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Editorial

Special Issue: Soil Hydrological Processes in Desert Regions: Soil Water Dynamics, Driving Factors, and Practices

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1. Introduction

Soil hydrology is an inter-discipline of soil science and hydrology that mainly focuses on interactive pedologic and hydrologic processes and properties [1]. The Critical Zone is the thin layer of the Earth's terrestrial surface and near-surface environment and plays a fundamental role in sustaining life and human society [2,3]. Deserts, altogether a unique ecosystem, have become a more critical research area in the Earth's Critical Zone framework but one that is less managed. There is a vast amount of literature suggesting that we could tip the climate to a more humid and productive stage if we could vegetate these desert regions [4].

The significance of desert ecosystem management requires supportive and regulatory ecosystem services, ecosystem sustainability, and a feedback loop between ecological and hydrological processes [5]. Although the benefits of reversing desertification, preventing erosion, and providing biomass have been recognized, the effects of anthropogenic revegetation on soil water and carbon cycles, among many other soil hydrological processes, are still poorly understood. Over recent years, the soil structure, water retention capacity, fertility including organic carbon, and aggregation after the conversion of native desert soil into irrigated arable land have significantly changed [6]. Assessments of soil water dynamics and their driving factors are urgently needed for artificial-vegetation restoration in desert areas and the sustainability of dryland ecosystems.

This Special Issue aims to provide the highlights of the recent advances in several aspects related to the soil hydrological processes in desert regions, such as the control of land degradation and desertification, climatic and soil–water interactions, soil–plant–water–biota processes, the biogeochemical process for C and nutrient cycling, etc.

2. Summary of the Special Issue

This Special Issue publishes eleven articles, each providing valuable insights into deeply understanding the soil hydrological processes in desert regions. All the article contributions to this Special Issue are crucial for desert ecosystem management and dryland sustainability from plant responses to soil hydrological process, soil–water interaction, and practice implication perspectives. The studies covered a broad range of topics including desert-dominant species' response to soil water dynamics in extremely dry shifting desert regions; the driving factors of soil moisture in alpine deserts, desert wetlands, and desert lakes; the biogeochemical process for C and nutrient cycling in extremely dry desert regions;

the dynamic changes of soil erosion in urban desert areas; and practices for a biological protection system in shifting-sand deserts.

In the context of dominant natural species' response to soil water dynamics in extreme dry shifting desert regions, Qin et al. [7] compared the differences in the water use characteristics between two dominant species of the Badain Jaran Desert mega-dunes—*Zygophyllum xanthoxylum* and *Artemisia ordosica*—by investigating ^{2}H and ^{18}O in plant xylem and soil water and ^{13}C in plant leaves. The results confirmed that the differences in water use between the two studied species were mainly related to their root distribution characteristics. Liu et al. [8], based on the mechanistic understanding of how plant photosynthesis responds to plant drought resistance in desert regions, analyzed the daily dynamics of gas exchange parameters and their responses to photosynthetic photon flux density at three irrigation levels for two main species, *Calligonum mongolicum* and *Haloxylon ammodendron*. The results showed that *Haloxylon ammodendron* was better adapted to drought stress than *Calligonum mongolicum*. Furthermore, in determining the optimal water-saving irrigation regime, Liu et al. [9] examined the effects of irrigation regimes on the soil water dynamics and quantified the irrigation intervals and periods based on a field test of precision irrigation control in the Taklimakan Desert Highway shelterbelt. The results displayed that combining 35 mm irrigation with 10 days was beneficial to soil water storage and plant use for *Calligonum*, while combining 35 mm irrigation with 40 days was best for *Haloxylon*. In addition, Ma et al. [10], based on the issue of the impact of artificial shelterbelt constructions with saline irrigation on the soil water characteristic curve, conducted three treatments including one under the shelterbelt, on bare land in the shelterbelt, and in shifting sandy land in the hinterland of the Taklimakan Desert. The results pointed out that the influence of organic matter and salinity affected the soil water characteristic curves, which should be considered in future modeling.

Given the lacking degree of investigation on the driving factors of soil moisture in alpine deserts, desert wetlands, and desert lakes, Zhang et al. [11] examined the spatial heterogeneity and driving factors of soil gravimetric water content in the typical alpine valley desert of the Qinghai–Tibet Plateau using geostatistical analysis and the geographical detector method. The results indicated that the spatial heterogeneity and its driving factors of the soil gravimetric water content are ranked as elevation > slope > location > vegetation > aspect. Wang et al. [12], based on the issue of less attention to soil moisture and salinity in arid desert wetlands, assessed the soil moisture and salinity in the Ebinur Lake Basin. The results demonstrated that the spatial distribution of soil moisture had a higher mutation rate and stronger heterogeneity than that of soil salinity in the Ebinur Lake Basin. Jia et al. [13] investigated the hydrochemical status and evolution of lakes in the Badain Jaran Desert to understand why diverse lake water types exist under the same desert climatic conditions. The results showed that the evaporation–crystallization reactions are the controlling factors of lakes.

In the studies on the biogeochemical process for C and nutrient cycling in extremely dry desert regions, Zhang et al. [14], based on the issue of the elusive factor determining the leaf nutrients of phreatophytes in desert regions, revealed the key factors affecting the ecological stoichiometry of desert phreatophytes in the shallow groundwater of three oases in the southern rim of the Taklimakan Desert. The results showed that groundwater depth played a critical role, which was closely related to the mineralization degree of the groundwater, the topsoil C and P concentrations, and the topsoil salt content and pH. Huang et al. [15], on the issue of the little attention paid to the effects of increasing water availability on N use strategies in desert shrub species (*C. caput-medusae*), examined the changes in plant biomass, soil N status, and plant N traits, and addressed the relationships between them in 4- and 7-month-old saplings and mature shrubs after 28 months. The results displayed that increasing water availability increased the total N uptake and N resorption from old branches to satisfy the N requirement.

In an urban desert area, Zhang et al. [16] worked on the issue of the soil erosion modulus, which is closely associated with desert evolution and desertification controls.

They analyzed the spatial and temporal dynamics of soil erosion in the North and South Mountains of Lanzhou City and the soil erosion characteristics under different environmental factors and found that the soil erosion modulus is the greatest in the pedocal of the North and South Mountains and the least in the alpine soil of the mountains.

Finally, Zhao et al. [17], based on the challenge of building a highway and its biological protection system in the Taklimakan desert, comprehensively illustrated that local saline groundwater irrigation offered potential advantages and opportunities for the growth of halophytes and sandy soil development in hyper-arid desert environments.

3. Conclusions

This Special Issue highlights the current understanding of the soil hydrological processes in desert regions, as well as the plant responses to soil water. Likewise, this Special Issue will not present all the aspects, such as the challenges of soil hydrological process research and its opportunities in the desert regions. It only provides notable highlights to help understand the soil hydrological processes and their application in desertification control, particularly regarding the ecological engineering approach. In this context, we especially hope this Special Issue will enrich soil hydrology in the desert regions for advancing critical zone science in the Anthropocene.

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