FURTHER INVESTIGATIONS ON KARST SOILS IN HUNGARY

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Questions of soil acidification have been discussed extensively in the last fifteen years both by biology and geography. Lately, the emission of nocuous materials has increased considerably, sulphur dioxide, nitrogen oxides and halogenous materials being the most significant of them. Although these materilas also have natural sources, they are present in nature in much smaller quantities than emissions from human activity. The material emitted into the air forms acidic aerosol with the vapour particles of the air, and a significant portion gets onto the ground with precipitation. The chemical reaction of the precipitation in Europe, according to *Clausnitzer* (1979), ranges between 5,5-5,8 pH in natural circumstances. In wet climatic areas the acidic depositions that get onto the ground change the mineral and biotic conditions of soils. (*Arnold*, 1984).

The puffer ability of soils formed on calciferous base-rock is higher than that of soils formed on other base-rocks, yet the increase of acidic depositions necessitates the examination of the ways they affect karst soils and karst formation processes. (*Arnold, A.* 1984).

On the basis of representative data from Central Europe, Neumüller (in: *Arnold*) has shown that 8,1 gs of NO/NO_2 will make 11,7 gs of nitrous acid and nitric acid (HNO_2/HNO_3), and 20,2 gs of SO_2 will yield 30,6 gs of H_2SO_4, i. e. sulphur acid. This 30,6 gs of sulphur acid dissolves 20,6 gs of calcium carbonate ($CaCO_3$) per square metres per annum, the 11,7 gs of nitrous and nitric acid dissolving 10,6 gs of calcium carbonate, which results altogether in the dissolution of 31,2 gs of calcium carbonate per square metre in a year. According to the theoretical data of *Arnold* (1984), this dissolution produces approximately 13,3 cubic metres of cave-space in karstic areas.

On the basis of the above there can be no doubt as to the necessity, in karstic examinations, of detailed studies of the corrosion amplified by acidic depositions. Extensive studies of sub-soil karst corrosion have been conducted by *Trudgill*, S.T. (1973, 1976, 1985, 1986), *Crabtree-Trudgill* (1984), mostly on carboniferous limestone surfaces. The works cited have given the annual values, in mms, of karst corrosion on limestone surface under various soils. The dissolution loss is greatest below podzol soil formed on glacial moraine (0,2-0,3/year), next is the value under acidic brown soil (0,02-0,1). The dissolution rate is lowest under rendzina (0,01-0,02 mm/year) and wet calciferous soils. The value of the latter equals that of the corrosion under sloping soils. (*Trudgill, S. T.* 1985).

The above data are the results of correct experiments and have informational value since the experiments took place under oceanic conditions, with a vegetation dependent on the environmental factors of that region.

These results, however, do certainly justify similar examinations carried out in other areas. Earlier studies have convinced us that *soils covering the karst-forming rock, through the a-biogeneous and biogeneous processes going on in them, indicate the nature and the order of magnitude of the corrosion process.* The inner processes and dynamics of soils, in addition to reflecting the changes of external ecological factors, also show the properties deriving from the nature of the baserock and reflect their interactions.

Thus when tendencies of acidification of soils are discussed, its effect on the micro morphological changes of karstic surfaces has to be examined as well. The development of these studies is further justified by the fact that the water seeping through the soil affects subsurface karstic formations, that is formation of dropstone (*Jakucs, L.* 1987)

The climatic and soil characteristics of the area under examination

The sulphur dioxide background concentration of the air has been constant in Hungary in the last decade, while its nitrogen dioxide concentration has doubled. Sulphur derivations make up 57 %and nitrogen derivations 43% of all acidic depositions (wet and dry depositions) (*Horváth, L.* 1988). Sulphur pollution taken into consideration, Hungary qualifies as a moderately polluted area in Europe, the pH value of precipitation being 4,8. The above value of air pollution is significantly affected by climatic factors.

Climatically the country belongs in the wooded-steppe zone, the medium height mountain karstic plateau (800–900 ms above see level) displaying the characteristics of a humid cool climate with cold winters (*Kakas, J.* 1960). The degree of continentality is lower than in lowland areas. The annual number of sunshine hours is 1.900. The mean annual temperature is 6,0–7,0 C°. The annual quantity of precipitation is around 800–900 mms, the number of summer days is 3, while the freezing, winter and harsh days number 131, 61 and 19, respectively. It is a dry area compared to its height, on account of the foehn-like northern winds. In summer this is the coolest, although in winter not the coldest, region of the country. Average thickness of snow is 9 cms, ocassionally reaching even 80 cms. The base-rock of the plateau is mid-Triassic blue-gray and white 'plateau' limestone, which form karsts easily. Its natural vegetation is formed by mountain or unmixed beeches *(Aconito–Fagetum)*. Among the forests mountain meadows, hairgrass lawns *(Festuco ovinae Nardetum)* and high stalk assosiations can be found. Its soils are shallow layered rendzinas and brown clay soils, the typical black rendzina frequent in the northern expositions, the brown clays, idicative of the dynamics of forest soils, to be found accumulated in the bottom of valleys and dolinas.

