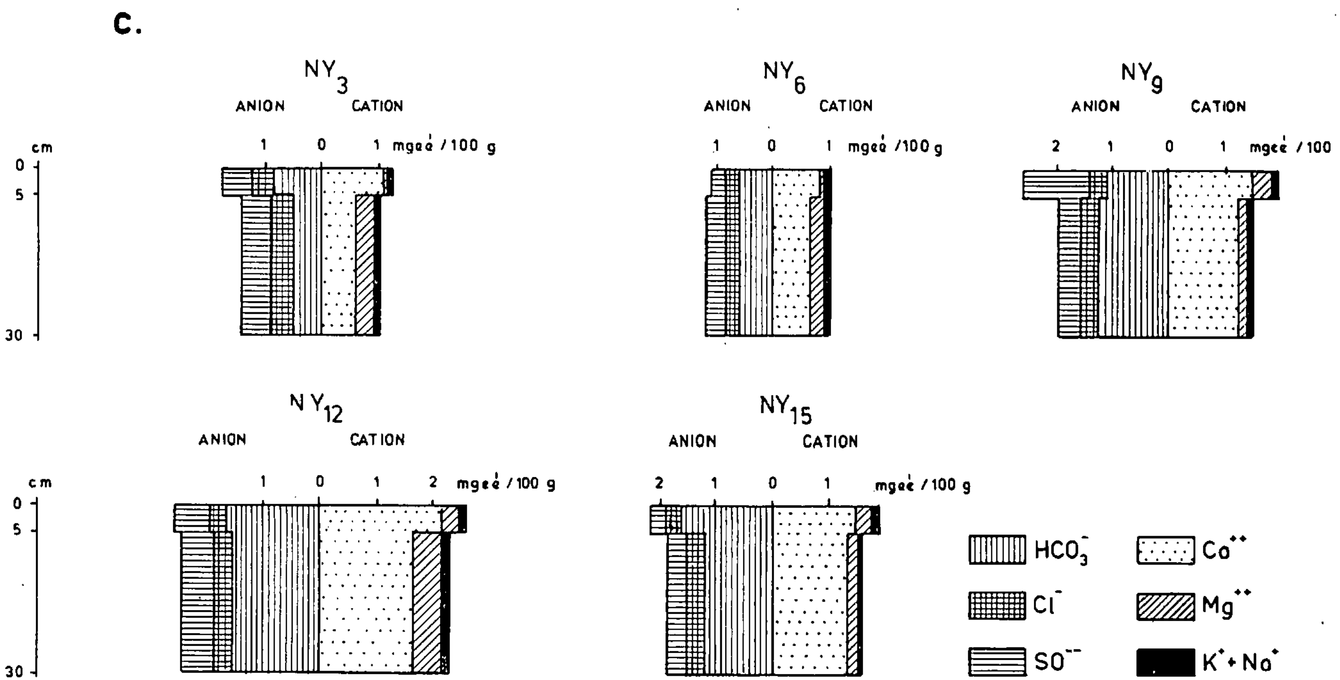

Fig. 2c. The number of anions and cations which are soluble in water in the western slope. Ny_3, Ny_6 = the western slope at the levels of 3, 6 meters.

