Integrated methodology to characterize hydro-geochemical properties in an alluvial coastal aquifer affected by seawater intrusion (SWI) and submarine groundwater discharge (SGD)

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ABSTRACT

Coastal zones are increasingly demanded spots for human settlements and economic development, which subject alluvial coastal aquifers to the threat of seawater intrusion (SWI). But they are also strategic areas for the chemical exchange between the continent and marine ecosystems, providing a source of nutrients from the submarine groundwater discharge (SGD) from the aquifer. Furthermore, in these contexts, the characteristics of the freshwater-seawater interface (FW-SWI) and its dynamics are strongly conditioned by the lithology and, among others, the typology of the discharge, density contrasts and tides.

The proper management of such enclaves requires full understanding of the SWI-SGD system, which can only be achieved through a multidisciplinary and multi-scale characterization of the considered aquifer.

For that purpose, we have developed an experimental field site in a coastal alluvial aquifer close to the mouth of a temporary stream in the Maresme coast line (Barcelona, Spain). The aquifer is formed by unconsolidated heterogeneous and polygenic alluvial sediments ranging from very fine to very coarse grained sand with discontinuous interfingering lenses of gravel and silt. All these sediments have around 20 m thickness and are overlying a weathered granitic basement.

Several boreholes were drilled perpendicular and parallel to the shoreline, at various depths to reach different hydraulic conductivity areas along the mixing zone. Hydraulic parameters were assessed using slug tests and taking advantage of the effect of tides in the measured heads. Geophysical techniques including electrical resistivity tomography, fiber optics and different types of logging (induction, spectral gamma ray and magnetic susceptibility) have been performed to characterize the salinity gradient and distinguish sedimentary bodies.

Moreover, a fully hydrochemical investigation was carried out to define the initial groundwater composition using TOC/DOC measurements, mayor and minor elements analysis and radium and radon isotopes quantifications. Also lithological description, sedimentological correlation and geochemical analysis of the cores obtained after drilling (X-ray diffraction, rock total analysis for chemical composition, cation exchange capacity, BET surface area, radium content and grain size distribution) were integrated to fully characterize the initial stage of the experimental site. This integrated multidisciplinary and multi-scale methodology will enable understanding the coupled effects of SWI and SGD in FW-SWI dynamics and give some insights for the study of seawater intrusion processes in many other sites.

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