The factors of the processes in karstic soils.

During earlier examinations of karstic soils in Hungary, I have found, through analizing the correlational connection between the water soluble cations and anions of the soil, that in the last few years this connection has not been significant, which is the result of the changes in the soil in the last few years (*Bárány, I.* 1987). The comparison of water and KCl pH values has indicated a tendency of the soil to acidify (*Bárány, I.* 1988).

Apart from the physical and chemical processes in soils biogeneous activity is also very significant in karst formation, that is to say, karsts are the products of biogeneous activity , as *Jakucs L.* (1980) put it. The correct thesis he formulated, however, is exact only if, in addition to the activity of the marco-flora of karstic soils, the activity of the micro-flora and -fauna is also examined. In the area we have examined, in 1 gr of soil bacteria have been found in an order of $1-10x10^6$, and fungi of various kinds in an order of $1-10x10^3$. The micro-organism population under forest covered areas is 5 – 10 times the size of the population under open grass (*Bárány, I.* 1980). This is closely related, on the one hand, to the less extreme micro-climate of the soils under forest vegetation associations and, on the other, to more favourable soil wetness (*Bárány, I. – Mezősi, G.* 1978).

Although the chemical reaction of the soil affects the reaction of micro-organisms is faster if chemical reaction has changed. According to *Francis, A. J.* (1982). decomposition of organic matter is most favourable around neutral pH, while the decomposing activity of microbes is reduced on acidic soils. Chemical reaction has a particularly important effect in respect of nitrogen transformation, the most important link in the nutrition-chain (cycle). Lasting acidification of soils resulting in the extinction of certain bacterium species, their place will be taken by acid-tolerant or acid-resistent species.

Tendencies in the changes of karstic soils in Hungary

In Hungary, between 1977 – 80 and 1983 – 85, the *Plant Protection and Agrochemical Centre* examined the acidification of soils in two cycles (*Búzás Istvánné – Csemátony Csabáné – Herczeg Annamária*, 1986). It was found that in Hungary the territory of soils with a reaction below 6,0 pH (KCl) increased by 7% at the expense of the territories with pH values over 7.0 (KCl). At the time of the first examination $CaCO_3$ could not be detected on 51% of the examined areas, and this number increased to 54% by the time of the second examination.

Nor is the area of the limestone mountains an exception from this tendency throughout the country. Similar changes took place between 1985 and 1988 in the rendzina and brown clay soil formed on the limestone in the dolinas. Limestone plateau of the Bükk hills. The laboratory pH (KCl) analysis of 32 samples from both years showed the following changes:

pH(KCl)	1985	1988
4,0	-	9,4%
4,1-4,5	-	6,3%
4,6-5,0	6,3%	18,8%
5,1-5,5	18,8%	6,3%
5,6-6,0	15,6%	12,5%
6,0	*40,6%*	*53,1%*
6,1-7,0	56,3%	46,9%
7,0	3,1%	-

Chemical reaction affects the macro- and micro-element content of soils since their getting into solutions depends are directed to the micro- and macro element content of soils so that the indicators of the degree of nutriment dupply could be established for different kinds of soils. However, the intensity and potential of the soil nutriment does not equal the measured values of the nutriment elements, since their intakeability depends on a number of factors. The micro- and macro-element content of the soils that we have examined is not authentic either for vegetable nutrition, but the data are useful to indicate tendencies. On the other hand, the element content soluble in water or other solvents for examinations of karsts may yield information on the extent of the eluviation in the soil. The element content of the soil solution is indicative of the aggressivity of the water which dissolves the calciferous surface.

