INTERRELATION OF SOME FACTORS OF KARST CORROSION IN A BÜKK DOLINE

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In our earlier investigations relating to the variations in the soil temperature (BOROS J. — BÁRÁNY I. 1975; BÁRÁNY I. 1975; BÁRÁNY I. — KAJDOCSY K. 1976) it was found that the heat levels on the various exposures in dolines exhibit differences in their vertical movement and in the temperature extremes. There are also differences with respect to exposure in the soil moisture content as a function of temperature, and in the interrelated microbial activity in the soil, which is an additional factor affecting the intensity of karst corrosion.

JAKUCS L. (1971) demonstrated this exposure tendency on the basis of the differences in the gaseous CO_2 levels of soils. He correlated the CO_2 production in the soil with the characteristic features of the various association types covering the soil, and at the same time pointed out that the variations in the CO_2 level are also influenced by the fauna and flora living in the soil, by means of their metabolisms.

Although not in microareas but in macro dimensions, NYIZAMETDYINOVA J. F., DADABAYEVA D. and PATTAKHOV N. (1971) studied the differences in the microflora of the soil with respect to exposure, and established that the quantitative and qualtitative compositions of the microflora are different on the northern and southern exposures. The number of bacteria is higher on the shaded, moister northern exposure than on the southern exposure (it is known from the work of BECK T. (1968) that the bacteria preferably live in wetter soil, and the fungi in drier soil).

In the present paper an examination is made of the interconnection of the soil temperature, the soil moisture and the number of microbes in a microarea of a Bükk doline, and an effort is made too to detect differences with respect to exposure. The doline examined lies in the Lusta Valley, west of the town of Miskolc, on the eastern part of the Bükk Plateau (φ=between 48° and 48° 15'; λ=between 20° 30' and 20°45') (see Fig. 1).

The thickness of the soil layer and the vegetation on it (by means of its transpiration and root respiration) affect the microbial activity, and a consideration of these factors is therefore indispensable. The greater part of the doline is covered by an association of Nardo-Agrostion tenuis (hilland meagre lawn), into which association fragments of limestone and dolomite rock-lawns are mixed on the steeper rocky parts. Tall-stemmed vegetation is to be found in the doline, with Rumex, Cirsium and Urtica species. A rich moss level appears on the nothern exposure.

With the exception of the examination site of the 3 m relative contour line, the soil layer is the thinnest on the eastern exposure, 50 cm at 6 m and at 9 m, and is strongly mixed with rock debris at the latter level. At 12 m the thickness of the soil

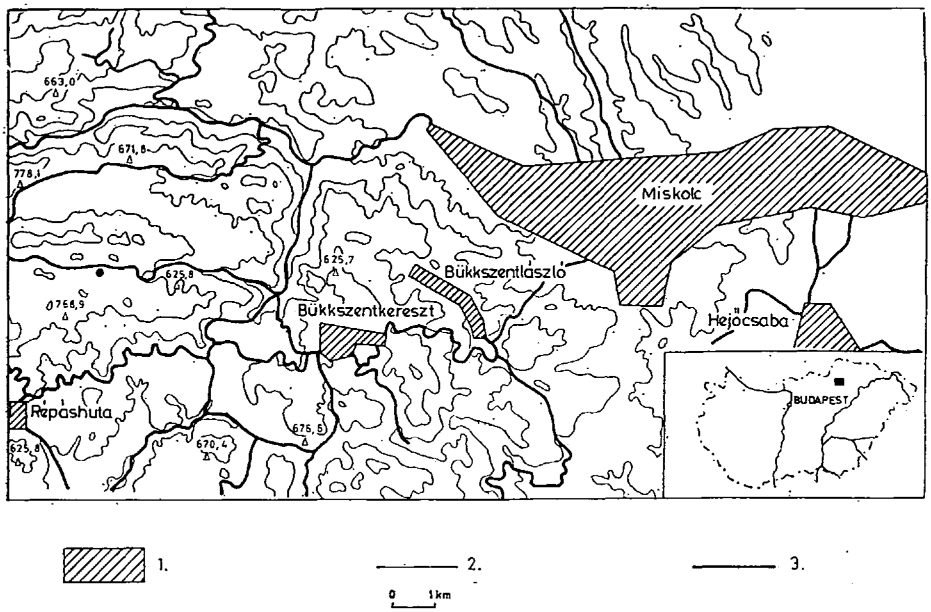

Fig. 1. Geographical location of the doline investigated.
1 = settlement; 2 = contour line; 3 = road.

