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Editorial

Soil Hydrology for a Sustainable Land Management: Theory and Practice

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Abstract: Soil hydrology determines the water–soil–plant interactions in the Earth's system, because porous medium acts as an interface within the atmosphere and lithosphere, regulates main processes such as runoff discharge, aquifer recharge, movement of water and solutes into the soil and, ultimately, the amount of water retained and available for plants growth. Soil hydrology can be strongly affected by land management. Therefore, investigations aimed at assessing the impact of land management changes on soil hydrology are necessary, especially with a view to optimize water resources. This Special Issue collects 12 original contributions addressing the state of the art of soil hydrology for sustainable land management. These contributions cover a wide range of topics including (i) effects of land-use change, (ii) water use efficiency, (iii) erosion risk, (iv) solute transport, and (v) new methods and devices for improved characterization of soil physical and hydraulic properties. They involve both field and laboratory experiments, as well as modelling studies. Also, different spatial scales, i.e., from the field- to regional-scales, as well as a wide range of geographic regions are also covered. The collection of these manuscripts presented in this Special Issue provides a relevant knowledge contribution for effective saving water resources and sustainable land management.

Keywords: soil hydrology; sustainable land management; soil water content; water fluxes; soil erosion; runoff; spatial variability; BEST-procedure; Hydrus-1D; Arduino

1. Introduction

The United Nations defines sustainable land management as "the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions".

Soil hydrology determines the water-soil interactions in the Earth's system. Specifically, soil acts as an interface within the atmosphere, biosphere and lithosphere, and regulates main processes of the hydrosphere as runoff discharge, aquifer recharge and soil water content [1–3], represents a critical part of environmental sciences. However, due to the ongoing climate change, more sensitive agro-environments will have to adapt to the changed thermo-pluviomentrical trends (among others, the increase in crop evapotranspiration, impact of rainfall erosivity) [4–6], and sustainable land management will the main issue, especially for countries of Mediterranean basin. As a consequence, there is a need to develop and test new methods and experimental procedures to assess those changes from a soil hydrology perspective.

The main goal of this Special Issue (SI) was to present advanced researches on soil infiltration methods, grand water recharges, soil water content dynamics, and about the impact of vegetation type on physical and hydraulic properties of the soil (i.e., water repellency, hydraulic conductivity, soil water content). Contributions of this SI were focused on: BEST-procedure [7] application, for a simple and expeditious method for estimating hydraulic properties of the soil [8–11]; Steady version of the Simplified method based on a Beerkan Infiltration run (SSBI method) [12] for field saturated hydraulic conductivity (K_s) estimation [13]; Hydrus-1D and SWAP codes for modelling soil water dynamics [11,14,15]; a new low-cost device for the automation of K_s measurements in the laboratory [16]. Also, investigations on the topic of rainfall erosivity [6,17], or the impact of land-vegetation cover interaction on soil water content [18] and soil water repellency [19], increased our knowledge on the sustainable management of specific agro-environments. A synthesis of main results and/or innovative methods to assess those changes from a soil hydrology point of view were reported in the following section.

2. Overview of This Special Issue

This Special Issue collects 12 original contributions focused on soil hydrology and aimed to address the challenging topic of sustainable land management. From a methodological point of view, the contributions involve both field [8–11,13,19] and laboratory [14,15] experiments, and modelling [6,16–18] studies. The Special Issue includes studies carried out at different spatial scales, from the field- to regional-scales. A wide range of geographic regions are also covered, including Brazil [11,13], Mexico [16], Mediterranean basin [6,8,10,14,18], and Central [15,17,19] and Western [9] Europe. Specifically, contributions focus on five main topics including (i) land-use change [8,12,18,19], (ii) water use efficiency [14], (iii) erosion risk [6,17], (iv) solute transport [15], and (v) new methods and devices for improved characterization of soil physical and hydraulic properties [9–11,16].

Topic (i) comprises four papers. Hewelke et al. [19] assessed the influence of the abandoning arable use and the spontaneous afforestation with a pine stand on soil hydraulic properties. This author showed evidence of the occurrence of soil water repellency on the surface layer.

Lozano-Baez et al. [13] investigated the recovery of top-soil saturated soil hydraulic conductivity (K_s), soil physical and hydraulic properties in five land-use types in the Brazilian Atlantic Forest. The studied land-use types included (i) a secondary old-growth forest; (ii) a forest established through assisted passive restoration 11 years ago; (iii) an actively restored forest, with a more intensive land-use history and 11 years of age; (iv) a pasture with low-intensity use; and (v) a pasture with high-intensity use. They used the Beerkan method to determine K_s values in the field and also measured tree basal area, canopy cover, vegetation height, tree density and species richness in forest covers. These authors reported that K_s estimates decreased when land use was more intense before forest restoration actions.