The macro- and micro-element content of soils

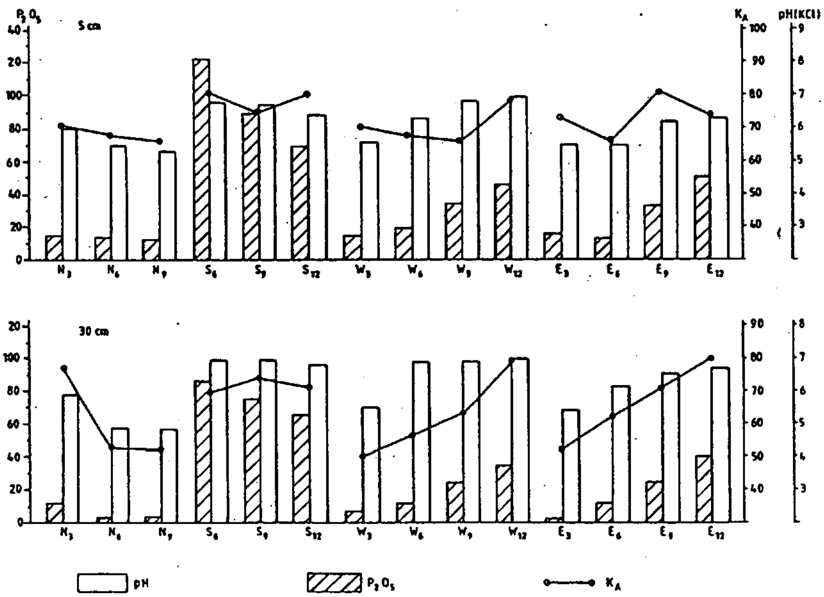
Macro-elements in pedology usually mean humous nitrogen, phosphorus and potassium, but calcium and magnesium also belong to this group. The microelements are sodium, zinc, copper, manganese and molybdenum.

First the distribution of macro-elements will be examined. *Humus content* is one of the most important of the macro-elements since nitrogen content, the hardness of the soil is closely related to it. In the area we have examined, the humus content of the soils that are described as clayey adobe and clay is high, over 5% except in a few sampling places. The NO_2 NO_3/ppm values were higher in 1988 than they had been in 1985, especially near the surface of the soil, at the depth of 5 cms. The same can be said of the SO_{2-4} (ppm) value (ppm = mg/kg soil). The quantity of potassium (K_2O) usually depends on the hardness of the soil. The degree of supply in the Bükk soils in 1985 is weak and medium, but in 1988 the degree of potassium supply is very low, which is in connection with the increasing eluviation. Where the pH (KCl)value is low, the quantity of potassiun also decreases. The high hardness of the soils here is not accompanied by good potassium supply.

The increase of NO_3+NO_2 and SO_{2-4} values can be related to the effect of acidic depositions, and perhaps also to the change of the vital bacterium population, which decomposes organic matter and transforms N.

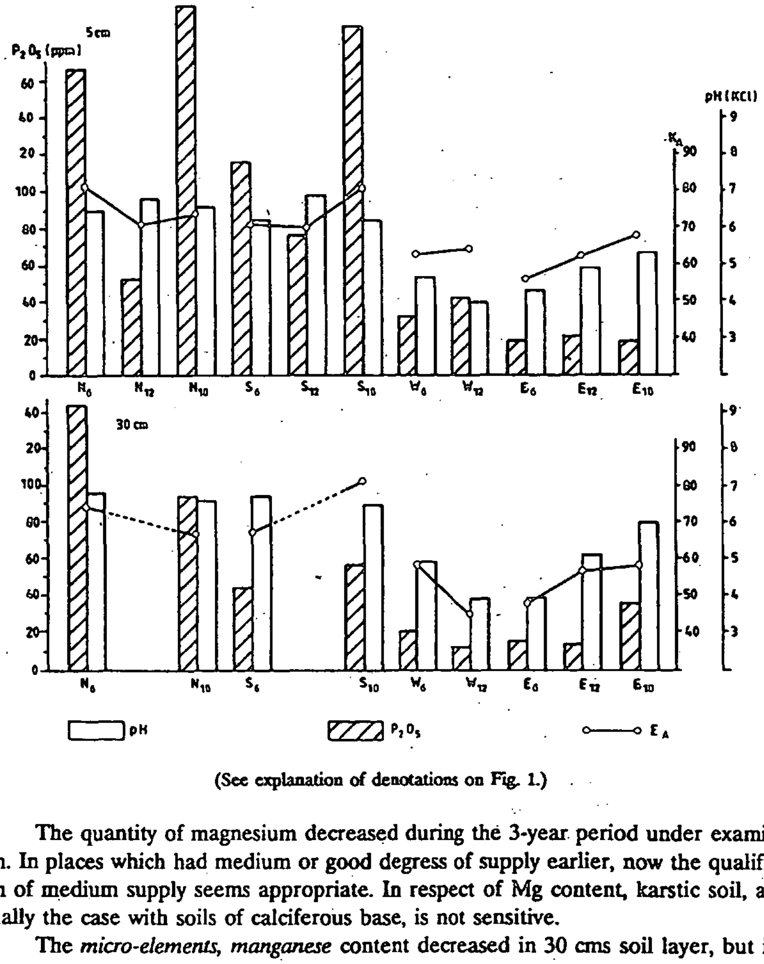
The degree of P_2O_5 supply is related to pH conditions and carbonate content. The increase of pH usually causes the increase of phosphorus content. However, it can be established that this synchronic change is more conspicuous in the data from 1985 *(Figure 1. 2.)*. On the slopes of dolinas the differences regarding phosphorus are quite considerable. The phosphorus content is the highest on slopes of southern exposition, whereas elsewhere these values are lower.

