The KARMA Project

Photo: Nico Goldscheider

Karst groundwater availavility in the Mediterranean region

Key findings

Karst aquifers represent a relevant source of high-quality waters, due to their occurrence in European territory (>20%) and mainly to their huge volumes of spring discharge

Accurate water balances realized in the study sites confirmed the relevant infiltration rate of karst aquifers in the Mediterranean area, with at least 50% of precipitation feeding groundwater resources

The evaluations at the scale of single catchment until regional ridges (from 25 km² to about 1000 km²) carried out with different methods allow comparable and reliable assessment of groundwater recharge

The APLIS method results to be the more reliable in assessing groundwater recharge, accounting for geological and morphological conditions at the catchment scale, with some limitations

The upscaling process towards the entire Mediterranean area has been performed and synthetized in MEDKAM, highlighting a general underestimation of recharge rate respect with study-site values

Why karst groundwater resource assessment is important?

Mediterranean karst aquifers are important resources for human and environment, due to their occurrence in European territory (>20%) and mainly to the significant spring discharge they usually provided to the freshwater drinking supply of many Mediterranean cities. Assessing karst resource quantities is a fundamental issue to allow their correct management, specially in current times when overexploitation and climate change are summing their negative effects on effective water availability.
The main aim of KARMA project was to improve the management of groundwater availability and quality across all scales, moving from single catchment and/or spring towards a continental scale approach (Fig.1). An accurate evaluation of water availability has been performed in five study areas, corresponding to karst aquifers with a wide range of recharge area, from 25 km² up to 1000 km².

Recharge rate assessent at spring and aquifer scales

The application of different methods for assessing the karst aquifer recharge rate in case studies located in five Mediterranean countries reveals how APLIS method (Andreo et al., 2008) is a consistent tool for recharge estimation at the aquifer scale, offering results coherent with other classical methods as water budget analysis. Specific limits of APLIS have been found for: i) the net recharge of permanent snow cap; ii) the need to include impermeable areas, with consequent infiltration reduction; iii) discrepancies during drought periods, probably due to the enhancement of evapotranspiration effect.

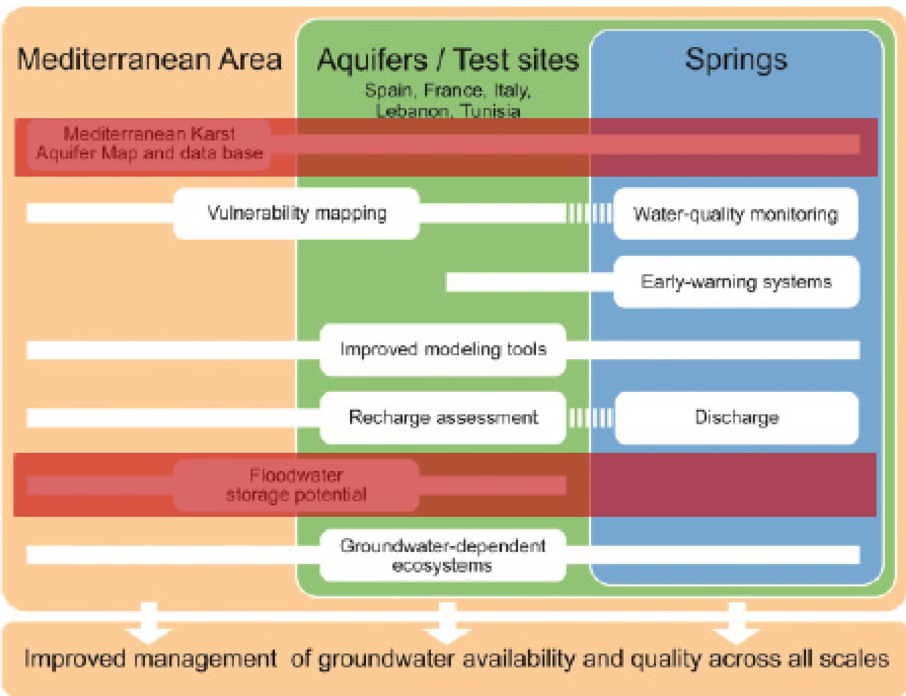

Figure 1: Methodological multiscale approach of KARMA project; the activities related to water availability assessment are highlighted in red.

