Carpth. J. of Earth and Environmental Sciences, 2007, Vol. 2, No. 1, p. 17 - 24

WATER MANAGEMENT OF FOREST SOILS BELOW DIFFERENT WOOD STANDS

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Abstract. The investigations about the water capacity of the forest soils rise up their sensibility for the climatic changes. In Hungary, the forest shows a climatic zonation and the productivity and the health state of trees are strongly influenced by properties of soil level. The most frequent soil type is the brown forest soil, in which the influence of the arborescent vegetation and the climatic factors are most relevant. For study the action of climatic factors about the soil structure, the physical measurements and their results as concerning the water distribution are presented. The application of this method are exemplified with two stands from Visegrád Mts., with similar geological background, but different morphology and orientation, and consequently, with different water management of the soil level. Thus, the correct estimation of the water capacity and the water retention is important to know, for prevailing the negative effects of the prognosis climatic changes.

Key words: Hungary, Forest, Brown forest soil, Water capacity, Climatic change

1. THE FOREST STRUCTURE OF HUNGARY

It is well known, that Hungary occupies the lowest territory of the Carpathian Basins: from the total 93,000 sqkm, 68% represent the plain-type basin area, 15%, the low hills, 14% the 200-400 m high Middle Mountains and only 2% rise above 400 m.

In the territory of the country, three provinces of the temperate climatic zone manifest their influence: the continental, the oceanic and the Mediterranean provinces. The distribution of the different kinds of the forest areas reflects the climatic characteristics, mainly by the distribution of the humidity and of the disposable water supply (Várallyay, 1985).

In Hungary, the natural, indigenous, untouched forest areas have disappeared many centuries ago. Now, the majority of the forest areas are planted ones, or they grow under strong human control. The main aim of the silviculture is the economy of the wood production and the maintenance of a near-natural state of forest in the protected areas. In this situation, the success of the silviculture is assured by the knowledge about the appropriate water management of the forest soils. Generally, the beech-tree woods occupier the most favourable, the most humid zones, the hornbeam grows on the favourable ones and the oak forest are situated on the „supportable" areas from point of view of the water supply.

Apart from the forest in mountainous areas, notable surfaces of the country are occupied by robinia and poplar (plantation and self-growing) forest. On the riverside of the most important water flows and channels, gallery-type forest belts occur. We cannot omit the great number of dendrologic parks, arboretums and experimental stations with autochthonous and exotic tree species (e.g. Gödöllő Arboretum, Kuti et al, 1992).

2. THE BROWN FOREST SOIL TYPES

The water management of the wood-covered areas depends mainly on the characteristics of the superficial, loose sediment cover, i.e. the soil level. The main soil types, which are present in the Hungarian forest, are the brown forest soils.
The brown forest soil types were grouped on the Middle- and Southestern European Brown Main Soil Group. The majority of the forest soils of Germany, Austria, Czech Republic, Slovakia, part of Romania and Serbia belong to this main group.
The characteristics of the brown forest soils are the following:

- They are soils formed under influence of the woody vegetation;
- The soil forming is determined by the presence of the relative high amount of the precipitations;
- The characteristic, well developed soil section consists of an upper, thin, humic, a middle leaching and a down-situated accumulation levels (Stefanovits, 1971).

Note, that this (theoretical) level structure is observable only in case of the moderate slope conditions, with cohesive state of the surface deposits and without active erosion.

The Main Middle and Southeastern European Brown Soil Type differs substantially from the podzolic forest soils of the East European Plain, and differs from the West-European similar soil formations, too.

The climatic conditions of the formation of the different sub-types of the brown forest soils of the Carpathians are presented in table I:

Table I.

Annual average temperature	Annual precipitations	Other characteristics
9-11°	600-800mm	4 months with average temperature above to +10°; No months below 300mm precipitations Oak belt
8-9,5°	600-800mm	Below 500 m: oak belt; 500-800 m: oak and beech belt
2,9-5,2°	900-1400 (1600) mm	800-1500 m: Acid and podzoled acid brown forest soils, light brown forest soils; beech and pine belt

Thus, in changing climate conditions, the specific composition of the forest cover will be modified, and consequently, the characteristics of the soil will change. On he contrary, by studying of the soil characteristics and of the changes of the water management, we could appreciate the effects of the real or presumed climatic change (Duchaufour, P. 1982).

3. THE CLIMATIC CHANGES AND THE SOIL LEVELS

The climatic changes, which could determine modifications of the characteristics of the soils are the following:

- Disturbation in the annual distribution of the precipitations: less snow and more rain-showers;
- Increase of the annual average temperature;
- The disappearance of areas with high annual amount of the precipitations (i.e. the lack of the areas with more, that 750 mm/year)
- The extension of the areas with <500 mm annual precipitation.

