



## **Assessing vulnerability mapping and protection zones of karst spring waters and validating by the joint use of natural and artificial tracers. The case of Auta Spring (Southern Spain)**

Ana Isabel Marín (1), Matías Mudarra (2), and Bartolomé Andreo (2)

(1) European Topic Centre (ETC-UMA), University of Málaga, 29071, Málaga, Spain, (2) Department of Geology and Center of Hydrogeology of the University of Málaga (CEHIUMA). Faculty of Sciences, E-29071, Málaga (Spain)  
(mmudarra@uma.es; andreo@uma.es)

Delineation of protection zones for water supply and implementation of proper land-use practices in surrounding areas are crucial aspects for a sustainable use of valuable drinking water resources. This is even more important in karst aquifers, which are particularly sensitive to contamination, having a very low self-cleaning capacity due to their structure and hydrological behavior. Consequently, specific methodologies adapted to the particular characteristics of karst media are necessary. In this work, an approach for protection zoning of the pilot site of Auta karst spring (southern Spain) is proposed, based on the application of COP+K method for contamination vulnerability and validation of results by natural (organic) tracers of infiltration ( $\text{NO}_3^-$ , TOC, intrinsic fluorescence) and by a dye tracer test conducted on June, 2011 (injecting 500 mg uranine). The aquifer drained by Auta spring (8.5 km<sup>2</sup>) presents a complex geological structure, formed by Jurassic dolostones and limestones highly folded and fractured. Recharge takes place by the infiltration of rainfall through karst landforms and also by losses in an adjacent river when it flows over the carbonate outcrops (dye injection point). Drainage is mainly through several springs located at the southwest, including Auta spring and 5 overflow springs.

The source vulnerability map obtained by applying COP+K method can be adopted as the baseline to delineate the protection zones, through the conversion from vulnerability classes to degrees of protection. Dye tracer test and natural tracers of infiltration corroborate that aquifer sectors influenced by the river can be extremely vulnerable to pollution, but also well-developed exokarst features. In fact, slight evidences of pollution have been detected during the study period, with relatively-high  $\text{NO}_3^-$  contents and high fluorescence linked to bacteriological activity in Auta spring water. The jointly use of natural and artificial tracers constitute a reliable and effective procedure for validating vulnerability mapping of karst systems and springs used for water supply. This procedure is meant to implement and to complement protection zone mapping, particularly in countries lacking guidelines for protecting the water resources of karst aquifers.