J. Hydrol. Hydromech., 71, 2023, 2, 123–124
https://doi.org/10.2478/johh-2023-0014

sciendo Journal of Hydrology and Hydromechanics Institute of Hydrology SAS

Biological factors impact hydrological processes

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In every climate zone, vegetation significantly affects the water cycle (Chang, 2006). As ecohydrological interactions play key role in ecosystem functioning, understanding the mutual relationship between the amount of water supplied to the water circuit and the water that is taken from the soil is critical to vegetation (Thom and Keeton, 2019). Projections suggest that Europe will receive an increased water input in the spring, but they will be exposed to more frequent and intense droughts in the summer (Lehner et al., 2006). The role of water and his interaction with biota will determine the fate of human societies (Keesstra et al., 2021).

Most recent research works (Allen et al., 2020) embracing both global and very detailed approaches, show how important and current the biological factors impacting the hydrological processes are. The current state of knowledge about the mechanisms of water capture by vegetation, the quantity and quality of water that reaches the soil, and the quantity and quality of water that is taken up by trees, many questions remain open. With the development of new computational tools and more accurate research apparatus, there are opportunities for comprehensive studies into the water cycle.

The special issue contains 9 papers whose authors participated in the 6th Biohydrology conference (held in Krakow, Poland, on September 6–9, 2022), supplemented with two biohydrological papers (by Balashov et al. and Ng et al.) in order to have 10 full-text papers in issue 2/2023. The papers examined the wide range of processes that drive soil biology/hydrology interactions from the micro- (water storage capacity of lichen thallus or water stability of aggregates) to regional- (how hydrology is affected by increased acreage of eucalyptus in the highlands of Ethiopia) scale.

In the surface boundary layer, actual evapotranspiration is one of the components of water balance affecting crop yields. Balashov et al. (this issue) estimated the thermal and hydrophysical properties of the sandy Haplic Podzol during the growing period of spring wheat. Spearman's rank correlation coefficients showed that the increase in soil moisture content (SMC) from 0.10 cm^3 cm^{-3} to 0.26 cm^3 cm^{-3} resulted in a significant increase in thermal conductivity, volumetric heat capacity, and thermal diffusivity. Actual evapotranspiration increased with the increasing SMC and matric water potentials. As a consequence of the changes in SMC, the Spearman's rank correlation coefficients supported the strong positive relationships of actual evapotranspiration with volumetric heat capacity, thermal conductivity, and thermal diffusivity.

Dew (as an important fraction of the non-rainfall water, NRW) serves as an important water source in the Negev dew desert. According to the classical model, local nocturnal katabatic winds that descend down the slopes during the night to the wadi beds are responsible for the accumulation of cold air, subsequently triggering dew formation in the wadis. Kidron et al. (this issue) found that whereas the classical model takes place during the winter during which the katabatic winds may play a central role in dew formation, the occurrence of the sea breeze (regional wind) during the late summer and fall overshadows the effect of the local katabatic winds. These findings point to the possibility that the classical model may not adequately predict dew formation in regions subjected to sea-breeze winds.

Klamerus-Iwan et al. (this issue) examined the relationship between polycyclic aromatic hydrocarbons (PAHs) accumulation and rainwater uptake for two lichen species, common in urban forests around the world – *Platismatia glauca* and *Pseudevernia furfuracea*. Water storage capacity, *S*, of lichen thallus was determined using laboratory-simulated rainfall. PAH bioaccumulation differed between species and among the samples from clean and polluted environments. After exposure to polluted air, the concentration of PAHs was higher in *P. glauca* than *P. furfuracea*. Samples from the non-urban setting, however, showed no differences between the two species. In the case of *P. glauca*, *S* decreased from 35.8% in samples from clean environment to 8.3% after six months of exposure in the urban setting. The respective *S* values for *P. furfuracea* were 25.4% and 12.4%. Results strongly suggest that PAH exposure reduces S in both lichen species. The results obtained in this experiment confirm the effect of pollutants on lichens (Klamerus-Iwan et al., 2020).

