Introduction to Special Issue on Biohydrology

Biohydrology deals with the investigation, modelling and mitigation of the impact of biological factors on hydrological processes in the unsaturated zone of soil (vadose zone), above all on the downward and upward movements of water, and the distribution of the rainfall into the infiltration and the runoff at the soil surface. The acceleration of the upward movement in the vadose zone is caused by the uptake of water by plant roots. While the slow upward movement of water is driven by evaporation, the rapid upward movement of water is driven by the transpiration of plants. To have sufficient water for transpiration, evaporation, and cooling, the roots transport water during hot days from greater depths to the near-surface layer at night (the hydraulic lift). The acceleration of the downward movement of rainwater in the soil matrix is caused by the surface-vented macropores formed by plant roots and burrowing soil animals. Covering soil particles, the amphiphilic compounds released from decaying leaves and roots, soil animal (earthworms, ants, etc.) exudates, as well as root and microbial mucilages, can change the pore characteristics by influencing the soil-water contact angle. As a result, water repellency (hydrophobicity) or wettability (hydrophilicity) of the topsoil can influence the distribution of the rainfall into infiltration and runoff. Soil water repellency can also reduce the agricultural production by a patchy growth and a delay in germination. Cultural practices like core aerification, topdressing with sand, inoculation with wax-degrading bacteria, claying, liming, and the use of wetting agents (surfactants) are used to increase the infiltration rate in the water repellent soils. On the other hand, a shallow ploughing can reduce the bypass flow and deeper penetration of solutes via soil macropores.

The international conference on "Bioclimatology and Natural Hazards" held in Zvolen and Poľana nad Detvou, Slovakia, 17–20 September 2007, covered the interactions between meteorological, climatological, hydrological, and biological processes in the atmosphere and the soil. More than 250 participants from 16 countries of 4 continents presented 141 oral and 67 poster contributions in 12 sessions. Special issue on biohydrology features 14 peer-reviewed papers of the selected contributions from the Plenary session (2) and four special sessions (Biohydrology (8), Hydrology and pedology (2), Natural hazards (1), and Air pollution and technological bioclimatology (1)), and 6 papers of excellent scientists dealing with this field. A special issue is dedicated to the 80th Anniversary of Prof. Miroslav Kutílek, whose CV is presented in the next paper.

In the papers, the results of the fundamental research on biology-hydrology interactions in soil are presented, including new measurement and modelling techniques that help us unravel this complex problem. Kutílek and Jendele focused on the impact of the soil structure on the hydraulic properties. The separation procedure for the two mutually different domains – structural and matrix pores was proposed. For each domain was obtained its water retention function and unsaturated hydraulic conductivity function. It was concluded that the separation of hydraulic functions for the two domains is a key problem in the solution of flow in such soils.

Šimůnek *et al.* briefly reviewed some recent applications of the HYDRUS models that used nonequilibrium features to simulate nonequilibrium water flow and the solute transport in the vadose zone. The HYDRUS models were applied for the simulation of the water flow and the solute transport in structured soils where either zones of immobile water or (and) preferential flow occurred. Many situations of the dissolved substances transport involved not only physical nonequilibrium but also chemical one. The two-site kinetic sorption concept was applied in such cases. In addition, the transports of colloids and bacteria were also simulated using the HYDRUS models. This documented the applicability of HYDRUS software packages for a wide variety of hydropedological problems.

Rajkai selected several Hungarian studies to discuss four primary and three secondary soil roles in bioclimatology. He discussed the primary soil impact on the dew formation and the plant water

supply, retaining of water in and evaporating it from the soil, hydrology formation of a lowland Scots pine forest, and the stand climate in a Sessile Oak forest. The secondary soil impact concerned greenhouse gas (CO_2) emitting and fixing by different plant production forms, moisture status in weather formation, and storm formation. He concluded that a new discipline, investigating the soil role in bioclimatology, may be accelerated by the growing environmental and economical impacts of changing climate and weather extremes which are more and more obvious and pressuring.

The chernozem soil water regime response to the predicted climate change scenarios was presented by Farkas *et al*. The simulation results, accomplished by using soil hydrophysical data from three soil management systems of a long-term tillage experiment, indicated that appropriate soil tillage systems that are combined with mulching and ensure soil loosening, could reliably decrease water losses from the soil. From this aspect, the cultivator treatments created the most favourable soil conditions for the plants.

Although ephemeral and difficult to measure, the occult precipitation resulting from wind driven low clouds and fogs can represent an important delivery mechanism in many coastal and mountainous regions, both from hydrological and ecological points of view. Fišák *et al*. deals with this transport mechanism and compared pollutant concentrations in samples of water collected from both solid (rime) and liquid (fog) types of occult precipitation. The importance of the deposited precipitation was proved for the observed region of the Czech Republic

Gömöryová *et al*. examined the windthrow and fire disturbances as a process affecting soil properties, especially microbial activity, in the Tatra National Park (Slovakia). The extensive experimental research was performed at four research plots differing in the maintenance of the forest canopy affected by a forest fire (an area where timber was extracted, a non extracted site, a burnt site, and a reference site covered by mature spruce forest). Based on the evaluation of the soil samples analyses, the microbial activity on each experimental site was evaluated and it was proved that the highest microbial activity occurred on the plot affected by fire while the soil microbial activities on the extracted and non-extracted sites were similar.

