FURTHER DATA CONCERNING THE MORPHOGENETICAL EVALUATION OF KARST DOLINES IN BÜKK

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In the case of the greater number of karst dolines in the Bükk region of Hungary the vegetal covering varies. Some are tree-covered, some are covered by mixed vegetation, but most are grass-covered. In the case of the latter, elements of undergrowth are often involved in the association of highland meagre lawn and limestone rock-lawn. Their presence in the alien environment suggests that earlier (perhaps some centuries ago) these dolines were covered by forest. The change in the vegetal picture has affected and is affecting the courses of relief-development.

As an effect of tree-planting or re-afforestation the microclimate of the dolines changes, physical, chemical and biological courses are modified in the soil: thus, as a compound effect of all this, the rate of karst corrosion occurring in the soil is modified, too. It is obvious that anthropogen interference upsets the natural balance; it might induce positive or negative reactions. Forestries in Bükk tend to plant the open, grassy areas, without, however, obtaining uniformly satisfactory results since the soil and climate vary in the micro-areas. It is the same in the case of dolines, too, since on slopes of different character conditions also differ. While in former studies (BÁRÁNY, 1975, BÁRÁNY–KAJDÓCSY, 1976, BÁRÁNY–MEZŐSI, 1977) this problem was examined from the point of view of the development of the dolines, in the present paper the study will be extended – in close connection with the former studies – to the possibilities of afforestation.

The Bükk dolines which have been examined hitherto are to be found in the Great Bükk Plateau at an altitude of 700 m above sea-level (average altitude). This time a synthesis of 30 dolines was carried out in the Little Bükk Plateau (average altitude: 450 m above sea-level) where there are a great number of dolines relative to the size of the area. In order to analyse the connection between moisture and bacteria-population 2 out of the 10 "Soros"-dolines were chosen. The "Soros"-dolines are situated south of Varbó (see fig. 1.). One of them, called hereafter S–2 doline, is one of a doline compound, the greatest relative height-difference being 10 m. This doline was chosen because it seemed to the least distrubed by human interference of the "Soros"-series of dolines, although young pines were found on the entire area of the southern slope in strip cultivation. On the other slopes and at the bottom of the doline natural soft-stemmed vegetation was dominant. In the middle of the northern slope (at the 6 m level) a few natural groups of bushes were found. The whole of the western slope was scattered with bed-rock and bushes could be found on the brim of the doline. The doline is oval, lying north-west to south-east.

The relative depth of the other doline, called hereafter S–4, is 14 m. It is also oval, lying north-west to southeast. The entire doline is covered by pine-woods in