Abandonment of agricultural fields triggers the ecosystem recovery in the process referred to as secondary succession. Lichner et al. (this issue) studied the impact of secondary succession during 12 years lasting abandonment of agricultural fields with loamy sand and sandy loam soils on soil properties, namely soil organic carbon content, pH, water and ethanol sorptivity, hydraulic conductivity, water drop penetration time (WDPT), and repellency index (RI). The studied soils showed a permanent increase in WDPT and a monotonous decrease in pH and water sorptivity with the duration of field abandonment. The dependence of the other characteristics on the duration of field abandonment was not unambiguous.

Ng et al. (this issue) investigated the effects of biochar on the soil hydrological and agronomic properties of two decomposed soils (i.e., completely decomposed granite (CDG) and lateritic soil) for the growth of *Pinellia ternata*, the root tuber of which has been used in recovering COVID-19 patients. The macro-nutrient (i.e., N, P, K, Ca, and Mg) concentration of both soils increased substantially, while the pH and cation exchange capacity levels in the amended soils were altered to facilitate optimum growth of *P. ternata.* The tuber biomass in biochar amended CDG at all amendment rate increases by up to 70 %. In case of lateritic soil, the tuber biomass increased by 23 % at only 5% biochar application rate.

Leaf wettability is an important parameter characterising the plant's ability to retain water on its surface, and is linked to the ecosystems' hydrological and ecological functioning. Papierowska et al. (this issue) investigated the relationship between leaves' wettability based on contact angle measurements and water storage capacity (interception) for ten common wetland plant species collected from Biebrza peatlands (Poland). They used CAM100 goniometer for the wetting contact angle measurements on the leaves' surface, and the weighing method for the plant surface water storage determination. The wetland plants' initial contact angle values ranged from 64.7° to 139.5° and 62.4° to 134.0° for the leaves' adaxial and abaxial parts, respectively. The average plant surface water storage was equal to 0.31 $g \cdot g^{-1}$, and values ranged from 0.09 to 0.76 $g \cdot g^{-1}$. The leaf hydrophobicity contributes to the amount of retained water. With increasing average contact angle, the amount of water retained on the plant decreased.

The heat generated during wildfires modifies soil characteristics, including soil water repellency (SWR) and the water stability of aggregates, which are known to be interrelated. SWR lowers the rate of water entry into aggregates, minimizing aggregate disruption and subsequent erosion. Perera et al. (this issue) examined SWR and water stability of thermally heated water-repellent soil aggregates collected from *Eucalyptus grandis* forest soil. They found that all aggregates were wettable once exposed to 250°C, and water stability of aggregates increased with duration of heating irrespective of decreasing SWR.

Drylands are ecohydrologically-coupled ecosystems whose functioning depends on the interplay between hydrological connectivity between runoff source areas and the capacity of vegetation to retain water fluxes and associated resources. Rodríguez-Lozano et al. (this issue) present the BalanCR method (Balance between Connectivity and potential Water Retention Capacity), a new easily applicable methodology for the ecohydrological characterization of dryland ecosystem functioning. They applied the BalanCR method on four semiarid hillslopes along an altitudinal aridity gradient covered by Mediterranean alpha steppes. The obtained results were validated based on soil moisture data and vegetation greening and clearly recognized the four study sites as functional ecosystems, with very low water resource losses, and a pattern of increasing water redistribution processes as vegetation coverage declines.

Aggregates affect the flow of water in the soil and their formation is linked to soil organic matter. Šimanský et al. (this issue) studied how the rate of biochar and varying levels of nitrogen fertiliser being applied to silty loam soil (Haplic Luvisol) affect the dynamics of soil aggregation due to the increase in the content of soil organic carbon, labile carbon in the bulk soil and in the content of water-stable aggregates size-fractions. They found that biochar and N fertilisation had different effects on the aggregation processes in individual size-fractions of water-stable aggregates. Biochar was a significant variable in more water-stable aggregates size-fractions than N fertiliser. Biochar compared to nitrogen fertiliser more significantly affected the content of almost all the size-fractions of water-stable aggregates.