Jafarzadeh *et al*. evaluated the land suitability for wheat, barley, alfalfa, maize and safflower in the Bilverdy research station of the Islamic Azad University in East Azarbaijan (Iran). The Simple Limitation Method, the Limitation Method regarding Number and Intensity and the Parametric Methods such as the square-root and the Storie methods were used. The results showed that the most important limiting factors are climate, pH, organic matter, gravel, salinity and sodicity, taken either alone or in combination. For safflower, the cation exchange capacity can be added to these factors.

Kleidon quantified the entropy production by evapotranspiration with a climate system model of intermediate complexity and estimated its sensitivity to the vegetation cover. The hydrologic cycle is a system far from thermodynamic equilibrium that is characterised by its rate of entropy production in the climatological mean steady state. Over land, the hydrologic cycle is strongly affected by the presence of terrestrial vegetation. In order to investigate the role of biota in the hydrologic cycle, it is critical to investigate the consequences of biotic effects from this thermodynamic perspective. The article present the analysis of geographical variability of the entropy production and its sensitivity to the vegetation cover.

Lukács *et al*. developed a multi-scale complex stress diagnostic system based on the water balance calculation with a smaller pot number. They presented the results of drought stress studies of two different winter wheat genotypes and concluded that the operation of their diagnostic system was successful, and that it can be used to estimate the elements of the soil water balance in plant drought stress tolerance studies under glasshouse conditions.

Merta *et al*. used three experimental basins of different sizes (from 7 to 384 square kilometers) as the field laboratories with sophisticated long-term measurements of hydrological processes in order to analyse the effect of land use changes on the runoff generation processes and on the hydrograph. Two different models were used in the project of flood protection and nature conservation in the Eastern Ore Mts. (Germany) to determine the risk areas with quick runoff processes and to simulate the discharge for selected scenarios. Based on the model simulations, a well-preserved and structured landscape seems to be positive both for the flood prevention and nature conservation.

Novák presented the term physiological drought as a state of soil, in which both the soil water content of the root zone decreases below the limit called critical soil water content of limited availability for plants, and the transpiration rate decreases below its potential transpiration rate. He concluded that this situation leads to a drop in the biomass production.

Šír *et al*. evaluated the heat balance, potential and actual transpiration, entropy production and gross primary productivity in order to assess synergy between hydrologic extremes, plant transpiration, gross primary productivity, and soil water retention. The results obtained, that are based on an experimental research in the Šumava Mts. (Czech Republic), clearly demonstrated that the soil water retention is the crucial factor determining the hydrologic pattern and gross primary productivity. In the case of a watershed with a sufficient enough retention capacity and covered by transpiring vegetation cover, the hydrologic cycle is generally more resistant to great climatic perturbances in the course of vegetation season.

Šútor *et al*. presented a new classification system for the soil water regime based upon quantified data sets. They applied this method for the data measured in one region of the East Slovakian Lowland that displays large variations in soils and depths to ground water level. They suggested that the method is valuable and progressive since the present classification systems of the soil water regime evaluation have been mainly based upon climatologic factors and soil morphology.

Tesař *et al*. assessed the extreme surface runoff formation governed especially by the soil water movement and retention. In the time period observed the extreme runoff was generated by the saturation excess caused by extreme rains that the soil cover was not able to catch and thus prevent catastrophic floods. As a case study, the mountainous region of the Krkonoše (Giant) Mts. was chosen during August 2002, when intensive rainfalls afflicted the whole Czech Republic.

Four papers in this special issue deal with soil water repellency. Hallett described this phenomenon arising from the fundamental principals of the water transport and storage in soil. Exacerbation of repellency through climate changes and the use of "engineered" soils for amenity surfaces were demonstrated using the research findings from around the globe. It was concluded that before developing a rapid solution to repellency based only on water transport rates, a holistic understanding of the impacts on soil water relations is essential.

Czachor applied two simple models of a non-cylindrical (wavy) capillary to show the impact of the pore shape and the wetting angle on water sorptivity in soils. It was found that the wetting angle derived from the Washburn approach gives an overestimated value because of pores being modelled as round capillary tubes, whereas in reality they are tortuous, wavy, and interconnected. In wavy capillaries, the impact of the wetting angle on water sorptivity and capillarity driven water transport can be much more pronounced compared to that in Washburn approach.

Orfánus *et al*. measured the variability of water repellency of pine-forest arenic regosols and its influence on the infiltration processes using the water drop penetration time tests and infiltration tests with a miniature tension infiltrometer (3 mm diameter). All results suggest that hydraulic properties of soil change below the centimetre scale resolution of the current study, probably due to the presence of unevenly distributed hydrophobic material.

Wahl estimated the variability of water repellency on forest sites with identical substrate and climatic conditions, but differing in the tree age and species. Both the water drop penetration time test and the critical surface tension test revealed a seasonal variability in water repellency, exhibiting the highest water repellency for the upper 10 cm of the soil during the summer months, whereas the variability between the different plots seems to be less significant.

We would like to conclude by expressing our hope that the results of the present special issue will act as a stimulus for initiating new research projects dealing with the worldwide increasing trend concerning the impact of biological factors on soil hydrology.

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