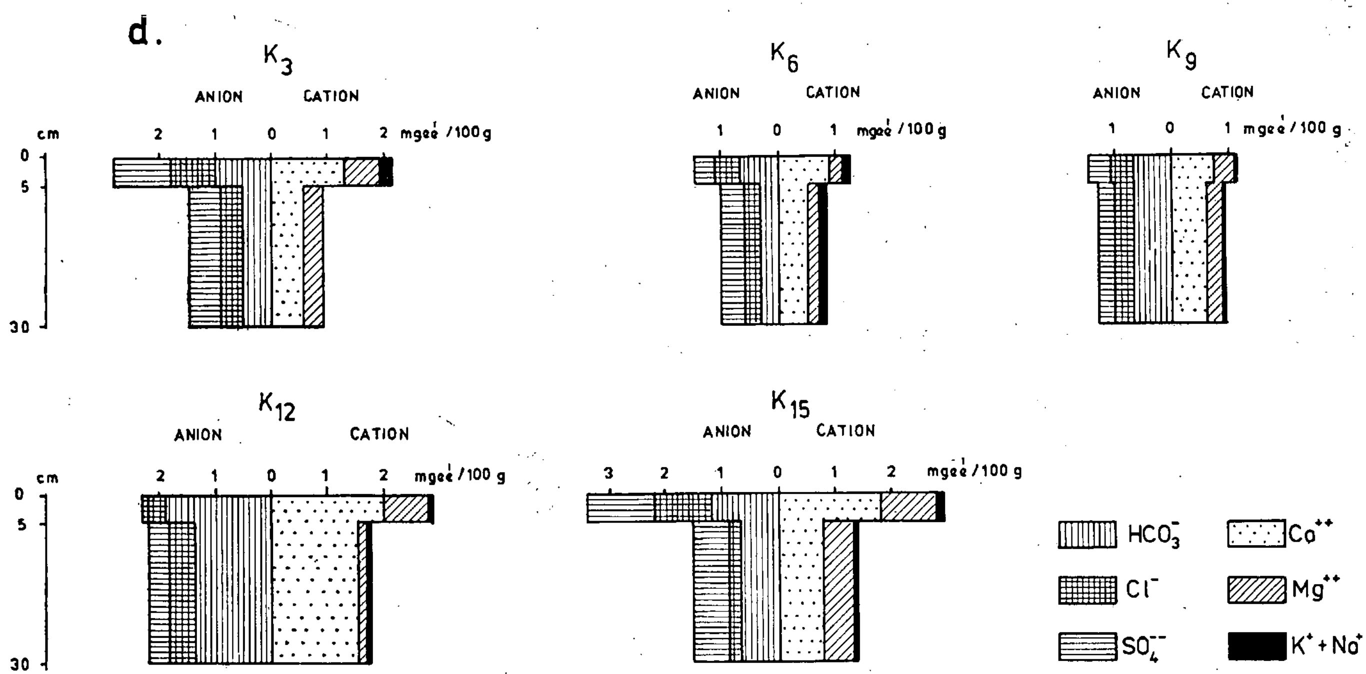

Fig. 2d. The number of anions and cations which are soluble in water on the eastern slope. K_3, K_6 etc. = eastern slope at the level of 3, 6 metres.

K^+ and Na^+ ions representing the fastest ions are present in smaller quantities in the soil.

It is clearly shown in the above analysis that in the corrosion processes of karst stones covered with doline soils, the content of $CaCO_3$ and humus in the soil together with the quantity of Ca^{++} and HCO_3^- from among the other ions altogether can result in local differencies.

If the number of bacteria and content of humidity on the different slopes is studied paralelly with the above data there is sure to be a connection between the latter and the chemical properties of soil. (See Figure 3a, b.)

The relatively high humidity of the soils on the southern slope (between 40—70%) and its higher pH values (between 6—7) favoured the growth of bacteria population especially in the depth of 5 centimeter of soil. Taking into consideration its absolute values, the number of bacteria is smaller in the depth of 30 centimeter but at the same time there is the minimal number of very high values on the different parts of the slope.

Naturally, final consequences on the genetics of the dolines can not be drawn purely on the basis of the absolute number of bacteria but these values can serve as important data from different points of view when analyzing and studying different slopes. It can be stated, thus, that the number of bacteria is rather high on the southern slope (northern exposition) from 3rd meter on downwards. Here, the pH value of soil is between 6 and 7 which together with the richness in humus and the high value of humidity promote bacterial activity. Inspite of the bound soil the high content of lime makes it possible that a good structure of soil be formed. Meanwhile the number of bacteria on the eastern slope (southern exposition) is low. There cannot be shown any significant differencies in the number of bacteria in the E—W direction. The only differencies can be noticed in the depth of 5 centimeter on the eastern slope and in the depth of 30 centimeter on the western slope where the number of bacteria is higher. This latter fact is undoubtedly connected with the smaller differencies in soil properties and those of microclimate. On the E—S direction in the respect of boundedness, content of humus and pH circumstances there significant differencies while in eastern-western direction the above differencies are more moderate.

Summerizing our results it has been found that chemical properties of soil differ from each other the most significantly on the eastren-southern slopes. On the southern slope (northern exposition) as an influence of less extreme climate changeability of biogen processes is also more moderate and the number of bacteria is evenly high. All these findings can be originated from the fact that high content of humus, Ca^{++} and ion constituents are eroded into deeper layers of soil in a smaller degree than on the other slopes and here the pH of soil is nearly neutral.

The more extreme microclimate of the northern slope has an effect on the composition of vegetation and the activity of soil flora. On this slope the content of humus and the value of soil pH are also smaller.

In east-western cross-section the change of chemical properties seem to testify our earlier findings considering the streching tendencies (north-western — south-eastern streching). In the west at the level of 6 metres, in the east at the level of 12 metres the ion composition is significantly changed but at higher levels ionic constituents remain in large quantities which favour the circumstances for further intensive erosion that is to say the circumstances for the consequently stronger errosive activity.