is only 35 cm. On the other exposures it is 60—80 cm. At the deeper levels of the doline and at the doline bottom, soil layers thicker than 1 m are found. As regards its physical nature, the surface is covered by a crumbly, well-aerated soil.

The soil samples were collected from depths of 5 and 30 cm from the four exposures of the doline, on a sunny August day in 1976. The material destined for examination was de-aerated and transported to the laboratory under ice-cooling; there the moisture content and the microbe count were determined. The soil moisture was expressed as a percentage of the dry weight. The number of microbes was determined from serial dilutions (inoculated) by surface streaking on a culture medium. The resulting values are given in Tables 1 and 2. The temperature data are the mean temperatures for several bright August days, and are therefore only of an informatory nature (Table 3).

The closeness and direction of the connections between the individual factors (temperature, microbe count and soil moisture) were determined by correlation calculation. Where it appeared justified, the regression lines too were plotted. The examination was carried out first on 25—30 data relating to the whole doline.

The development of the bacterium population is controlled to a considerable extent by the soil temperature and the soil moisture. With the increase of the temperature and moisture, the microbe count too increases to the optimum. At a depth of 5 cm, the correlation coefficient for the connection between the bacterium count and the temperature is $R = 0{,}46$. The connection between the temperature and the moisture is essentially weaker at this depth. At a depth of 30 cm, however, the correlation

Table 1. *Distribution of the soil moisture in a Bükk doline on 9 August, 1976 (percentage of dry weight)*

Exp.	at a soil depth of 5 cm							at a soil depth of 30 cm						
	0 m	3 m	6 m	9 m	12 m	15 m	18 m	0 m	3 m	6 m	9 m	12 m	15 m	18 m
E	31,2	28,9	30,7	48,4	40,6	26,2	—	25,7	17,3	26,0	42,3	31,7	19,5	—
W	31,2	45,0	31,3	36,9	55,8	40,7	—	25,7	24,9	19,6	27,2	51,0	37,4	—
S	31,2	24,4	30,6	28,3	31,9	20,6	28,0	25,7	17,8	14,4	13,4	12,5	13,2	20,6
N	31,2	45,6	39,2	41,8	—	—	—	25,7	23,7	22,6	21,9	—	—	—

Table 2. *Distirbution of the aerobic microbe count in a Bükk doline on 9 August, 1976 (10^6/g soil)*

Exp.	at a soil depth of 5 cm							at a soil depth of 30 cm						
	0 m	3 m	6 m	9 m	12 m	15 m	18m	0 m	3 m	6 m	9 m	12m	15m	18 m
E	4,0	1,6	1,7	9,1	1,3	1,0	—	5,2	11,0	1,9	4,3	0,8	0,4	—
W	4,0	2,1	1,5	1,4	2,1	1,0	—	5,2	2,3	1,6	1,2	1,9	1,5	—
S	4,0	3,4	1,5	1,4	4,1	2,0	1,1	5,2	0,4	1,4	0,5	0,6	1,7	2,9
N	4,0	4,0	0,8	0,5	—	—	—	5,2	1,9	1,7	0,7	—	—	—

Table 3. *Variations of the daily mean temperatures on the different exposures of a Bükk doline* (°C)