Despite of the strong influences of the parental rocks and of the morphology, the climatic changes are reflected on the structural peculiarities of certain brown forest soil sections.

4. PHYSICAL MEASUREMENTS, WHICH CHARACTERIZE THE WATER MANAGEMENT OF THE SOILS

For characterizing the water management of the forest soils, in our laboratory we determine some physical parameters (Ballenegger & Di Gléria, 1962), which influence the circulation of water in loose sediments (i.e. in the soils and in the under laying deposits), as follows:

- The maximal water capacity (WC_{max});
- The capillary water capacity (WC_{cap});
- The minimal water capacity (WC_{min});
- The value of the disruptive capillary humidity (DCH);
- The hygroscopic index (hy)
- The volumetric weight and the mass weight;
- The granulometric composition.

Using the above mentioned parameters, we could determine the amount of immobile water, the useful water for the plants, as the hardly, medium and easily take-off water amount (Harnaj, 1972).

The immobile water of the soils is strongly bounded to the mineral particles, or it circulates between pores in gas state (vapor). It could by extracted under 15-10,000 bars succion pressure. Note, that certain microorganisms (as Cyanophites) can use the 15-25 bars fraction. The amount of the immobile water is relatively high in case of the clayey deposits, which apparently are wet, but their humidity cannot feed the plant roots.

Based on the mobility, the useful water is classified in hardly, medium and easily take-off water.

The hardly take-off water is bounded to the particles of the soil with the capillary forces; thus, it fills the finest pores, and can be extracted under 0,3-15 bars succcion pressure.

The medium take-off water moves in soil pores under gravity, but with strong influence of the capillary forces. The succion pressure varies between 0,05-0,3 bars.

The easily take-off water moves under gravity force, using the supra-capillary pores, holes and cavities. The succion pressure varies between 0,0-0,05 bars

For the life of the plants, it is important to determine the value of the „fading point”, i.e. the water amount, below them the vegetal life is irreversibly damaged (Járó, 1978). Another useful parameter is the value of the disruptive capillary humidity (DCH), which defines the beginning of the free circulation of the water in the soil.

The relation between the kind of the water bond and the distribution of the pore space is presented in diagram of fig, 1.

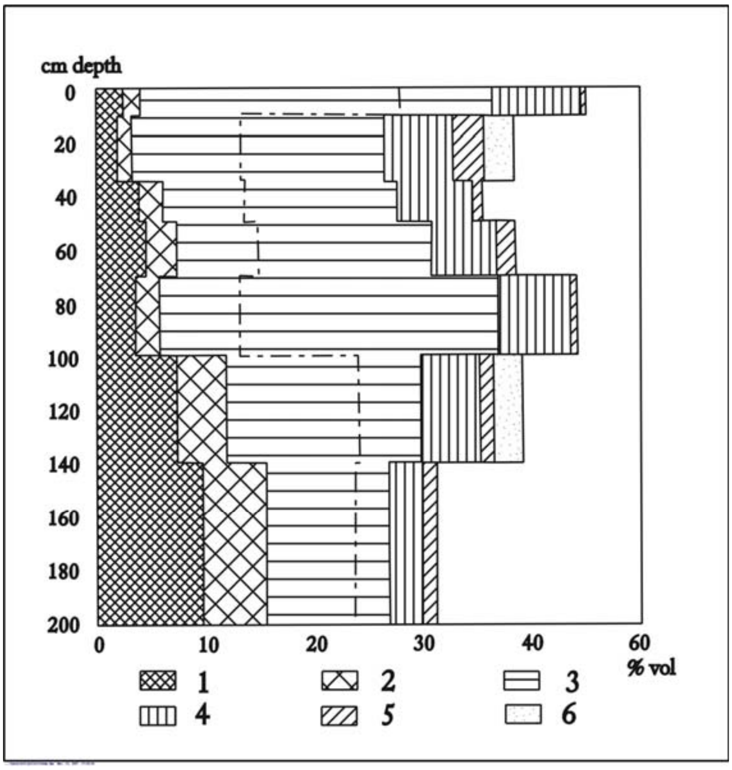

Fig. 1. Diagram showing the distribution of the pore space and water capacity in brown sandy forest soil, Gödöllő Arboretum. 1. Pores with strong bonded water; 2. Pores with scarce bonded water; 3. Capillary pores; 4. Pores of capillary-gravitational water; 5. Pores of gravitational moving water; 6. Empty pores.