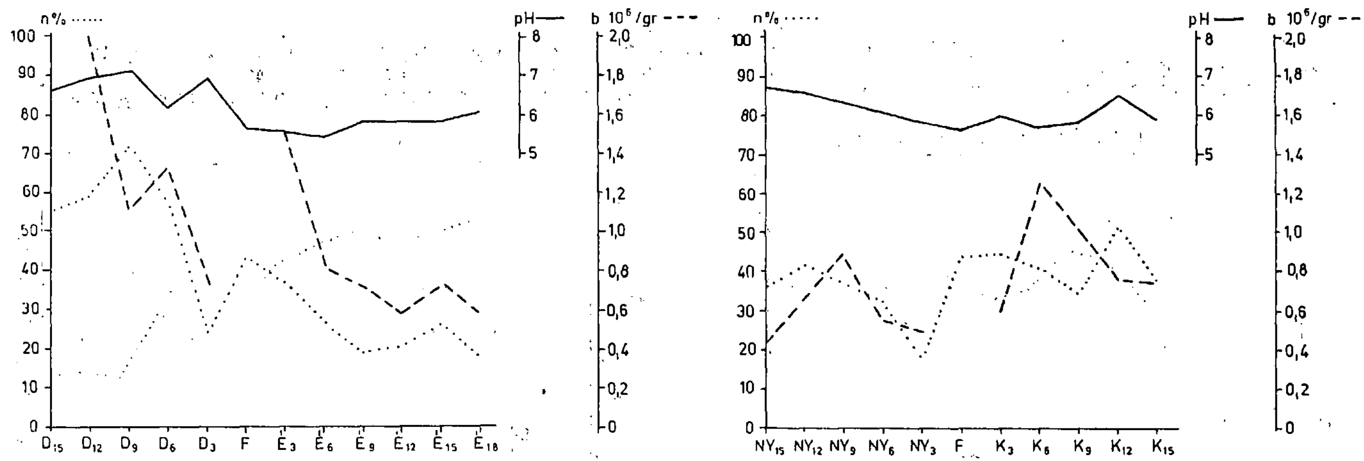

Fig. 3a. Distribution of soil moisture, bacterium count and the pH value at a depth of 5 cm. D_3, D_6 etc. = southern slope at the levels of 3, 6 metres etc. E_3, E_6 etc. = northern slope at the levels of 3, 6 meters; Ny_3, Ny_6 = wetern slope at the levels of 3, 6 meters etc.; K_3, K_6 = eastern slope at the levels of 3, 6 meters etc. F = the bottom of the doline. n% = soil moisture in %; b = bacterium count in 10^6/gramm.

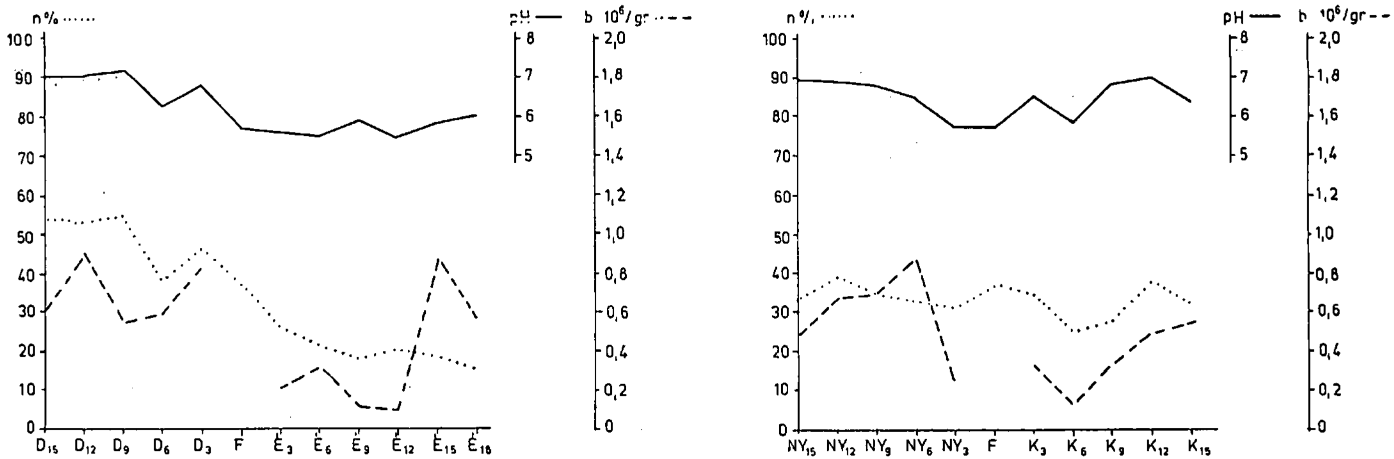

Fig. 3b. Distribution of soil moisture, bacterium count and the pH value at a depth of 30 cm. D_3, D_6 etc. = southern slope at the levels of 3, 6 meters etc.; E_3, E_6 etc. = northern slope at the levels of 3, 6 meters; Ny_3, Ny_6 = western slope at the levels of 3, 6 meters etc.; K_3, K_6 = eastern slope at the levels of 3, 6 meters etc. F = the bottom of the doline; n% = soil moisture in %; b = bacterium count in 10^6/gramm.

Naturally, the above local differencies in the chemical composition may vary or be modified in more dry or humid and either colder or warmer compared to the formelly observed and stated degrees and intensity. Nevertheless even the observations that have been made so far seem to provide us useful new points of view to get to know better the genetical properties and problems of unproportioned karst dolines. All these underline the importance and the further expansion of the researches that have already begun.

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