Exp.	at a depth of 5 cm					at a depth of 30 cm				
	0 m	3 m	6 m	9 m	12 m	0 m	3 m	6 m	9 m	12 m
	Average of daily mean temperatures for 31 July, 2, 7, 14, 15, 18 August 1971									
E	—	18,2	18,7	18,3	17,8	—	17,1	16,3	15,6	16,0
W	—	19,6	17,7	16,7	18,5	—	17,1	15,8	15,9	17,1
	Average of daily mean temperatures for 2, 3, 4, 5, 6, 7, August 1969									
S	17,7	—	19,1	19,4	18,9	15,9	—	17,3	16,1	16,7
N	17,7	—	16,1	15,3	12,2	15,9	—	15,0	14,1	11,6

coefficient for the moisture and the bacterium count is the higher (R=0,42), the connection with the temperature being very weak here. (Both correlation coefficients differ significantly from 0.) All this is related to the fact that the development of the bacterium population is affected in the soil layer close to the surface by temperatures exhibiting larger, extremes and at a depth of 30 cm by the less variable moisture content.

The regression curves (in our case straight lines) of the temperaturer vs. moisture and temperature vs. microbe count regression functions were drawn for a depth of 5 cm (see Fig. 2). The Figure indicates that the temperature optimum for which development of the bacterium population is most certain is found at 23,4 °C. At this temperature the soil moisture content is ca. 20%, and the microbe count is $3{,}9\times10^6$/g. The scatter was taken into consideration, and this optimum point was extended into an optimum range. This range can be given here with temperature values of 22,2—

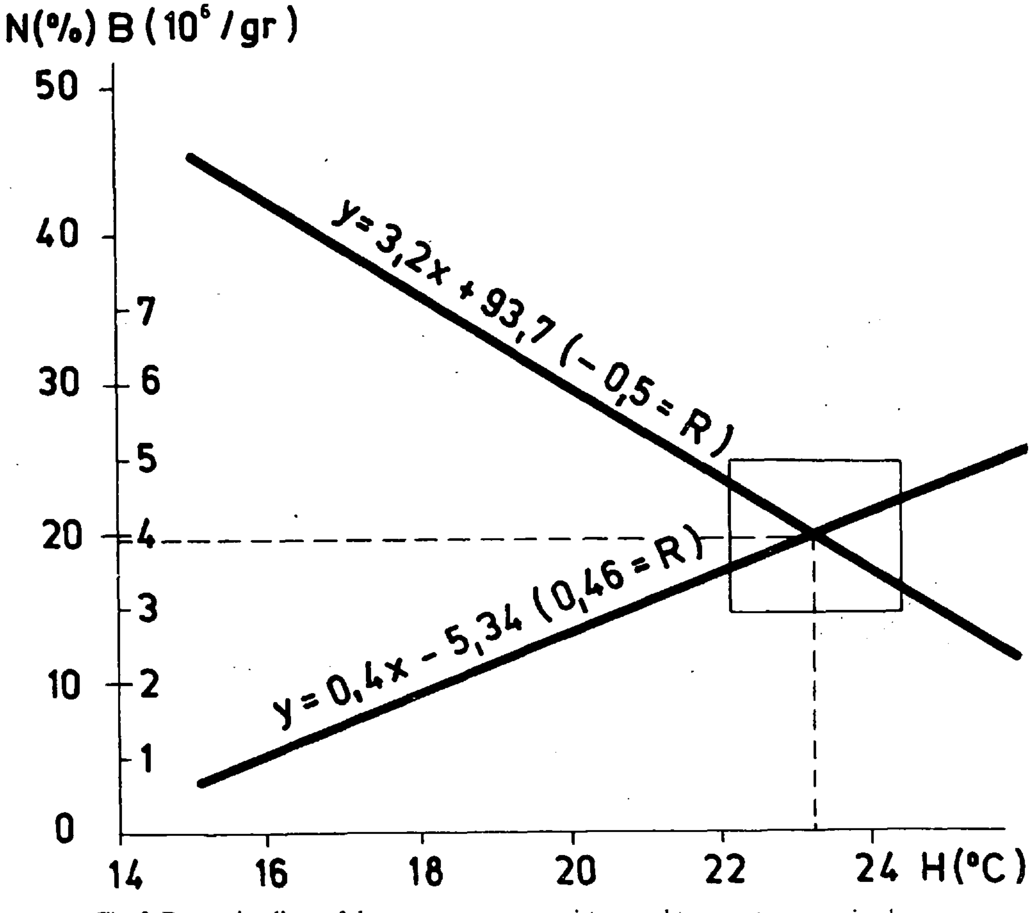

Fig. 2. Regression lines of the temperature vs. moisture and temperature vs. microbe count functions. N (%)=soil moisture; B (10^6/g)=microbe count; H (°C)=temperature.