Nevertheless, in each study site the calculation of the distributed recharge rate based on the APLIS application fits with the monitored spring discharge. Additional confirmations are offered by independent classical karst methods to compare recharge and discharge: both stable isotope analyses and their correlation with recharge areas, and the results of tracer tests performed during the project or collected from previous experiences, confirm the conceptual model of recharge for the studied springs. In detail, stable isotope values appear steady respect with past, evidencing the limited vulnerability of the studied aquifers to recent pressures. In addition, collection of tracer test results evaluated a wide time-transit range, since 2 m up to 2 km per day, with a clear influence not only by cave and conduit occurrence, but also by flow rate conditions. The recharge rates account at least for about half of the precipitation amount in each study site, calculated with APLIS, underestimating in some cases the spring discharge. Recorded recharge rates of 65% demonstrate how karst aquifers can retain up to 2/3 of rainfall, to be released by spring discharge frequently by modulated responses. The amount of groundwater availability in study areas depends on the aquifer extension, ranging from 5 million m^3 to more than 600 million of m^3 per year (see figure 2). Discrepancies of recharge calculated with APLIS with real discharge data are generally lower than 15%, but the underestimation of discharge can reach up to 75% for peak discharge periods. Therefore, APLIS application is not recommended during peak discharge events, but preferentially for average periods.

Water availability at differenet scales

The comparison of recharge rates assessed at the scale of study sites with the results published on the MEDKAM, based on the model proposed by HARTMANN et al. (2021), reveals in teresting bias and uncertainties, moving from recharge assessment at the catchment scale up to the Mediterranean scale. The recharge at local scale is usually higher than the one calculated at continental scale, causing a possible underestimation of real recharge in karst aquifers. This bias can be due to factors, as: i) impossibility to consider local altitude effects at the wider scale; ii) discarding of additional allogenic components due to the karst features at the local scale; iii) seasonal effects, due to the regional conditions, where temperature is a relevant driver in influencing the duration and the entity of summer droughts. A future validation of the recharge evaluation method is expected and it is recommended to take into account the above-mentioned factors emerged by local scale evaluations.

In terms of availability trends, the performed analysis at the Mediterranean scale is based on the groundwater storage calculated from GRACE satellite data (Xanke and Liesch, 2022): slight to severe lowering in groundwater storage has been found in 75% of Mediterranean countries, with a maximum rate of -25 mm/year. In some cases, the groundwater trend is increasing, up to 15 mm/year, with major effects on the southern boundary of the Mediterranean.

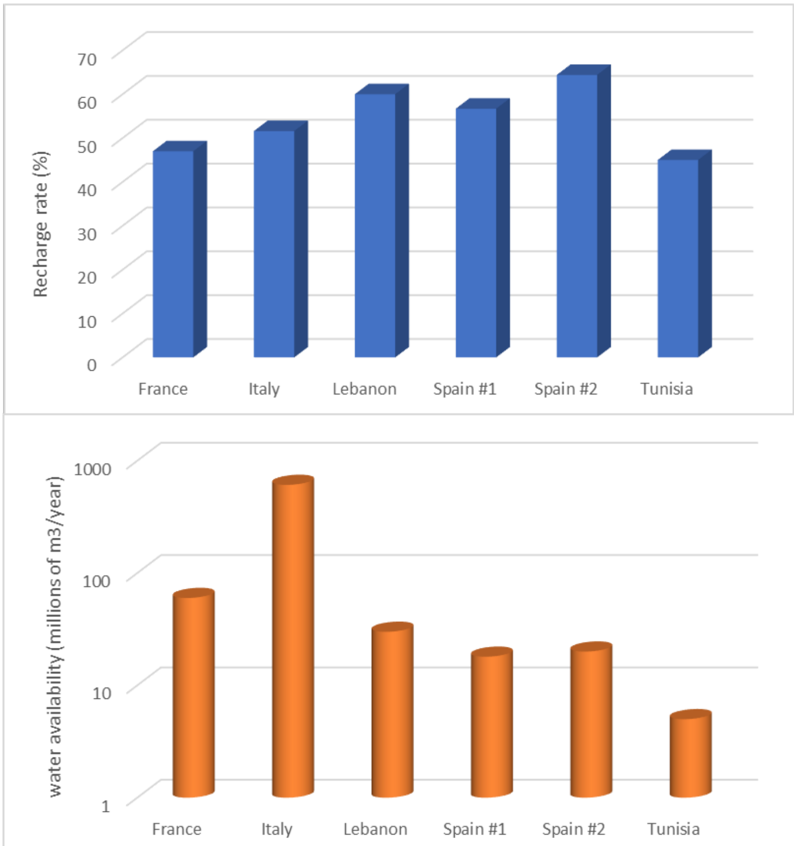

Figure 2: Recharge rate evaluated by APLIS method (above, in blue) and water availability (below, in orange) calculated for each study area.

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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