SOILS ON KARST AREAS OF THE BÜKK MOUNTAIN, HUNGARY

ANIKÓ ZSENI

Department of Physical Geography, University of Szeged, Hungary
6722-Szeged, Egyetem u.2.

Summary
The soil has an important role in the karst ecological system because it can buffer harmful effects and in the last ten years there have been several studies of soils in Hungarian karsts. However, there have been few measurements of soil nutrients in karst areas. During this investigation the pH (H_20) and pH (KCL) and the carbonate content of soils were measured. Soil moisture, which is important for plants take-up of nutrients, was also part of the investigation. On the basis of the results it is concluded that: the nutrient indices of the beech forest and beech with pine forest soils are most advantageous in respect of the plant available calcium, magnesium, potassium and total nitrogen. The plant available calcium is correlated with the plant available potassium and magnesium; the higher the calcium content the higher the potassium and magnesium content. The difference of the potassium content of soil between the different type of plants is lower than that in the case of the other nutrients. The soils are weakly supplied with magnesium. More than half of the examined soils are well-supplied with phosphorus.

Introduction

I studied the characteristics of the soil nutrient system in karst areas. In the last ten years the investigation of soils on Hungarian karst came into limelight. The soil has an important role in the ecological system because it can buffer the harmful environmental effects that take effect quickly (*Bárány-Kevei, I. 1980, Bárány-Kevei 1992, Bárány-Kevei, I. - Mezősi G. 1978, Zámbó, 1986*). The determination of soil nutrient content is not common on karst areas, so we have few results on this subject. There is only one soil profile in the Bükk plateau where among others the nutrients were determined. But there are great differences in the nutrient supply of the soil on small areas especially if we investigate it in different ecological conditions.

Methods

Two soil samples (from depths of 5-10, 10-20, 20-30, 30-40 cm) were collected from every km^2 in an 8 km^2 study area on the Bükk plateau (Bükk National Park, Hungary). The sites represented different ecological conditions: beech wood, pine forests, beech with pine forests, woodland nursery and open field. The quantity of total soil-nitrogen and of plant available phosphorus, potassium, calcium, magnesium were measured. Although, it is not actually a nutrient type, we have also measured the collective quantity of exchangeable and soluble sodium. This enabled us to calculate the S-value (exchangeable basis) of the

soil. The plant available Mg and Ca were measured by Atomic Absorption Spectrophotometer, the K and Na by flame photometer (extracted by 1 mol/dm^3 CH_3COONH_4). We used the modification of the technique devised by Kjeldahl to determine the total N and the Olsen's method to measure the plant available P. Investigation of soil cannot be carried out without the knowledge of pH and carbonate content of soil. Therefore the pH (H_2O) and pH (KCl) plus the carbonate content of soils were determined. The soil moisture – which is important for the plants nutrient take-up – was also measured.

Description of the sample sites

Sample site 1: Beech with pine forest, without any undergrowth. The 2-5 cm thick leaf-litter is mainly pine needles. The soil is greyish-brown. The stone content is about 50 % on the surface. There are a lot of roots in the upper 20 cm of the soil.

Sample site 2: Beech-wood. There is moss on the soil surface. The stone content is about 50 % on the surface. The soil is greyish-brown and interweaves with roots strongly.

Sample site 3: An about 100 years old beech forest. The area is exposed to northwards. The layer of leaf-litter is thick. The soil is dark brown. It has a high organic material content. The stone content is about 50 %.

Sample site 4: Open field on the ridge of a doline row. The soil is greyish-brown. The stones appear in the depth of 15-20 cm.

Sample site 5: Pine forest (Pinus sylvestris and Picea). The Pinus sylvestris trees are on the brink of ruin. Despite it is a pine forest, it has rich undergrowth. Nettle can be seen in the forest, which is not common in pine forest. There is 4-5 cm thick moss on the soil surface. The soil has a thick organic layer. The limestone appears in the depth of 5-10 cm. The stone content is about 60 %, while in the lower layer 80 %.