5. THE WATER CAPACITY OF SOILS AND THE LAND MORPHOLOGY

In case of the similar geological background and soil type, the forest stands with different expositions shows different behaviour of the pore water, i.e. the different kinds of the water retention. Thus, during the dry periods, they will reach the irreversible state loosing different amounts of water. A few thousands of pore capacity measurements (Kalmár & Szendreiné. 1999) permit to state, that the slope orientation modifies the pore structures and consequently, the water management of the examined soils. Using the parameters of these measurements, the forest soil sections could be classified in a few classes with similar properties, corresponding to soils of similar evolution state. From our experiences resulted, that the exposition and the loos of water of the soils show a strong correlation, however the geological background, specially, the composition of the parent rock is important to be known.

For example, two stands (61A and 65B) Visegrád Mts (fig. 2.) will be presented

Note, that among the stands, an important difference of the mean annual temperature was measured: for the 61A stand with northern exposition, 8,0-8,5°, for south oriented 65B stand, 9,5-10,0°. The annual precipitation for both is about 750°, but the distribution in time differs (Table II.).

The physical analysis of the soil samples show, that the water capacity differs, too (Kalmár et al, 2006). Significant differences appear between the samples of the stands concerning the useful water content:

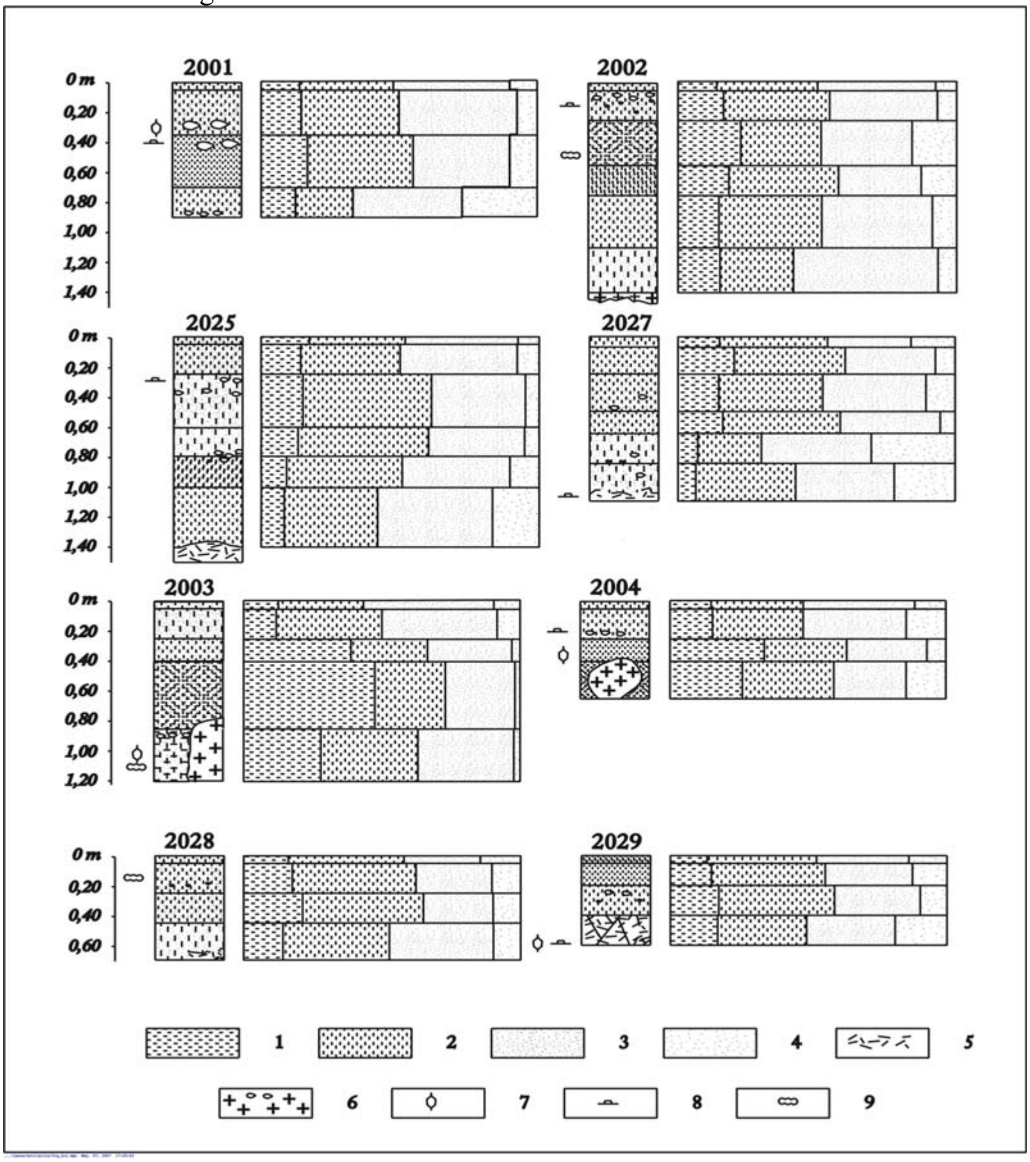

Fig. 2. Lithologic column and granulometric composition of some pedological sections, Pilisszentlászló, Visegrád Mts. 1. Clay; 2. Silt; 3. Sand; 4. Gravels; 5. Fissured andesite; 6. Massive pyroxene andesite; 7. X-ray sample; 8. Thin section sample; 9. Pollen sample.

Table II.

Morphology & Geology	Stand 61A	Stand 65B	Difference
Slope conditions	Steep (8-15°)	Gentle (0-8°)	Yes
Orientation	NE to NW	S to SW	Yes
Hydrologic network	Creeks	Streamlets, marches	Yes
Thickness of the soil level	0,6-1,6 m	0,6-1,4 m	No
Soil stratification	Scarce	Scarce	No
Parental rock	Andesite	Andesitic tuff	Yes
Alteration state of the rock	Medium	Medium	No
Sand fraction of the soil	34,81-69,89 %	26,89-58,54 %	Yes
Composition of the sand	Andesite	Andesite & pumice	Yes
Clay content of the soil	11,81-47,56 %	6,43-20,39 %	Yes
Illuvial clay concentration	Present	Present	No
Clay minerals	Mm+ill (±Kaol)	Mm+ill (±Kaol)	No
Content of montmorillonite	26-39 %	~20 %	Yes
Other minerals	Q+Plag ±Amf	Q+Plag ±Amf	No
Fissuration of the rock	Intense	Scarce	Yes

Table III.

Soil level	Stands	Immobile water	Hardly bounded water, %	Useful water, %	Medium bounded water, %	Fading point, %
A_0	61A	5,90	26,20	29,90	3,70	11,20