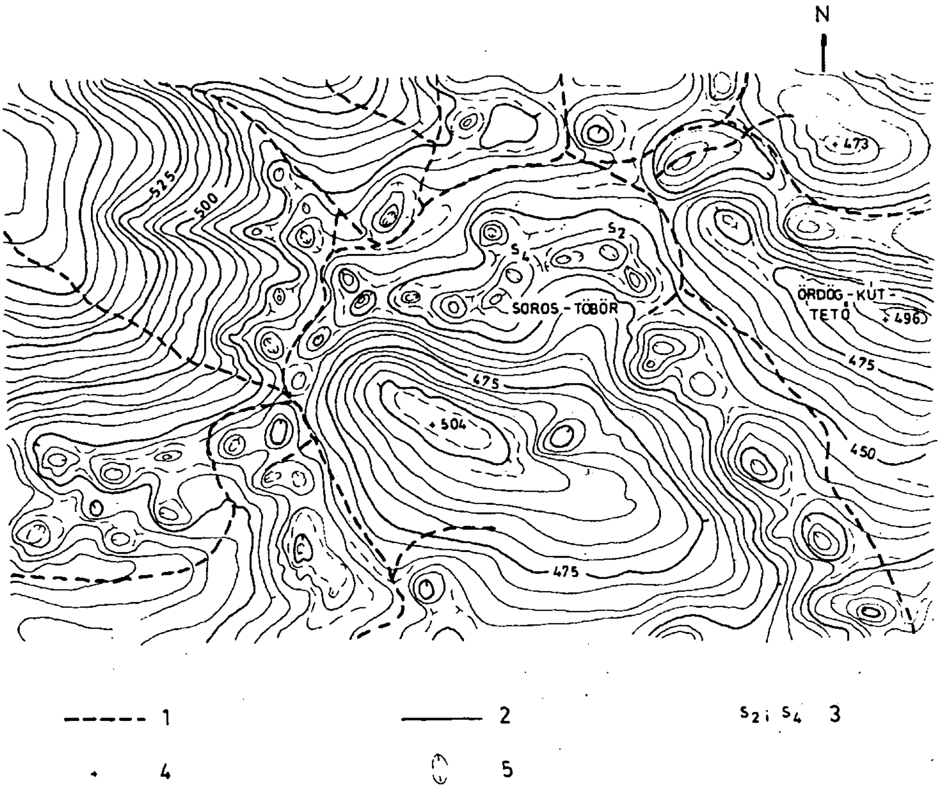

Fig. 1. Geographical situation of the examined dolines
1 = contour line, 2 = path, 3 = examined dolines, 4 = point of altitude, 5 = sink-hole.

strip cultivation. On the western slope at the 4m level a steep rock wall emerges for some metres. On the less steep parts, as well as on the eastern, southern and northern slopes, a fragment of long-stemmed association is mixed with the young pine trees.

The soil samples which were to be examined for moisture and bacteria-count – in accordance with previous experiences (BÁRÁNY–MEZŐSI, 1978) – were collected from the slopes of the four cardinal points at 3m grade differences and were transported for analysis to the laboratory with the air removed. At the same time as the samples were taken the temperature of the soil was taken at the two depths at which the samples were taken (4 and 30 cm) at the 6 m level on all four slopes. We have a double aim in analysing the data. On the one hand we should like to enlarge on the results we have previously achieved in the field of differences in denudation. On the other hand, by revealing the expositive differences in soil-moisture and bacteria-count as well as those of soil-temperature, we should like to evaluate the modifications, differences which result from different ecological relations. Obtaining data proved to be difficult in some cases because of the rocky surface, so the data do not form a complete series.

Connection between soil moisture and bacteria count

It has been documented by previous data that the connection between soil-moisture and bacteria count is in close correlation at a depth of 30 cm. The closeness of the connection of the two factors – as was described in a previous paper (BÁRÁNY–MZŐSI, 1977) – changes at a depth of 5 cm as a function of the soil-temperature. By analysing the data of the S-2 and S-4 dolines our former statements referring to exposures will be reinforced; on the other hand we should like to describe the changes which result from different ecological conditions and the modiffcation which result from the changes.

Moisture-content (expressed as a percentage of the weight of dry soil) and the relevant bacteria-count (at a value of 10^6/gram) are shown on a mirror diagram (see figs. 2,3).

The temperature of the soil at the time of taking the samples (in the morning of 13 July, 1977), the highest being on the western slope (eastern exposure) was: 16.8 °C at a depth of 5 cm, 15.1 °C at a depth of 30 cm; the values for the eastern slope were 15,1 °C and 14.7 °C; the northern slope 16.2 °C and 14.9 °C, on the southern slope, 16.3 °C and 13.3 °C .The value of soil-moisture in the case of both dolines at a depth of 5 cm is higher on the southern slope (northern exposure) and on the western slope (eastern exposure) than on the other two slopes. As can be seen, the bacteria count is very high, too, at his depth. At a depth of 30 cm the bacteria count is higher on these two slopes, too, however it should be mentioned that here the accidental high values are more frequent than on the other two slopes. Soilmoisture has the same values on the eastern and northern slopes at depths of 5 and 30 cm. The soil was moister at a depth of 5 cm than at a depth of 30 cm. As is the case with the western slope of the S-4 doline (eastern exposure) the value of soil-moisture increases to half-way up the southern slope of the S-2 doline (northern exposure). After that point the moisture decreases. In accordance with prevrious experiences w th tree-covered dolines, iso-humid lines divide the doline into two parts in a north-west to south-east direction, thus emphasizing the continental character of the eastern and northern slopes. A significant connection was found between moisture and bacteria count ($r = +0.71 \pm 0.05$) at a depth of 5 cm in the case of the S-2 doline. The same connection cannot de demonstrated mathematically at a depth of 30 cm. A slight, but significant, connection was found at a depth of 30 cm in the case of dolines which had been disturbed by young trees. The development of a mutual connection was disturbed by the breaking up of the soil and the immediate effect of shade in the part near the surface (at a depth of 5 cm).