Sample site 6: Open field at a doline edge. The stones appear in the depth of 20-30 cm, the stone content is 40-50 %. The stones are rounded; processes of the solution are well visible. The soil is brown; former it was a forest soil.

Sample site 7: Pine forest (Picea), the undergrowth is rare. The upper 20-25 cm layer of the soil is dark grey, the lower is clayish, lighter.

Sample site 8: Pine forest on the bottom of a doline. The undergrowth is rare. The soil is moss covered and light brown.

Sample site 9: Beech-wood with rare undergrowth. The soil is very strongly interweaves with roots. The organic, humic layer is 4-5 cm thick. The stones appear in the depth of 10-15 cm. The stone content is 40 %. The soil is greyish brown.

Sample site 10: Beech-wood, which is not so closed and according to this the undergrowth is thicker. It is on a slope, dipping at angles of 10 degrees. The soil is a dark brown rendzina and it is getting darker downwards in the soil profile. The humic layer is very thin. The stone content is about 50 % from the surface.

Sample site 11: Open field on the bottom of a doline which, is a sinkhole as well. The upper 20-cm of the soil is strongly interweaves with roots. The clay appears in the depth of 30 cm.

Sample site 12: Beech with pine forest. The undergrowth is thick because the forest is relatively opened. There is a 5-10 cm layer of leaf-litter on the surface. The soil is greyish-brown. The stones appear in the depth of 25-30 cm.

Sample site 13: A woodland nursery (mainly pine but there are some beeches as well) on the edge of a doline. The soil is a dark grey rendzina. The stone content is 80 % on the surface.

Sample site 14: Open field on the slope of a twin doline. The soil is yellow-brown with high clay content. It is getting light-coloured downwards in the soil profile.

Sample site 15: An old beech forest with thick undergrowth and with a lot of fern. There is moss on the surface of the stones. The soil is a dark brown rendzina. The stone content is 50 % from the surface. Because of the stones and roots were so dense, we were able to dig only to the depth of 30 cm, so we have only 3 soil samples from this sample site.

Sample site 16: Open field on the „Nagymező". The upper 10-cm of the soil is black. The lower part is yellow with high clay content.

Discussion

Following the measurements we were able to compare the nutrient system of the soils which occurred in different ecological conditions. There are differences between the nutrient status of the soils from beech and pine forest and from open fields:

The nutrient indices of the soils of the beech wood and beech with pine forest are the most advantageous in respect of the plant available calcium, magnesium, potassium and total nitrogen.

The soils of the open fields have the lowest nutrient status but the highest plant available phosphorus.

Determination of pH and carbonate content of soils is important not only because of the nutrients. In the case of karst areas it is important to know the connections because the characteristic of the bedrock point towards the fact that the soil has high carbonate content and according to this has neutral pH. After the measurement we have made we found that the soils of Bükk plateau have a low carbonate content, which has a big influence of the presence of the nutrients. In connection with this the pH of the soils is also lower than it was expected. In the case of $\Delta pH = pH\ (H_2O)$-$pH\ (KCl)$ the often high (around 1) values show that in these soils the acidification is important.

The pH is connected with the calcium content of the soil. The soils with lower pH have lower plant available calcium content. The soils which are mixed with fragments of limestone (Sample sites 1, 2, 3, 4, 5, 6, 9, 10, 12, 13 and 15) have a higher plant available calcium content than those which have not been (Sample sites 7, 8, 11, 14 and 16). In the soils, in which the ΔpH is high, the plant available calcium content is always low. In the soils which are mixed with fragments of limestone, the pH and plant available calcium content increase downwards in the soil profile. The plant available calcium content decreases downwards in the soils which have not been mixed with limestone. (*Fig. 1*)