The P_2O_5 content of the karst soil *Fig. 1.*
and the value of boundedness according to Arany
and pH(KCl) in the depth 5 cms and 30 cms. (Bükk Mountain Hungary 1985).



N_3, N_6 etc. = northern slope at the levels of 3,6 metres;
S_6, S_9 etc. = southern slope at the levels of 6,9 metres;
W_3, W_6 etc. = western slope at the levels of 3,6 metres;
E_3, E_6 etc. = eastern slope at the levels of 3,6 metres;

The P_2O_5 content of the karst soil *Fig. 2*
and the value of boundedness according to Arany and pH(KCl)
in the depth 5 cms and 30 cms. (Bükk Mountain Hungary 1988).

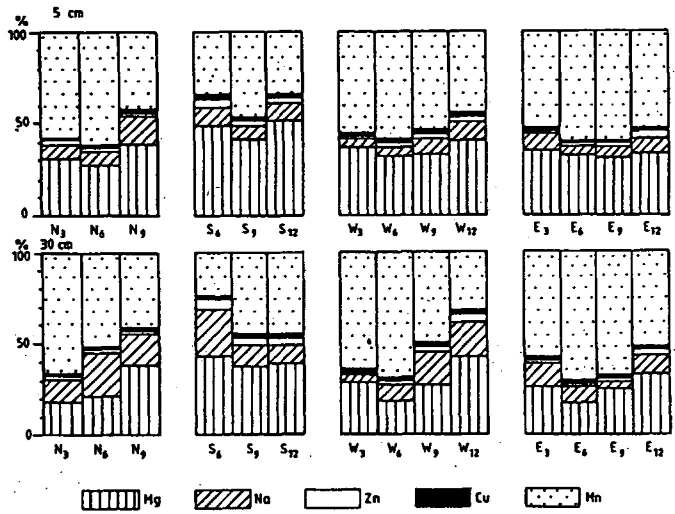


(See explanation of denotations on Fig. 1.)

The quantity of magnesium decreased during the 3-year period under examination. In places which had medium or good degress of supply earlier, now the qualification of medium supply seems appropriate. In respect of Mg content, karstic soil, as is usually the case with soils of calciferous base, is not sensitive.

The *micro-elements, manganese* content decreased in 30 cms soil layer, but it is still higher than the 118 ppm which is supposed to be a limit value under 6.0 pH; with even the possibility of Mn toxicity in some places. *(Fig. 3. 4.)*.

The content of magnesium and micro-elements of the karstsoil in the depth of 5 cms and 30 cms. (Bükk Mountain Hungary 1985). *Fig. 3.*



(See explanation of denotations on Fig. 1.).

The quantity of *zinc* remains below 10 ppm in 2/3 of the cases, and never surpassing the value of 20 ppm in the rest of the cases. Interestingly, lower zinc values can be found with lower pH values. Zinc values do not seem to have a connection with either lime content or phosphorus content.

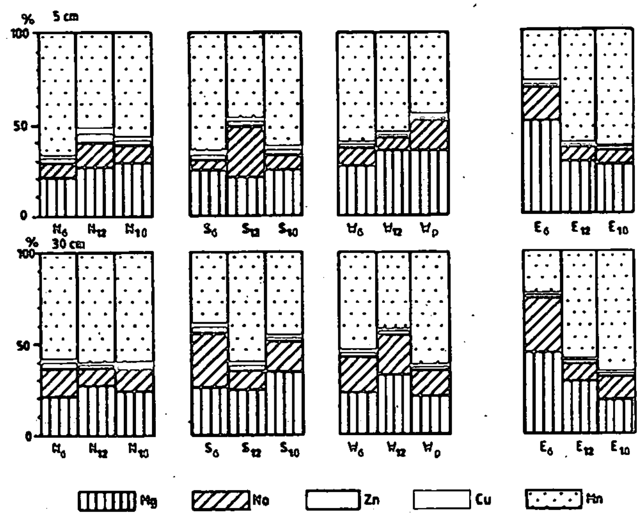
Copper content ranges between 1–10 ppm. Its quantity is usually assosiated with humus content. The humus content in our case is higher (over 5%) than the 3% humus content given as the limit value of Zn supply. However, copper content does not change in direct proportion with the humus content. Usually, lower pH content will have lower Zn content, which is also the result of more forceful eluviation.

