

Karst groundwater-dependent ecosystems in the Mediterranean region

Key findings

Karst groundwater-dependent ecosystems (KGDE) in the Mediterranean region were studied, based on expert consultation and literature review of 112 selected examples.

KGDE in the Mediterranean region contribute considerably to biodiversity including endemic species, but suffer increasingly under anthropogenic pressures.

The most common threats identified among the selected KGDE are direct human disturbances, water-quality deterioration and water shortage from aquifer overdraft and/or climate change.

Some KGDE are covered by the RAMSAR convention or Natura 2000 network, but many others are unprotected.

Raising environmental awareness, efficient groundwater protection and management strategies, and increased interdisciplinary research are required.

Introduction

Mediterranean karst aquifers are important freshwater resources and associated with valuable karst groundwater-dependent ecosystems (KGDE). Groundwater-dependent ecosystems (GDE) are ecosystems whose structure and functioning rely essentially on groundwater. GDE provide important ecosystem services, such as fish and plant production, water purification and supply, and recreation (IAH 2016). KGDE receive water from karst. The diverse hydrogeological and climatic conditions in the Mediterranean area enable the development of diverse KGDE. Due to their typical properties, such as rapid infiltration and transport of pollutants, karst aquifers are highly vulnerable to contamination. To demonstrate the importance and diversity of KGDE, data on 112 representative sites in the Mediterranean region was collected and evaluated using multidisciplinary criteria, including climatic, hydrogeological and ecological properties, as well as information on protection, threats and human impacts.

KGDE variety

Karst springs are prime examples of KGDE and represent diverse, endangered and socio-ecological interacting ecosystems. Yet they are insufficiently 100% appreciated by the public, due to lacking knowledge of their distribution and types (Cantonati et al. 2020). In dry climates, KGDE serve as refuge for species, e.g. at Ein Feshkha oasis (Israel), which is fed by springs transforming the arid environment into wet and green areas. Limestone-precipitating springs host unique habitats for specifically adapted species (Cantonati et al. 2020), e.g. the Plitvice Lakes (Croatia). Karst springs also support the biodiversity of associated wetlands, rivers and lakes. It is often difficult to determine the groundwater contribution and requirements of these ecosystems, but essential to design appropriate management strategies.

Other unique habitats related to the hydrologic variability of karst systems are intermittent lakes, e. g. the Pivka intermittent lakes and the Cerkniško polje in Slovenia. The variable hydrologic conditions induce the presence of plant communities and raise the conservation value of these ecosystems (Ravbar and Pipan 2022).



Figure 1: Percentage of the KGDE in the data collection protected by national, EU and international agreements grouped by the ecosystem types (cave, lake, river, springs, wetland).

KARMA - Karst Aquifer Resources availability and quality in the Mediterranean Area www.karma-project.org The KARMA project aims to achieve a better karst groundwater management across the scale of the Mediterranean area, single catchments and selected springs.



Underground habitats, such as caves, are associated with special environmental conditions (darkness, limited nutrient supply) to which species must adapt. Stygobionts are aquatic species that only occur in subterranean habitats, mostly crustaceans and other invertebrates, but large cavities can also harbor fish and amphibians. Due to the high degree of isolation, cave species often have a limited distribution, which makes them vulnerable to changing environmental conditions (Ravbar and Pipan 2022).

Protection and management

The data evaluation demonstrates the conservation value of KGDE: 63% of the selected sites have endemic species, most frequently at springs and caves. However, many caves are not protected in any sense of legislation. The data collection includes the two caves with the highest reported biodiversity in the world, Postojna cave (Slovenia) and Vjetrenica cave (Bosnia-Herzegovina) in the Dinaric Karst – a hotspot of KGDE. Increasing anthropogenic pressures endanger KGDE. Although some KGDE are protected under national and international conservation programs, e.g. the Ramsar Convention or the EU Habitats and Birds directive, many others remain insufficiently protected. Direct human impacts prevail and must be addressed by restrictions and increased environmental awareness. Negative impacts include habitat destruction and groundwater pollution; water shortage related to increasing droughts and overexploitation also threatens KGDE.

Groundwater management and landuse planning should aim to minimise negative impact on KGDE to sustain ecosystem functions and services which are important for human wellbeing (IAH 2016). Therefore, efficient hydrogeological and ecological monitoring are necessary. A reserved ecological flow helps to ensure basic KGDE requirements. Furthermore, the recognition of invertebrates in conservation programs in required, especially for caves and springs, which stand out by exceptional invertebrate diversity. Interdisciplinary ecohydrogeological research provides the basis for suitable ecosystem management and conservation.



Figure 2: Petelinjsko jezero, one of the Pivka intermittent lakes in Slovenia; a) flooded conditions; b) dry conditions. Photos: Nataša Ravbar.



Figure 3: a) The Postojna-Planina cave system hosts various habitats including seeps (sampling point on the left side of the image), an underground river (on the right side) (photo: Blaž Kogovšek, with permission) b) An endemic of the Dinaric Karst, Proteus anguinus, the first described cave animal in the world. The photo shows a young animal with eyes still visible, later covered with skin (photo: Tanja Pipan).

- Cantonati M et al. (2020) Ecohydgeology: The interdisciplinary convergence needed to improve the study and stewardship of springs and other groundwater-dependent habitats, biota, and ecosystems. Ecological Indicators. IAH (2016) Ecosystem Conservation & Groundwater. International Association of Hydrogeologists. Strategic Overview Series. Ravbar N, Pipan T (2022) Karst Groundwater Dependent Ecosystems—Typology, Vulnerability and Protection. In: Tockner K, Mehner T (eds) Encyclopedia of Inland Waters.

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

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