The KARMA Project


Photo: Jaime Ortega

Groundwater vulnerability mapping to pollution in Mediterranean karst sites

Key findings

This study assesses the groundwater vulnerability to pollution of Mediterranean karst aquifers by the application of COP method, which complies with the conceptual approach of the European COST Action 620.

The Mediterranean karst aquifers studied in KARMA present high spatial heterogeneity regarding vulnerability to pollution, where the most vulnerable areas correspond to highly karstified limestones and thin/bare soils or also drainage areas of sinking rivers and endorreic areas, which natural drainage occurs through swallow holes hydrologically connected to shafts and other endokarst features.

The reliability of the vulnerability maps has been validated by different techniques. This reinforces the viability of these maps as a tool to support decision-making in spatial planning and the progress toward the achievement of the Sustainable Development Goal 6 (SDG6) of the United Nations in order to ensure availability and sustainable management of water and sanitation for all.

Introduction

The water supply of many countries around the world depends -to a large extent- on groundwater. However, the use of groundwater as drinking water depends on its availability and quality. The karst aquifers are especially vulnerable to pollution due their hydrologic behaviour derived from karstification. In this kind of aquifers, contaminants may easily reach the saturated zone and then be rapidly transported through karst conduits over large distances (Figure 1).

Under the current climate change context, the increase of extreme drought frequency is expected in the Mediterranean region. Hence, groundwater quality constitutes a key issue to ensure the water security in karst regions. Groundwater vulnerability assessment methods have been developed to provide the necessary basis for implementing preventive measures facing groundwater protection, considering the delimitation of protection zones one of the most relevant techniques. Therefore, they have are effective tool in the protection of water resources.

The groundwater vulnerability of Unica springs catchment (Slovenia), the Lez spring catchment (France), Ubrique test site (Spain) and Qachqouch spring catchment (Lebanon) have been assessed under KARMA project by COP and COP+K methods (Vias et al., 2006, Andreo et al., 2009) that comply with the conceptual approach of the worldwide applied COST Action 620 (Zwahlen, 2004).

The resulting maps of the KARMA test sites present a high variability of the vulnerability degree due to the complexity and heterogeneity of geological and structural features among the investigated aquifers.

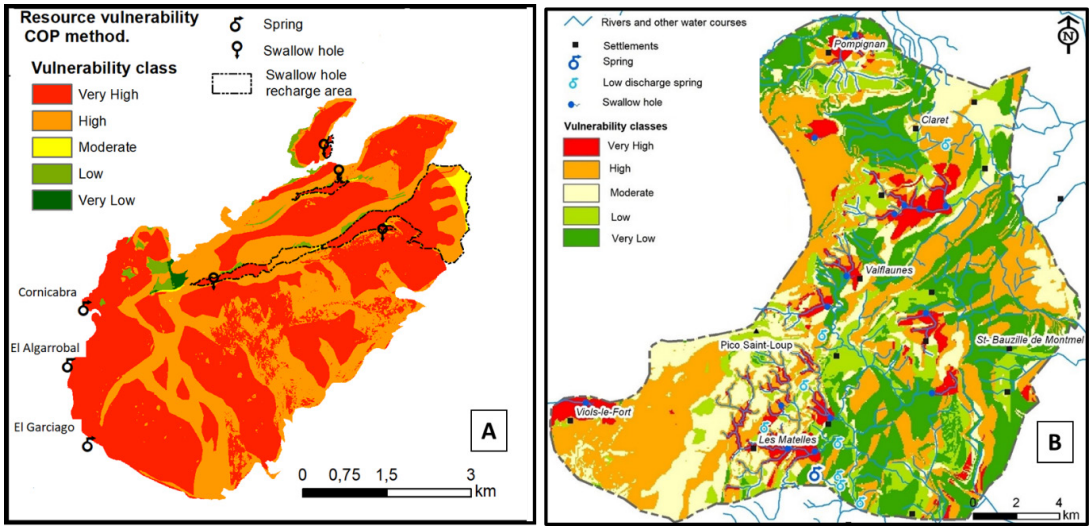

Figure 1: Maps of resource vulnerability to contamination of two KARMA test sites: (A) Ubrique aquifer, Spain, (B) Lez spring catchment area, France

