MONITORING HYDROLOGY AND SEDIMENT TRANSPORT IN A MEDITERRANEAN AGRICULTURAL CATCHMENT (MALLORCA, SPAIN)

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ABSTRACT. A study of hydrological and sediment transport was conducted in Can Revull, a Mediterranean agricultural small catchment (1.03 km^2) mostly under-drained. Mean annual precipitation and discharge are 517 mm and 4.1 l s^{-1} respectively. On the annual and seasonal time scales, PET generates a succession of three hydrological periods and plays an important role in baseflow dynamics. The annual average SSC was 17.3 mg l^{-1}, with a maximum of 2,270 mg l^{-1}. Suspended sediment yields were an order of magnitude lower than other Mediterranean catchments because the historical use of soil conservation practices. At event-scale, multiple regression models identify the significant effect of water-storage capacity and under-drainage conditions over quickflow response, a fact made evident by the high annual runoff rates (≈ 25%). However, rainfall intensity variables negatively correct the runoff behaviour as the Hortonian response is limited to dry seasons when baseflow is not present and discharge values therefore tend to be lower. Nevertheless, rainfall intensity is the most significant variable in sediment supply.

KEY WORDS: Water balance; rainfall-runoff; suspended-sediment transport; multiple regressions; under-drainage system; Mediterranean.

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1. Introduction

The hydrologist's interest in small catchments is very old; the tradition of hydrologic studies of small catchments started more than 100 years ago (Walling 1975). Early hydrological studies were summarized for instance by Keller (1988). Crucial to the understanding of catchment processes, and so to the ability to predict future changes in an ecosystem, is identification of hydrologic pathways within the catchment and the related transit times for water and sediment. Each catchment may be dominated by a particular mechanism depending on climatology and geology and different processes may be dominant in a given catchment at various times as a function of storm intensity and duration, and catchment antecedent wetness.

Additionally, small river catchments are spatial units that are especially sensitive to natural and man-made processes. In view of that, intensive land use has transformed historically the ecosystems of the Mediterranean Sea basin, with the clearing of fields for agriculture (Grove 1996) being the major factor affecting erosion and hydrological processes (Douglas 1993). However, the implementation of soil conservation practices can result in reduced sediment yields because are aimed at increasing moisture retention and storage and reducing the on-site impacts of soil erosion linked to reduced soil productivity and crop yields (Walling 2006), whilst traditional water extraction practices may cause an enhancement of streamflow. Consequently, for more than two millennia, in Mediterranean countries traditional soil conservation and water extraction practices, including terraces on steep slopes and subsurface tile drainage systems on gentle slopes (Grimalt et al. 1992; Zgaier and Inbar 2005) have been applied to provide effective protection of cultivated land.

A research project is in progress in the Na Borges catchment since 2004, an agricultural lowland river located in the island of Mallorca, aiming at establishing a comprehensive water and sediment budget (Estrany and Garcia 2005). In this context, Can Revull is a representative area selected to study hydrological and sedimentary dynamics and contribution of headwater catchments to the Na Borges catchment. This study emphasizes the need for a better understanding of the hydrology and suspended sediment (hereafter SS) transport of Mediterranean rainfed herbaceous crop areas, the role played by tile drainage on runoff (hereafter R) variations and by soil conservation practices in sediment mobilization. Specific objectives involve the analysis of flow and SS transport at different time scales:

(a) At annual and seasonal time scales were carried out a simple water balance; analyzed the flow duration curves of R and its components; and assessed SS concentrations (hereafter SSC), loads and yields.

(b) At event scale, multiple regression models were constructed to analyze the rainfall-runoff relationships and SS transport dynamics.

2. Study area and methods

2.1. Study area

The Can Revull gauging station drains an area of 1.03 km^2, flowing into the Torrentó de Boscana (7.9 km^2), a headwater tributary of the Na Borges River; this is a lowland agricultural basin (319 km^2) located in the north-eastern part of Mallorca, Spain (Figure 1). The geology of Can Revull is characterised by a structurally gentle alpine relief in the Central Ranges of the island composed of molassic and Miocene calcarenites, which rest discordantly over a deformed Mesozoic-Cenozoic substratum. The maximum altitude of the catchment is 144 m a.s.l. The channel length is 2.4 km and the average channel slope is 4.7% (10% in the first 400 meters, and 2% downstream).