Exposure differences in soil temperature

Vegetation which covers the surface of the dolines and the quantitative and qualitative characteristics of bacteria population in the root-zone are in close connection with the climatic conditions of the micro-region. The ecological factor which defines biogen activity primarly, the temperature of the soil which varies on a wide scale in slopes of different exposure, have a decisive effect on the development of the dolines. In a previous analysis (BÁRÁNY–KAJDÓCSY, 1975), attempts were made to demonstrate the exposition tendencies of soil-temperature. Wagner (WAGNER–

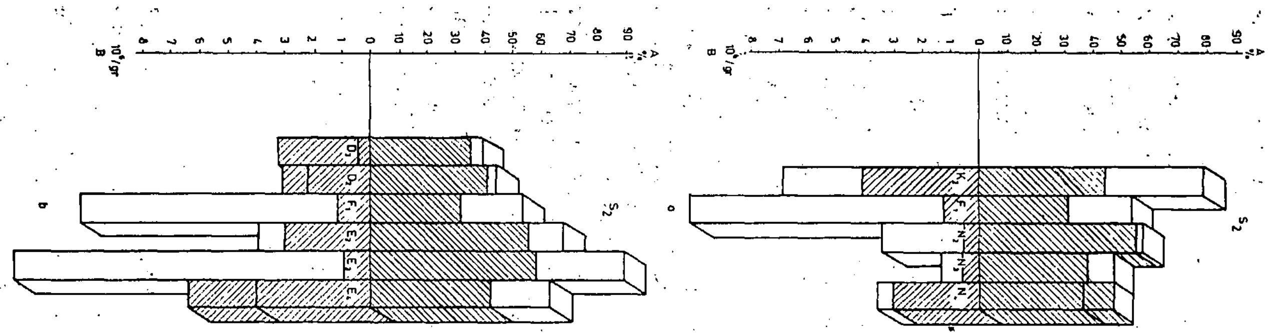

Fig. 2. Distribution of moisture and bacteria count along the E—W (a) and N—S (b) lines at every 3 metres in the S—2 doline

F_1 = bottom of the doline, N_2, N_3, K_2, etc. in the W and E exposures, E_2, E_3, D_2, D_3, N and S exposures data gained at every 3 metres, in both causes measured from "O". If the lined part means covers the blank part, the letter is separated by an inner dividing line. The lined part means a depth of 30 cm, the blank part means a depth of 5 cm. A = soil moisture (dry weight %) B = the aerob vateria count (10^6/gr.).