Thus micro-elements change in direct proportion with the change of pH.

The examination, on the basis of the 1985 data, of *water soluble cations and anions* revealed that as it was the case in earlier examinations, they are present in larger quantities on southern and western slopes (slopes of northern and eastern exposition). *(Fig. 5.)*.

Ion content is the lowest on southern slopes (of northern exposition), which is related to the more lasting wetness due to the exposition. Ion content is also lower at the bottom of the dolina on account of stronger outwashing.

The content of magnesium and micro-elements of the karstsoil in the depth of 5 cms and 30 cms. (Bükk Mountain Hungary 1988.). *Fig. 4.*



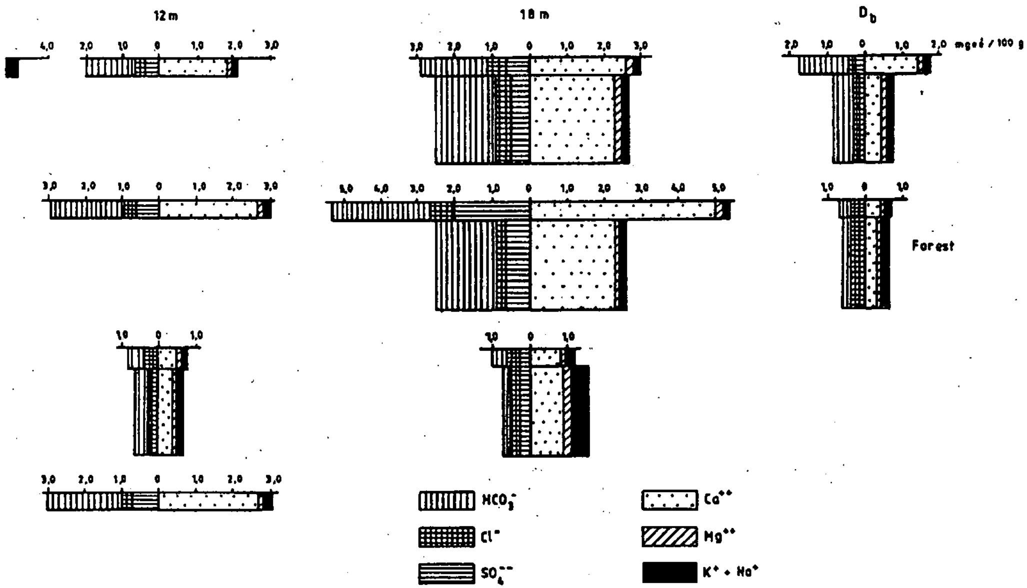
(See explanation od denotations on Fig. 1.).

Naturally, the expositional properties are closely related with the humusforming, organic-matter-producing activity of the slope. The production of air-dry organic matter (heated at 105 C°) on the different slopes of a dolina distributed in the following way (projected to 1 m^2):

Southern exposition (northern slope)	306 grs.
Western exposition (eastern slope)	275 grs.
Northern exposition (southern slope)	324 grs.
Eastern exposition (western slope)	241 grs.

The higher organic matter production of the slope of northern exposition is due to the more even (less extreme) micro-climate, which, indirectly, affects the high humus content, the decomposition of organic matter being slower here.

The water-soluble cations and anions of the karstsoil in the Bükk Mountain (Hungary 1985). *Fig. 5.*



(See explanation of denotations on Fig. 1.).

The number of micro-organisms which decompose organic matter is the highest on the southern slope (of northern exposition), the bacterium number at 5 cms being $8-10x10^6$, and going down to $1-3x10^6$ at 30 cms. The number of bacteria is also quite high on the northern slope (of southern exposition), which here is also accompanied with high organic matter content. On the western slope (of eastern exposition) the bacterium number is in one case higher than $10x10^6$, while in the eastern slope (of western exposition) it never reaches $10x10^6$.

Futher, detailed examinations of both inorganic and organic soil components are an important task of karst soil studies. By defining possible soil charachteristics, the present paper has wished to show the present state and partly the tendencies in the changes of the karstic soils of areas with temperate atlantic and continental, transitional climates.

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