24,6 °C, moisture contents of 14—25%, and microbe counts of $3\times10^6-5\times10^6$/g. The appreciable decrease of the soil moisture at a higher temperature has an unfavourable effect on the development of the microbe count.

Fewer data (in general 10) were available for analysis of the differences with respect to exposure, but the tendencies can be well demonstrated. Figures 3 and 4

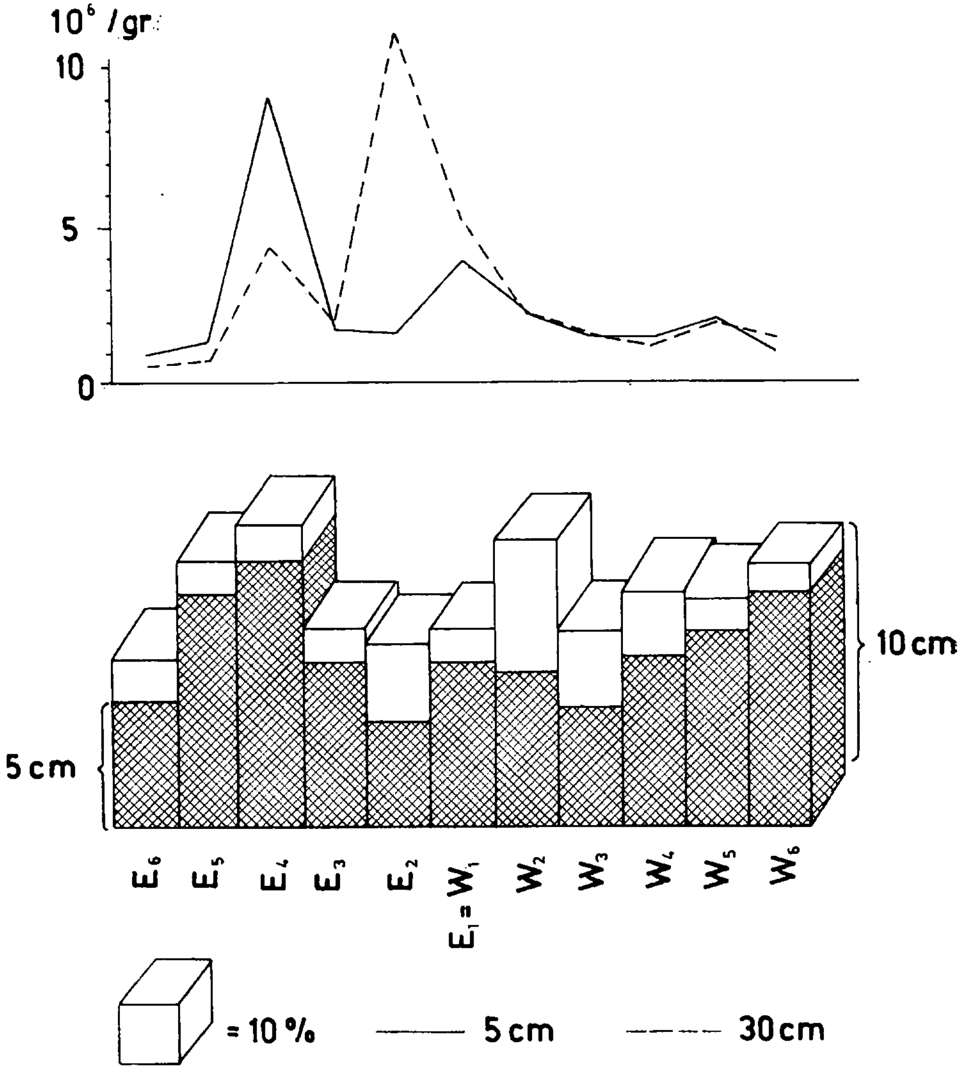

Fig. 3. Variations of the soil moisture and the aerobic microbe count on the E and W exposures. $E_1 = W_1$ = doline bottom; E_2—E_7: 3, 6, 9, 12, 15 and 18 m on E exposure; W_2—W_7: 3, 6, 9, 12, 15 and 18 m on exposure.