A_0	65B	2,70	33,20	37,80	4,60	4,60
A	61A	6,60	24,70	28,10	3,40	11,20
A	65B	2,80	31,1	35,10	4,00	4,40
B	61A	10,70	23,70	27,40	3,70	15,30
B	65B	8,50	22,90	26,80	3,90	10,60

If the difference between the value of the useful water and the fading point is significant (Table III.), the probability of the drying of the soils and the pert of the trees is low. The problems appear on the stands, where during the long dry periods, with short time rainfalls, an dried soil levels can be formed, impeding the natural water take up of the trees. In this kind of the soils, in the accumulation level in some case the upper value of the useful water content is near to the fading point.

Examining the different soil sections, with different geological background and for different tree species, it is clear, that during their long time evolution, the proportion between the forest forming tree species was stabilized. In some cases, it is important to determine, what is the relation between the momentary humidity and the kind of water, which is present in the pores. The knowledge about the soil characters and their water managements' peculiarities permits to promote the adequate technology of the exploitation of the forest, taking account of the presumable climatic change.

Now, in our Institute, a project in which the relation between the parents rocks, the soil level and the state of the vegetation, especially the growth rate of the trees, in different morphological condition will be studied. Finally, according to the tendencies of the climatic parameters, some recommendations on the plantation, maintenance and felling of these will be proposed.

6. CONCLUSIONS

The Hungarian forests present a zonal distribution, beginning from the oak and oak-hornbeam zone and finishing with the beach-tree zone. This zonality depends to the climatic factors, to the morphology (orientation of the slopes) and the soil structure. The most frequent soil type is the brown forest soil.

The physical properties of soils, as water capacity and pore space distribution could be determined by water absorbtion method. The aim of the determinations is to follow the water management of the soils, i.e. the presumed climatic changes, which influenced directly the optimal silvicultural strategy. As example, the physical measurements and soil mineralogy of two experimental stands were shown.

7. ACNOLEDGEMENTS

The authors are indebted of dr. János Kalmár and dr. László Kuti (Geological Institute of Hungary) for the field works and for the mineralogical studies. The paper was supported by GVOP found No. 3.1.1.– 2004–05–0190/3.0.

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Received: 13. 03. 2007,
Revised: 24. 04. 2007
Accepted for publication 21. 05. 2007