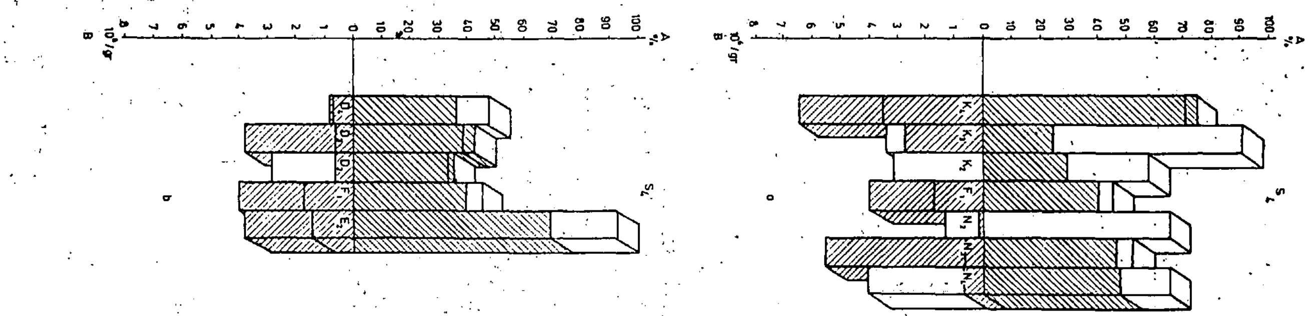

Fig. 3. Distribution of moisture and bacteria count along the E—W (a) and the N—S (b) line of the S—4 doline at every 3 metres.

F_1 = bottom of the doline N_2, N_3, K_2, K_3, etc. are data obtained on the W and E exposure, E_2, E_3, D_2, D_3, N and S exposures at every 3 metres. The lined part means a depth of 30 cm, the blank part means a depth of 5 cm. A = soil moisture (dry weight %) B = aerob bacteria count (10^6/gr))

TAKÁCS, 1976), while examining the zones of soil temperature, used the term "inversion layer". This is the layer in which be convergence and divergence levels of thermal conduction occur daily and which, on the basis of former investigations carried out in Bükk, go down to about a depth of 30 cm. By examining the situation of the cold and warm levels in this layer, useful information was obtained concerning the process of thermal economy of the soil. On the basis of isoplates it was stated that the movement of of the cold and warm levels takes place at a different pace at different exposures. For a further detailed analysis of the phenomenon the average soil temperature isoplates on 5 bright August days were drawn describing the slopes at the four cardinal points (see figs. 4–7).

On the northern slope (souther exposure) where an isoplate of 8 °C and 21 °C demonstrates the extent of extremity, the sinking of the warm and cold levels can be denoted as steady. This means that the thermal supply coming from a deeper layer during the night and from the surface during the day is of about the same value. The convergence and divergence levels deviate at a very small rate with depth in this case since the rate of the movement of heat changes at a depth of 14–15 cm which is the level of the inflexion point as has already been mathematically demonstrated. The cold level descends more rapidly, the warm level more slowly beyond this depth (see fig. 4.)

On the eastern slope (western exposure) the 11 °C and 16.5 °C isoplates demonstrate an extremity which is considerably less than the one described above. According to this, isoplates are not so frequent. While the tendency is the same as far as the sinking of the cold level is concerned, the movement of the warm level occurs at a slower rate. It is on this slope that the diversion of the inversion level is most evident. This proves that in the majority of the vertical levels heat-distribution is equal. Emission starts later in the afternoon and the quantity of heat gained during the period of illumination inhibits the lowering of the warm level (see fig. 5).

Extremity is least on the southern slope (northern exposure), the lowest rate isoplate being 10.5 °C, the highest 14.5 °C. The cold level sinks very slowly to a depth of 5 cm, then it goes down all of a sudden. The warm level never descends to a depth lower than 10 cm during the day. This demonstrates that here there is heat emission from the deeper layers of the soil during the day, too. This is due to the fact that the illumination of the surface is relatively less than that of the other exposures (see fig. 6).

On the western slope (eastern exposure) the cold level gradually descends; similar to the southern slope it reaches a depth of 30 cm, this being the slowest as a result of an emission of heat from the deeper layers of soil up till 4p.m. – as is the case with the southern slope. The line of the warm level is similar to that of the northern slopes, the values being nearly the same, too, so the direction and size of the courses of heat-exchange are more or less the same (see fig. 7.).