show the moisture values and the bacterium counts on four different exposures. The moisture and bacterium count vary in a characteristic manner on the eastern exposure. From the 3 m to the 9 m contour line the soil moisture increases, and above this decreases. On the other exposures of the doline the moisture content of the soil decreases from the deepest level to the middle of the slope, and subsequently increases. At depths of both 5 cm and 30 cm the microbe count is highest on the eastern exposure

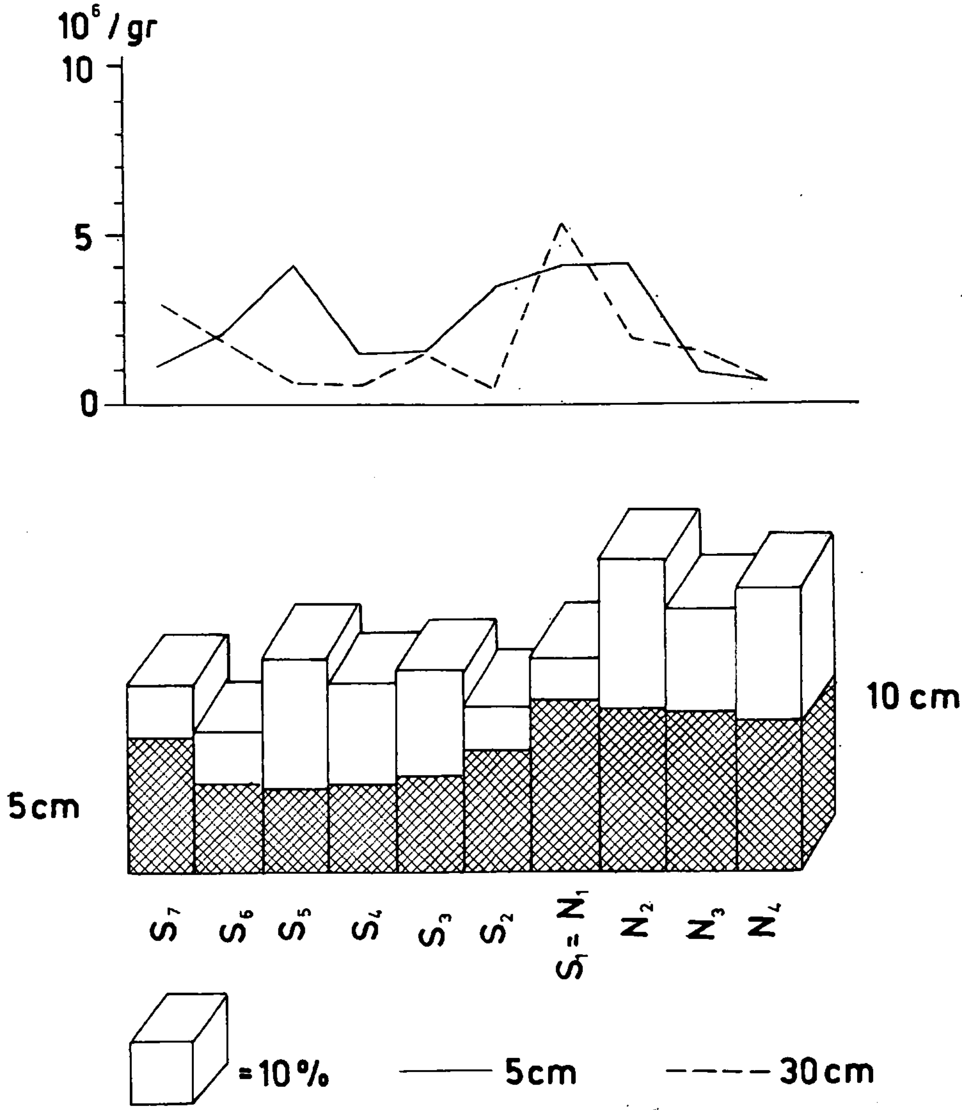

Fig.4. Variations of the soil moisture and the aerobic microbe count ont he S and N exposures. $S_1 = N_1$ = doline bottom; S_2—S_7: 3, 6, 9, 12, 15 and 18 m on S exposure; N_2—N_4: 3, 6 and 9 m on N exposure.

