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Origin and type of rainfall for recharge of a karstic aquifer in the western Mediterranean: a case study from the Sierra de Gador–Campo de Dalias (southeast Spain)

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Abstract:

Isotope signatures in precipitation from the Global Network for Isotopes in Precipitation around the Mediterranean basin and literature data are compared with isotopic data from a large karstic aquifer in southeast Spain to explain the origin and type of the precipitation events dominating recharge. Analysis of the deuterium excess d at the scale of the Mediterranean basin and at the regional scale allows us to understand the isotopic context of the study area: Campo de Dalias and the Sierra de Gador (Almería province). The origin of precipitation can be determined from its d value. The d value changes as a function of the initial evaporation condition. It depends on the relative humidity and temperature during the evaporation producing the water vapour of the clouds. The water vapour, which dominates the study area, is generated in two areas: the Atlantic Ocean ($d = 10‰$) and the western Mediterranean basin ($d = 15‰$). With increasing precipitation volume, the western Mediterranean character dominates. These heavier storms contribute mainly to recharge, as illustrated by the d value of 13·6‰ in deep groundwater of the Campo de Dalias. Weighted d values increase with the volume of precipitation, giving a significant relationship for the southern and eastern coasts of the Iberian Peninsula. This selectivity of d to monthly precipitation was used to estimate the return period of precipitation leading to aquifer recharge at 0·9–4·9 years. Moderate rainfall, which occurs more frequently, still represents ~60–90% of the total precipitation. One of the challenges to meet ever-growing water demands is to increase recharge from moderate events yielding intermediate quantities per event, but forming the bulk of the annual precipitation. Copyright © 2006 John Wiley & Sons, Ltd.

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INTRODUCTION

Water demand around the Mediterranean basin is growing at an alarming rate. Like many Mediterranean region, the Campo de Dalias (Almería province, southeast Spain) is suffering from large increases in the use of groundwater from its major aquifers. This region is a prime example of an area where the aquifers are under pressure, as groundwater supplies essential water needs for agriculture and tourism. Since the 1960s, Almería province has become the most important region of Europe for horticultural products. Agriculture and its parallel industry constitute the economic driving force in the region. Greenhouses now cover an area of more than 20 000 ha in the Campo de Dalias. Furthermore, the service industry is mainly oriented towards tourism, which is expanding. González-Asensio *et al.* (2003) estimated the annual water use at 140 hm^3 for 1999–2000, greatly exceeding the recharge of 50 hm^3 given by Pulido-Bosch *et al.* (1993). Although the aquifer volume is very large, exploitation of groundwater has produced environmental problems. The piezometric level has fallen to 30 m below sea level in the western lower aquifer (González-Asensio *et al.*, 2003), and some coastal areas suffer from marine intrusions, leading to salinization of groundwater (Pulido Bosch, 1998; Pulido Bosch *et al.*, 2000). Hence, the study of the aquifer recharge patterns is of major economical and environmental interest.

In the Mediterranean region, stable water isotopes (δD and δ^{18}O) have often been used to understand the recharge of aquifers (Bajjali *et al.*, 1997; Tantawi *et al.*, 1998; Nativ *et al.*, 1999; Maliki *et al.*, 2000; Longinelli and Selmo, 2003; D'Alessandro *et al.*, 2004). The deuterium excess ($d = \delta D - 8\delta^{18}O$) reflects the relative humidity and the air temperature of the region where the evaporation leading to rainfall occurred (Jouzel, 1986; Gonfiantini, 1996; Vandenschrick *et al.*, 2002). In regions with contrasting origins of precipitation, the d value could be a link with weather patterns that generated the precipitation. According to the relation existing between ^{18}O and deuterium, the deuterium excess d could also be used to determine the origin of precipitation and in which proportion rainfall from different origins contributes to

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