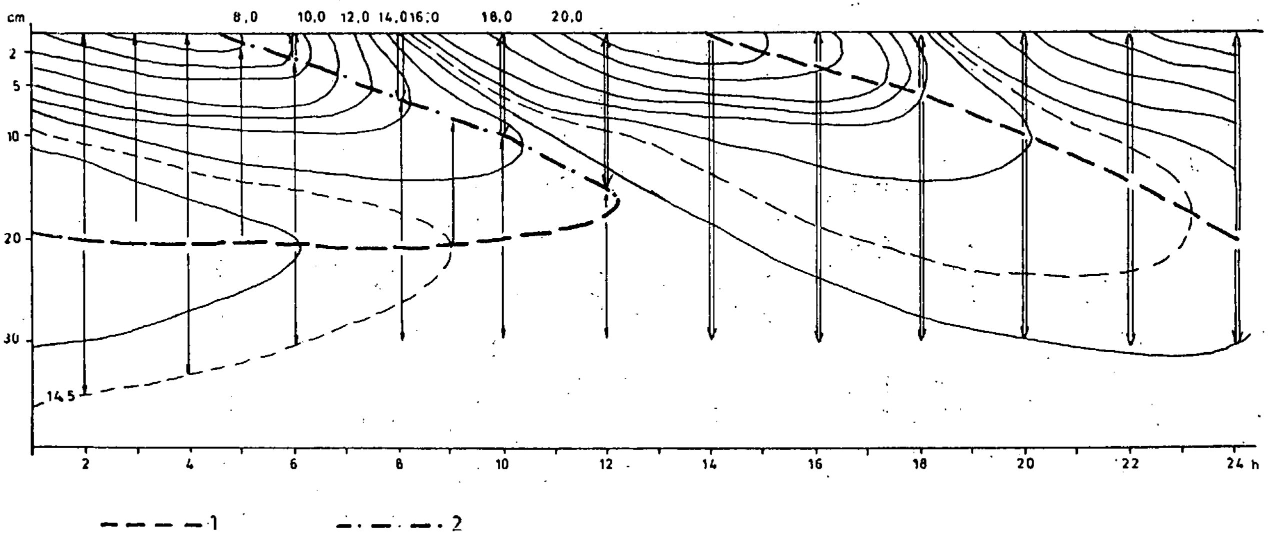

Fig. 4. Average temperature isoplates on the northern (I) slopes of a Bükk doline (southern exposure)
1. divergence line (warm level) 2. convergence line (cold level)