Castellini et al. [8] assessed the impact of alternative soil management strategies (conventional tillage and no-tillage) on physical and hydraulic properties of fine-textured soils, applying both field and lab procedures.

Lozano-Parra et al. [18] investigated the effect of the interactions between soil moisture and vegetation covers on soil temperature. These authors monitored for two and a half hydrological years of soil water content and soil temperature of open grasslands and below tree canopies.

Topic (ii) comprises one paper. Ventrella et al. [14] presented a method based on a physically-based Hydrus-1D model to increase the water use efficiency of cropping systems. This model was calibrated by optimizing the hydraulic parameters based on the comparison between simulated and measured soil water content values. The model allowed us to simulate the soil water contents measured under a typical cultivation scheme of a drip-irrigated horticultural system.

Topic (iii) comprises two papers. Gericke et al. [17] used the universal soil loss equation (USLE) to identify areas of erosion risk in the federal state of Brandenburg, NE Germany. Using an ensemble of climate scenarios, these authors assessed the impact of climate change on rainfall erosivity and the potential soil erosion risk.

Baiamonte et al. [6] applied the Revised Universal Soil Loss Equation (RUSLE) model to two Sicilian (Italy) vineyards subjected to different management practices. These authors studied the interactions of rainfall erosivity and cover management factors, as well as their time scale effects, for the vineyard crop.

Topic (iv) comprises one paper. Szymkiewicz et al. [15] used the SWAP model to simulate transient water flow and solute transport for ten layered soil profiles composed of materials ranging from gravel to clay. The simulated scenarios were compared with simplified approaches for estimating solute travel time.

Topic (v) comprises four papers. Castellini et al. [10] investigated the relationships between soil physical and hydraulic properties and wheat yield at the field scale and tested the Beerkan estimation of soil transfer parameter (BEST) method for the spatialization of soil hydraulic properties.

Silva Ursulino et al. [11] investigated the dynamics of soil water content in two plots in the Gameleira Experimental River Basin, Northeast Brazil. Specifically, Time Domain Reflectometry (TDR) probes and Hydrus-1D for modelling one-dimensional flow were used in two stages: with hydraulic parameters estimated with the Beerkan Estimation of Soil Transfer Parameters (BEST) method and optimized by inverse modelling. The performance analysis of the simulations provided strong indications of the efficiency of parameters estimated by BEST to predict the soil moisture variability in the studied river basin without the need for calibration or complex numerical approaches.

Bouarafa et al. [9] assessed the hydraulic properties of sustainable urban drainage systems (SuDS) located in the urban zone of Lyon (France). They used the BEST method to analyze infiltration data and for the determination of both shape and scale parameters of the soil water retention curve $h(\theta)$ and the hydraulic conductivity curve $K(\theta)$. This study allowed us to reveal the infiltration inefficiency of some of the structures.

Rodríguez-Juárez et al. [16] presented a new automated laboratory infiltrometer for the determination of the saturated hydraulic conductivity. The device consisted of low-cost components and was realized using the popular Arduino microcontroller board and commercially available sensors.

3. Conclusions

The 12 original manuscripts collected in this SI have reported experimental results, based on both standard and innovative methodologies, for the sustainable land management and from soil hydrology.

The collected contributions were summarized by grouping them into five main topics to show research advances in specific fields as effects of land-use change, water use efficiency, erosion risk, solute transport, and new methods and devices for improvements on the characterization of physical and hydraulic properties of the soil.

Highlights of this SI suggest, or confirm, that the main hydrological processes can be affected, both at the small or medium-large scale, by the changes in soil use by the stakeholders. These changes can worsen the optimal balance between water and air into the soil, can have relevance for the erosion processes of the soil, but also can change the hydrometeorology of specific environments. Investigations on specific environments, i.e., agricultural, forestry or of transition between them, were presented in this SI, and the man-made impacts were quantified to account for possible environmental effects.

Overall, the manuscripts of this Special Issue reported results for poorly investigated environments. However, for some relatively more investigated agro-environments (i.e., extensive or high-income crops), findings highlighted the need to establish further comparisons to select and evaluate eco-sustainable agricultural practices. A direct or indirect common thread among manuscripts was to share viable solutions to optimize the water resource, or to increase the water use efficiency in specific environments.

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