The exposure-different nature of the moisture content is exhibited undisturbed at a depth of 30 cm, since the soil moisture is prevented from becoming constant at a given level by the daily convection precipitation (in the midday and early afternoon hours) in the layers near the surface. In the vicinity of the surface the moisture also varies more rapidly than at deeper levels as a consequence of the evapotranspiration.

The characteristic daily courses of the temperature and the evaporation (early temperature and evaporation maxima, in general with lower values than on the western or southern exposure (do not result in such an extensive drying-out of the soil as on the western or southern exposures. In the course of the bacterium count determination, in harmony with the soil moisture, outstanding data were found for the 9 m contour line on the eastern exposure. At a depth of 5 cm, the bacterium count is $9,1 \times 10^6$/g, but even at a depth of 30 cm it is $4,3 \times 10^6$/g. Determination of the bacterium count still requires further control examinations, but this tendency with regard to the exposure must be accepted.

In the interrelation fo the bacterium count and the moisture, a similar tendency can be observed on the northern exposure, but here the quantitative proportions of the bacterium population are moderated by the lower nature of the temperature, and presumably by its daily course.

Both close of the surface and at a depth of 30 cm, the soil moisture percentage is lowest on the southern exposure, and this leads primarily to a decrease in the bacterium counts at deeper levels on this exposure.

When a study is made of the 5 cm soil layer adjacent to the surface on the various exposures, in addition to the correlation of the temperature and the moisture ($R = -0,60$), there are also close correlations between the moisture and the bacterium count ($R = 0,79$) and between the temperature and the bacterium count ($R-0,74$) on the eastern exposure. At a depth of 30 cm, these correlations are essentially weaker. The temperature optimum of the population here, determined with the aid of the regression lines, is at ca. 18 °C; this is associated at this depth with a soil moisture of ca. 30%.

Although the microorganisms develop under more constant ecological conditions at a depth of 30 cm, the characteristics are nevertheless more favourable in the case of the more rapidly variyng environmental factors (temperature, precipitation different intensities of evaporation) in the vicinity of the surface.

In the 5 cm soil layer on the western exposure there is no correlation between the moisture and the bacterium count, but the value of $R = -0,74$ for the correlation coefficient between the temperature and the bacterium count indicates an interrelation equivalent to that on the eastern exposure. In our previous publications it was pointed out that the soil is heated up more strongly here, and on proceeding upwards on the slopes the maxima are higher than on the other exposures; this leads to an enhanced drying-out of the soil, as a result of the increased evaporation. The heating-up is the most prolonged here, which gives an explanation for the lack of a moisture correlation.

Too few data are available for the southern exposure, and thus the correlation can not be evaluated mathematically.

It may be stated, therefore, that on the eastern exposure the temperature and the. moisture are in close correlation with the number of bacteria in the 5 cm soit layer next to the surface. On the southern and western exposures the bacterium counl is in close correlation with the temperature.

In the soil layer adjacent to the surface the number of microorganisms is determined predominantly by the temperature, whereas at a depth of 30 cm their number depends primarily on the soil moisture content.

On the above basis, it becomes understandable that the more intensive course of the dissolution processes is favoured by the characteristic temperature and moisture conditions of the soil on the eastern exposure, and by the microbe population there, which depends on these factors.

These results are in agreement with experimental data on the soil atmosphere composition (morphology of karsts) obtained in the Bükk in 1968, and throw new light on the theses of JAKUCS L. (1971) relating to the morphogenetics of karst dolines with asymmetric ground-plans and varying slopes.

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