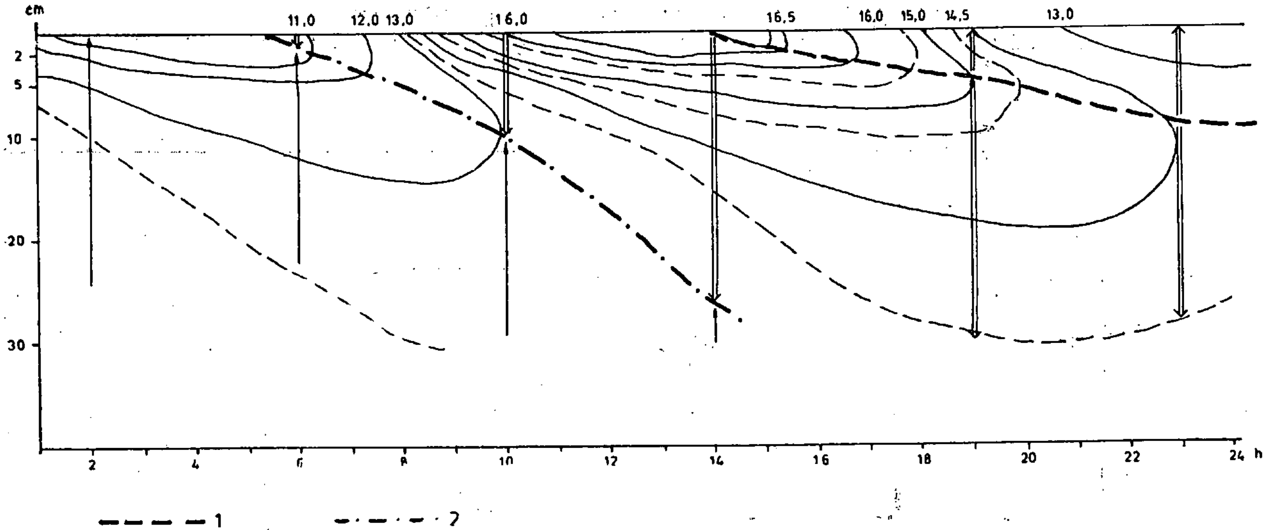

Fig. 5. Average temperature isoplates on the eastern (II) slopes of a Bükk doline (western exposure)
1. divergence line (warm level) 2. convergence line (cold level)

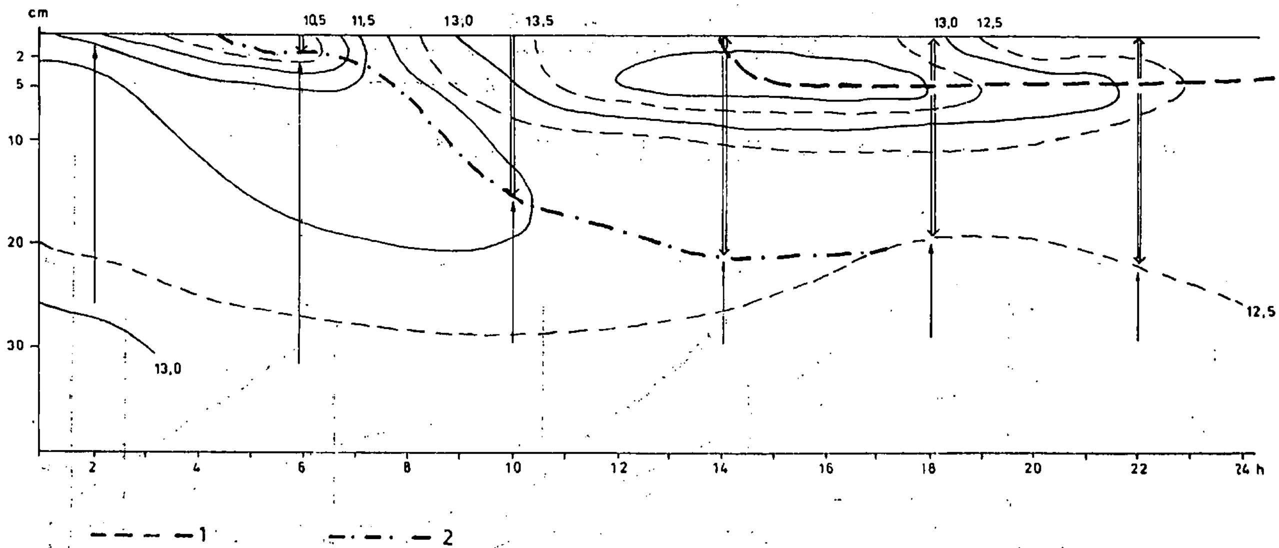

Fig. 6. Average temperature isoplates on the southern (III) slopes of a Bükk doline (northern exposure)
1. divergence line (warm level) 2. convergence line (cold level).