The plant available calcium is connected with the plant available potassium and magnesium; the higher the calcium content the higher the potassium and magnesium content and vice versa. (*Fig. 1, 2, 3*)

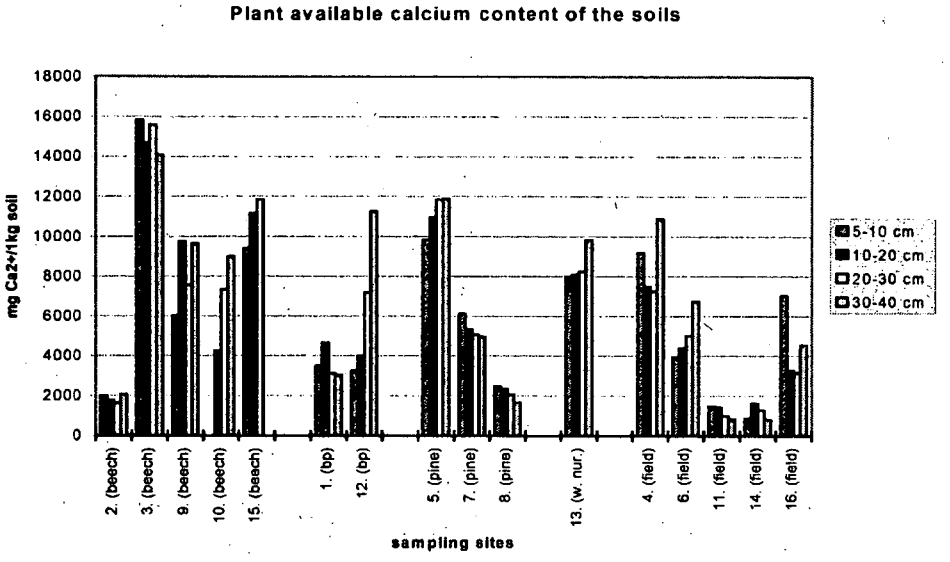

Fig. 1 Plant available calcium content of the soils

The difference between the potassium content of soil and the different type of plants is lower than that in the case of the other nutrients. (*Fig. 2, Table 1*)