The highlands serve as water towers for the blue water in the surrounding area, with often insufficient rainfall for rainfed crops. The population is growing in the highlands and changing the hydrology and blue and green water availability. One of the changes that affect the highlands of Ethiopia is the rapidly expanding areas of small patches of eucalyptus on farmers fields. Steenhuis et al. (next issue) developed a water balance model as a starting point to discuss how hydrology is affected by increased acreage of eucalyptus in the highlands. They found that patches of eucalyptus during the dry phase may withdraw water from the subsoil up to twice the rate of evapotranspiration when the soil water is not limited. Since saturation excess generates surface runoff in the subhumid and humid highlands, water withdrawn during the dry phase should be made up before the area with eucalyptus becomes hydraulically active. They also found that soil crusting and water repellency might induce infiltration excess runoff. A tentative implication is that since most blue water is produced in the areas with the highest rainfall, eucalyptus will affect the blue water supply in the surrounding lowlands but not the green water availability in the highlands.

Rainfall interception process is an important part of the biohydrological cycle, in which vegetation plays an important role by regulating the amount and dynamics of rainfall reaching the ground. Zabret et al. (this issue) performed an event-based analysis based on continuous measurements of soil volumetric water content VWC in the open and below groups of two deciduous (*Betula pendula* Roth.) and two coniferous trees (*Pinus nigra* Arnold), as well as rainfall in the open and throughfall on an urban experimental plot in Ljubljana, Slovenia. VWC values in the upper depth (16 cm) were the highest under the birch tree, followed by the location in the open and under the pine tree. However, VWC values in the lowest depth (74 cm) were the lowest under the birch tree. VWC responses to rainfall and throughfall showed seasonal patterns related to the pre-event wetness conditions, with a faster occurrence of maximum VWC values in the leafless period.

All these papers show how much the combination of biological and hydrological factors cannot be analyzed separately. It can be said that they often result from each other or strengthen or weaken each other's effect. Hydrological aspects will become more important due to the changing climate and changes taking place in each natural and anthropogenic environment.

REFERENCES

Allen, S.T., Aubrey, D.P., Bader, M.Y., Coenders-Gerrits, M., Friesen, J., Gutmann, E.D., Guillemette, F., Jiménez-Rodríguez, C., Keim, R.F., Klamerus-Iwan, A., Mendieta-Leiva, G., Porada, P., Qualls, R.G., Schilperoort, B., Stubbins, A., Van Stan, II, J.T., 2020. Key questions on the evaporation and transport of intercepted precipitation. In: Van Stan, II, J.T., Gutmann, E., Friesen, J. (Eds.): Precipitation Partitioning by Vegetation: A Global Synthesis. Precipitation Partitioning by Vegetation. Springer, Cham, pp. 269–279. https://doi.org/10.1007/978-3-030-29702-2_16

Chang, M.T., 2006. Forest Hydrology: An Introduction to Water and Forests. 2nd Ed. Taylor & Francis, 488 p.

Keesstra, S., Sannigrahi, S., López-Vicente, M., Pulido, M., Novara, A., Visser, S., Kalantari, Z., 2021. The role of soils in regulation and provision of blue and green water. Philosophical Transactions of the Royal Society B, 376, 1834, 20200175.

Klamerus-Iwan, A., Kozłowski, R., Przybylska, J., Solarz, W., Sikora, W., 2020. Variability of water storage capacity in three lichen species. Biologia, 75, 899–906. https://doi.org/10.2478/s11756-020-00437-7

Lehner, B., Döll, P., Alcamo, J., Henrichs, T., Kaspar, F., 2006. Estimating the impact of global change on flood and drought risks in Europe: a continental, integrated analysis. Climatic Change, 75, 273–299.

Thom, D., Keeton, W.S., 2019. Stand structure drives disparities in carbon storage in northern hardwood-conifer forests. Forest Ecology and Management, 442, 10–20.