INTRODUCTION

• Spring data is used to investigate the hydrological and hydrochemical processes in the subsurface that finally determine nitrate occurrence in groundwater and can also be indicative of the nitrate leaching toward the underlying aquifer (Fig. 1).
• Nitrate variations over time in springs are evaluated as a function of geological setting, land use and rainfall events.
• Nitrate concentration, electrical conductivity (EC) and spring discharge were measured in 13 springs every two weeks from January 2010 to February 2011. Two extensive hydrochemical analyses were also conducted.
• Springs are located in the Osona region (1,260 km², NE Spain), which has intensive livestock and agricultural activities. Average nitrate concentration in springs range from 8 to 380 mg/L (Fig. 2).

RESULTS: Discharge, EC and nitrate time series

Four common patterns, named Hydrologic Response Type (HRT), were identified among springs (Fig. 3):

HRT 1: Springs are found in crystalline rocks, unsuited to agricultural activities. Therefore, nitrate concentration is very low. Discharge, EC and nitrate content remain fairly constant throughout the year, with no influence from rainfall.
HRT 2: It represents springs that drain widespread surface deposits. Spring flow is governed by the hydraulic head in the alluvial formation, and it is insensitive to rainfall events. EC and nitrate are homogenized within the aquifer and show small variations along time.
HRT 3: Springs occur at the geological contact with the underlying, less permeable, marl or sandstone formation. Discharge trends show the influence of major rainfall periods, yet specific flow peaks after rainfall events were not always recorded. Discharge decreased progressively during low flow periods. In contrast, EC increased. Nitrate content, however, shows a small, progressive increase.
HRT 4: These springs drain sedimentary formations. Discharge and EC fluctuate consistently with rainfall periods. When no rainfall is reported, these variables remain fairly stable or decrease slightly. However, no clear relationship can be observed between nitrate content, and discharge and EC evolution.

Variogram analysis

• Geostatistical analysis of discharge and nitrate time-series (Fig. 4) provided an insight into their temporal correlation; i.e., how hydrological processes govern these two variables along its flow-path from recharge areas to springs.
• Nitrate variograms confirmed the finding that nitrate content in most of the springs is constant with small variability patterns.

CONCLUSIONS

• Even though discharge and EC can be related to specific hydrogeological behaviors, nitrate concentration remains remarkably stable throughout the sampling period in most of the springs.
• Geological setting and rainfall events control spring discharge and their hydrochemical characteristics, while the steadiness of nitrate contents is attributed to a homogenization of the subsurface processes after decades of fertilization.
• Land use and agricultural activities determine the magnitude of nitrate content in groundwater.
• Spring hydrological analysis stands as an indicator of groundwater quality and provides a pattern for nitrate input to groundwater, which can be used as a criteria for water resources management.