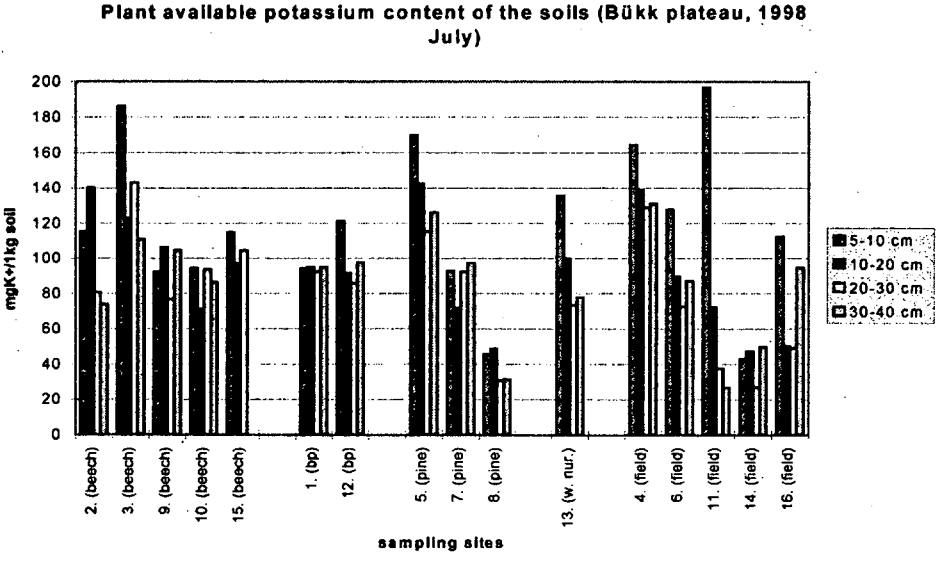

Fig. 2 Plant available potassium content of the soils

Table 1 Distribution of the potassium content

K content of soils	number of soil samples (%)					
	sum total	beech	beech with pine	pine	woodland nursery	field
very little	5 (7,9%)	0	0	2 (16,7%)	0	3 (15,0%)
little	7 (11,1%)	0	0	2 (16,7%)	0	5 (25,0%)
moderate medium	8 (12,7%)	3 (15,8%)	0	1 (8,3%)	1 (25,0%)	3 (15,0%)
medium	22 (34,9%	8 (42,1%)	7 (87,5%)	3 (25,0%)	2 (50,0%)	2 (10,0%)
much	10 (15,9%)	5 (26,3%)	1 (12,5%)	2 (16,7%)	0	2 (10,0%)
very much	11 (17,5%)	3 (15,8%)	0	2 (16,7%)	1 (25,0%)	5 (25,0%)
sum total	63	19	8	12	4	20

The soils are weakly supplied with magnesium. This is interesting because most of the examined soils in Hungary are supplied well. I have some soil samples in which the plant available magnesium content is lower than the lowest limit of the measurement. (*Fig. 3, Table 2*)

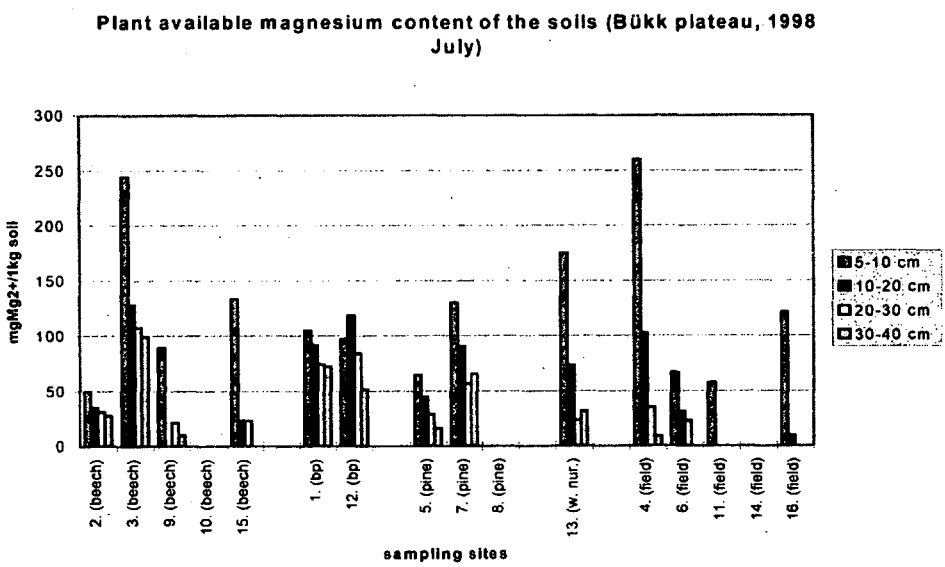

Fig. 3 Plant available magnesium content of the soils

Table 2 Distribution of the magnesium content

Supplying of soil with Mg	number of soil samples (%)					
	sum total	beech	beech with pine	pine	woodland nursery	field
weakly	47 (74,6%)	14 (73,7%)	4 (50,0%)	10 (83,3%)	2 (50,0%)	17 (85,0%)
moderately	7 (11,1%)	1 (5,3%)	3 (37,5%)	2 (16,7%)	1 (25,0%)	0
well supplied	9 (14,3%)	4 (21,1%)	1 (12,5%)	0	1 (25,0%)	3 (15,0%)
sum total	63	19	8	12	4	20

More than half of the examined soils are well supplied with phosphorus. The soils of the open fields have the highest plant available phosphorus content. (*Fig. 4, Table 3*)