The climate of the catchment can be classified as sub-dry Mediterranean, with a mean annual temperature of 16.5°C and mean annual rainfall of 517 mm (1974–2006, data from the Boscana Nou station, located 1.5 km from the Can Revull gauging station). The seasonal distribution of precipitation is Autumn > Winter > Spring > Summer with an inter-annual variability of 23%. The main characteristic of the rainfall is its torrential behaviour, especially during late summer and autumn when the daily intensity can reach 100 mm (i.e., 25-year recurrence interval). The average daily discharge was 4 l s^{-1} for the period 2004–2007. Potential evapotranspiration is 1,010 mm yr^{-1}, estimated after Thornthwaite (1948).

Soils are deep and well-developed on Quaternary alluvial sediments supported by an impervious lower-middle Miocene (Burdigalian) layer, characterized by a fine silt texture (Díaz Palmer et al. 2006). The soils, together with the concave low plain topography and the humid winters, are the main factors behind the construction of the subsurface-tile drainage network, which occupies 75% of the catchment.

The steep and convex topographic areas are terraced with dry-stone walls, a historical management practice on the island (Reynés and Riera 1994). The catchment land cover consists primarily of rainfed herbaceous crops (91%). These are located on the flat and subsurface drained areas. The main crops are cereals such as wheat

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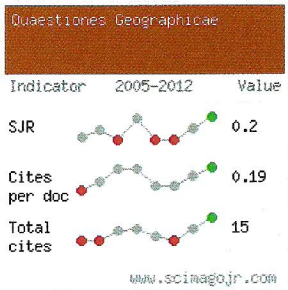

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Scope:

Quaestiones Geographicae was established in 1974 as an annual journal of the Institute of Geography, Adam Mickiewicz University, Poznań, Poland. Its founder and first editor was Professor Stefan Kozarski. Initially the scope of the journal covered issues in both physical and socio-economic geography; since 1982, exclusively physical geography. In 2006 there appeared the idea of a return to the original conception of the journal, although in a somewhat modified organisational form. Quaestiones Geographicae publishes research results of wide interest in the following fields:

•physical geography,
•economic and human geography,
•spatial management and planning, (source)

Charts Data

Indicators	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
SJR	0,171	0,102	0,103	0,102	0,101	0,101	0,112	0,144	0,102	0,190	0,102	0,100	0,148	0,201
Total Documents	0	0	10	8	0	7	8	18	20	18	19	36	40	29
Total Docs. (3years)	15	14	7	10	18	18	15	15	33	46	56	57	73	95
Total References	0	0	297	205	0	169	160	254	325	483	392	860	1.106	850
Total Cites (3years)	1	0	0	1	1	0	1	1	7	8	3	1	8	15
Self Cites (3years)	0	0	0	0	0	0	1	0	0	4	0	1	3	2
Citable Docs. (3years)	15	14	7	10	18	18	15	15	31	43	51	54	70	93
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Cites / Doc. (3years)	0,07	0,00	0,00	0,10	0,06	0,00	0,07	0,07	0,23	0,19	0,06	0,02	0,11	0,16
Cites / Doc. (2years)	0,07	0,00	0,00	0,10	0,06	0,00	0,00	0,07	0,17	0,17	0,03	0,03	0,11	0,19
References / Doc.	0,00	0,00	29,70	25,63	0,00	24,14	20,00	14,11	16,25	26,83	20,63	23,89	27,65	29,31
Cited Docs.	1	0	0	1	1	0	1	1	5	5	3	1	7	15
Uncited Docs.	14	14	7	9	17	18	14	14	28	41	53	56	66	80
% International Collaboration	0,00	0,00	0,00	0,00	0,00	28,57	0,00	0,00	0,00	0,00	0,00	2,78	2,50	17,24