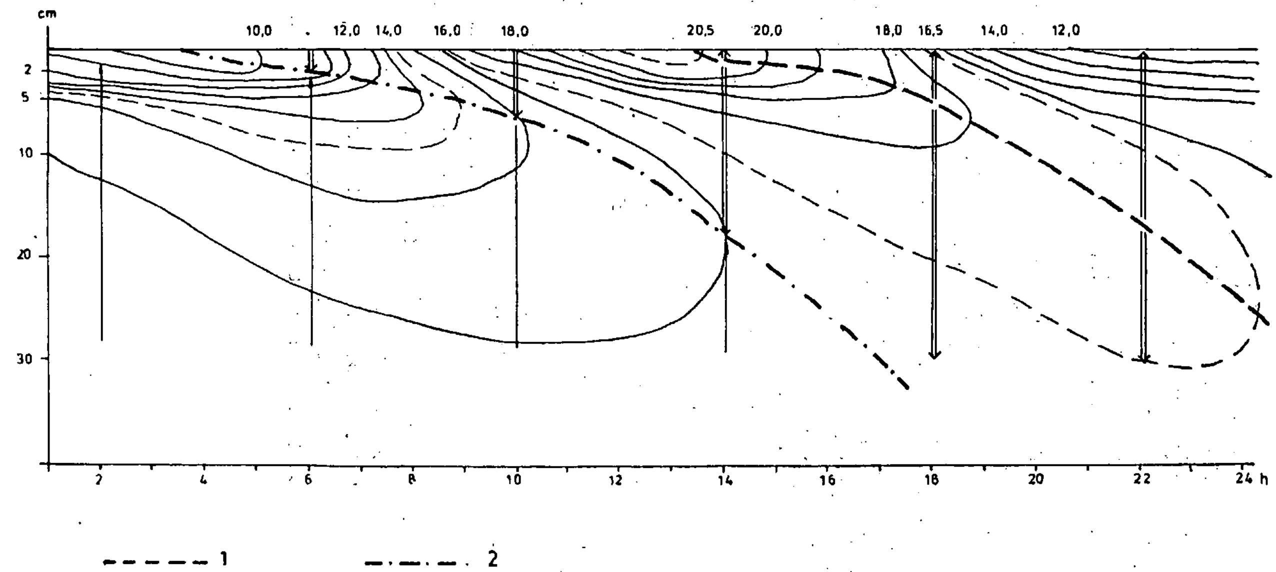

Fig. 7. Average temperature isoplates on the western (IV) slopes of a Bükk doline (eastern exposure)
1. divergence line (warm level) 2. convergence line (cold level)

Summary of the results

A summarizing statement can be made to the effect that the significant connection between soil moisture and bacteria count which was demonstrated at a depth of 5 cm is a characteristic feature of a doline with an undisturbed surface (natural vegetation and soil-bed). In the case of a doline with a distrurbed natural balance this connection can be demonstrated only at a deeper, i.e. 30 cm, level since the above-mentioned connection does exist at the 5 cm level, but cannot always be demonstrated.

While an examination according to the different exposures is carried out, the characteristic features of the soiltemperature must be registered sinc e, if the moisture and bacteria count only are taken into consideration, many connections are eccisental. In the case of the dolines which were examined by us the increase in the bacteria count could be demonstrated at a depth of 30 cm on the southern slope (northern exposure) if the moisture conditions were favourable. On the other hand at a depth of 5 cm the high value of moisture together with the low temperature did not result in a high bacteria count. This is in connection with the fact that the daily inversion level hardly descended to a depth of 5 cm. On the northern slope (southern exposure) the greater temperature extremes and the lower level of moisture-value resulting from this decreased the bacteria count especially at a depth of 5 cm. At a depth of 30 cm the bacteria count was higher which is due to the constantly favourable soil temperature during the day. On the western slope (eastern exposure) soil moisture was quite high; as a result of this, the bacteria count was high in the nondisturbed dolines. The same phenomenon could not be observed in the tree-covered dolines. This is caused by the activity of the warm level which becomes dominant in the daily temperature owing to the different slope-angle. This latter shows characteristics similar to those of the northern slope. On the eastern slope (western exposure) the bacteria population is not more favourable in spite of afforestation than on the northern slope, which fact is in connection with the lower value of soil moisture.

On the basis of examining the temperature moisture and bacteria, planting with young pine trees, taking into consideration the effect of exposure, seems to be favourable on the southern and western slopes since, as a result of the compound effect of the less extreme micro-climate, the soilecological conditions are favourable here. At the same time mention must be made of the fact that the steeper development of the western slope (which can be observed in most cases) somehow contradits the above statement. Thus a ground examination must be carried out before afforestation takes place.

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