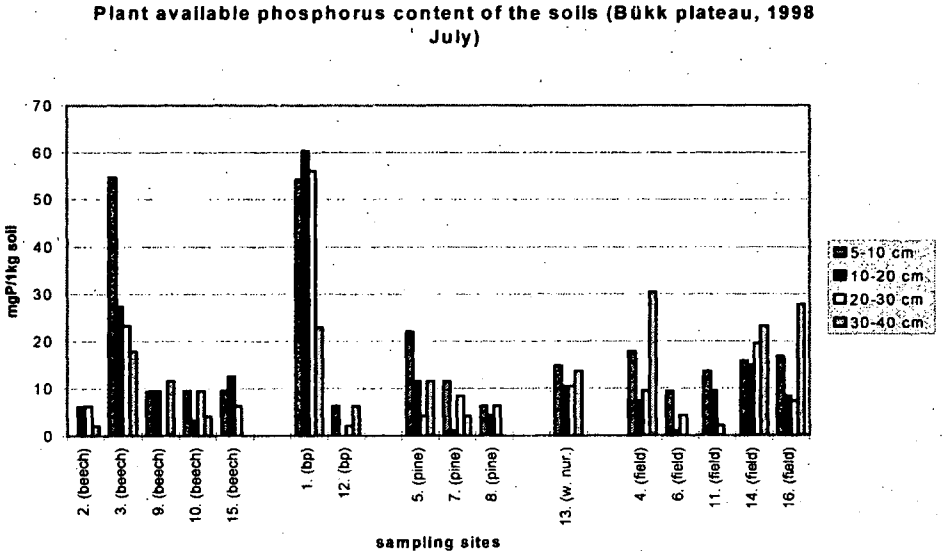

Fig. 4 Plant available phosphorus content of the soils

Table 3 Distribution of the phosphorus content

Supplying of soil with P	number of soil samples (%)					
	sum total	beech	beech with pine	pine	woodland nursery	field
weakly	15 (23,8%)	4 (21,1%)	2 (25,0%)	4 (33,3%)	0	4 (20,0%)
moderately	14 (22,2%)	4 (21,1%)	2 (25,0%)	4 (33,3%)	0	4 (20,0%)
well supplied	34 (54,0%)	11 (57,9%)	4 (50,0%)	4 (33,3%)	4 (100%)	12 (60,0%)
sum total	63	19	8	12	4	20

The soils are weakly and moderately supplied by nitrogen.

Two interesting connections between the nutrients and the ecological conditions are:

1. The open fields can be divided into two groups based on their pH, total carbonate content and plant available calcium content. The soils of sites 4 and 6 have higher pH and plant available calcium content than the soils of sites 11, 14 and 16. In the fore-mentioned two soils the pH increases downwards in the soil profile while in the latter three it does not. These three soils have very high ΔpH values (1-1,7) which show that in these soils the acidification is important. There is no carbonate content in the soils at sites 11, 14 and 16. In the other two soils the carbonate appears in the depth of 15-20 cm. Based on the environmental conditions the five sites can be grouped into two classes. In the case of sites 4 and 6, the limestone fragments appear in the depth of 15-20

cm in the soil profile whereas at sites 11, 14 and 16 there were no fragments as the parent material was not reached.

2. The connection of the plant available calcium, potassium and phosphorus content of the soils can be best seen in the three pine forest soils (sampling sites 5, 7 and 8). Sampling site 5 has the highest nutrient values and site 8 has the lowest.

Summary

The characteristics of the soil nutrient system in an 8 km^2 sized study area on the Bükk plateau were examined. The pH, total carbonate content, total soil-nitrogen content, plant available calcium, potassium, magnesium, phosphorus contents of 63 soils were measured. The nutrient system of soils in different ecological conditions were compared and differences between the nutrient status of the beech wood, pine forest and the open field soils were found. Knowledge of soil pH and the N, P, K, Ca and Mg content of soils can be can be important for environmental protection, sustainable forestry and management of meadows.

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