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Controls of infiltration–runoff processes in Mediterranean karst rangelands in SE Spain

Xiao-Yan Li [a,b,*], Sergio Contreras [b,c], Albert Solé-Benet [b], Yolanda Cantón [d], Francisco Domingo [b,e], Roberto Lázaro [b], Henry Lin [f], Bas Van Wesemael [g], Juan Puigdefábregas [b]

[a] State Key Laboratory of Earth Surface Processes and Resource Ecology, Beijing Normal University, Beijing 100875, China
[b] Estación Experimental de Zonas Áridas, Consejo Superior de Investigaciones Científicas, Carretera de Sacramento s/n, La Cañada de San Urbano, 04120 Almería, Spain
[c] Centro de Edafología y Biología Aplicada del Segura, Consejo Superior de Investigaciones Científicas, Campus Universitario de Espinardo, 30100 Murcia, Spain
[d] Departamento de Edafología y Química Agrícola, Escuela Politécnica Superior, Universidad de Almería, 04120 Almería, Spain
[e] Departamento de Biología Vegetal y Ecología, Escuela Politécnica Superior, Universidad de Almería, 04120 Almería, Spain
[f] Dep. of Crop and Soil Sciences, 116 ASI Building, The Pennsylvania State Univ., University Park, PA 16802, USA
[g] George Lemaître Centre for Earth and Climate Research, Earth and Life Institute, Université Catholique de Louvain, 1348 Louvain-la-Neuve, Belgium

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ABSTRACT

Semiarid karst landscapes represent an important ecosystem surrounding the Mediterranean Basin for which little is known on runoff generation. Knowledge of the sources and patterns of variation in infiltration–runoff processes and their controls is important for understanding and modelling the hydrological functions of such ecosystems. The objectives of this paper are to determine the infiltration rates and their controls in a representative mountain karst area (Sierra de Gádor, SE Spain) at micro-plots and to investigate the integrated response of rainfall on a typical hillslope. Rainfall simulations in micro-plots and natural rainfall-runoff monitoring on a hillslope were carried out complementarily. We investigated the role of soil surface components (vegetation, rock outcrop, fracture, and soil crust), topographic position, antecedent soil moisture, and rainfall characteristics in regulating infiltration–runoff processes. Results of rainfall simulation revealed the importance of vegetation cover and the presence of rock fractures in promoting the infiltration in the limestone karst landscape, while bare patches and rock outcrops acted as sources for runoff. All plots with >50% vegetation cover had no runoff with up to 55 mm h^{-1} of simulated rain. In contrast, nearly all bare plots had runoff under the same simulated rain, with runoff coefficients ranging from 3.1 to 20.6% on dry soil surface conditions, and from 2.0 to 65.4% on wet soil surfaces. Runoff coefficients amounted to 59.0–79.5% for rock outcrops without cracks, but were drastically reduced by the presence of cracks. The surfaces with rock fragments resting on the soil (generally located in the middle of the slopes) prevented more effectively the runoff generation than those surfaces where rock fragments were embedded in the top soil. Antecedent soil moisture had significant impact on runoff generation, with wet soil having doubled runoff coefficient, shortened time to runoff, and increased runoff rate compared to the same but dry soil. Linear regressions indicated that the main controls for constant infiltration rate were the cover percentages of vegetation and litter, plus rainfall intensity; while the major controls for runoff coefficient were the bare soil and vegetation coverage, plus rainfall intensity. High infiltration rates measured at the micro-plots agreed with low intra-event runoff coefficients (mostly below 1%) observed under natural rainfalls at the hillslope. Runoff depth and coefficient at the hillslope was significantly correlated with rainfall depth, maximum hourly rainfall intensity and antecedent precipitation over 20 days (AP_{20}). During the 1.5-year monitoring period from Sep-2003 to Mar-2005, the overall infiltration was 41% of the total rainfall amount and the maximum infiltration rate was almost 94% of the largest single rainfall event. The results from this study contribute to improved understanding of the magnitude and controls of the surface runoff in semiarid karst mountain areas.

1. Introduction

Hydrological processes in semiarid areas, such as infiltration and runoff are highly variable in space and time. Knowledge of the sources and patterns of variation in these processes and their controlling factors is crucial for understanding and modelling the hydrological functioning of semiarid ecosystems (Mayor et al., 2009). Previous

* Corresponding author at: State Key Laboratory of Earth Surface Processes and Resource Ecology, Beijing Normal University, Xinjiekouwai Street 19, Beijing, 100875, China. Tel.: +86 10 58802716; fax: +86 10 58802716.
E-mail address: xyli@bnu.edu.cn (X.-Y. Li).

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