The overall analysis of the KARMA vulnerability maps shows an elevated spatial heterogeneity. As a general trend, the highest vulnerability areas correspond to highly karstified limestones and thin/bare soils or also sinking streams catchments and endorreic areas, which natural drainage occurs through swallow holes hydrologically connected to shafts and other endokarst features. Aquifer sectors influenced by exokarstic landforms, such as karren field or dolines, tend to be less vulnerable than karst swallow holes although in some systems they can present extreme vulnerability. COP method identifies as Low or Very Low vulnerable areas the sectors where low permeability soils and lithology overlying the aquifer exist.

As an example of the results obtained with the COP method, Figure 1 shows the vulnerability maps of the Ubrique aquifer and the Lez spring catchment area. The differences between these maps can be seen in the range contrast of the obtained vulnerability classes in each area and in their spatial distribution. This shows that the vulnerability of karst aquifers, and therefore, the delimitation of the protection zones drinking water sources, require specific studies for each study area that the hydrogeological particularities of the aquifer.

Since the final goal of any vulnerability map is to support stakeholders for decision-making and to promote a land-use management compatible with the groundwater protection, the accuracy and reliability of the obtained maps is required for its practical applications. A solid understanding of the hydrogeological functioning of the aquifer constitutes a key issue for groundwater vulnerability assessment.

Validation may involve a wide range of methods and techniques such as field tracing experiments, analysis of natural responses of karst springs, study of environmental tracers, numerical modeling, etc. (Marín and Andreo, 2015). The natural and artificial tracers are useful techniques to validate the vulnerability maps that complement each other enhancing the knowledge about infiltration/recharge processes and vulnerability in karst aquifers (Figure 2).

In the framework of KARMA project, the vulnerability maps have been validated thorough the analysis of hydrodynamic and hydrochemical responses of the main springs that drain the aquifer, together with the evolution of natural tracers of infiltration and dye tracer tests (Figure 3). Although there is room for further improvement efforts to reduce certain uncertainties, the good results obtained in the validation of the maps demonstrate their usefulness for groundwater protection and land use planning in the recharge basins of the KARMA test sites.

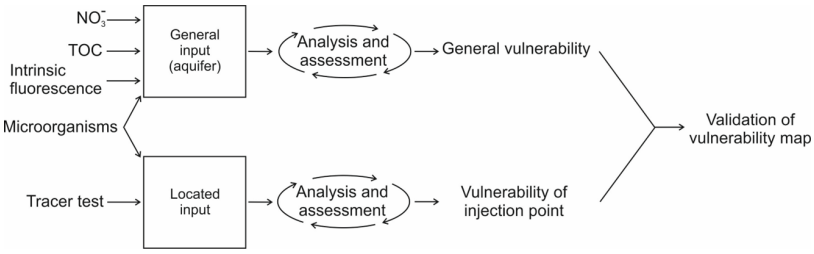

Figure 2: Natural and artificial tracers as techniques for validation of the vulnerability maps (Marín and Andreo, 2015)

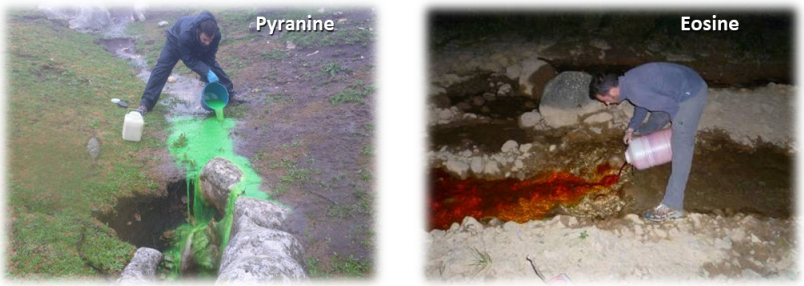

Figure 3: Dye tracer test injections (Karst aquifers in Southern Spain)

References and further Reading

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KARMA policy briefs present relevant scientific results of projects concerning a better karst groundwater management across the scale of the Mediterranean area, single catchments and selected springs.

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