

## **Hydrogeochemical processes and geochemical modeling in a coastal aquifer: Case study of the Marathon coastal plain, Greece**

Panagiotis Papazotos, Ioannis Koumantakis, Andreas Kallioras, Eleni Vasileiou, and Maria Perraki

National Technical University of Athens, School of Mining & Metallurgical Engineering, Heron Polytechniou Str. 9, Zographou, 15780, Athens, Greece (papazotos@metal.ntua.gr)

Determining the hydrogeochemical processes has always been a challenge for scientists. The aim of this work is the study of the principal hydrogeochemical processes controlling groundwater quality in the Marathon coastal plain, Greece, with emphasis on the origin of the solutes.

Various physicochemical parameters and major ions of twenty-five groundwater samples were analyzed. The hydrogeochemical data of groundwater were studied in order to determine the major factors controlling the chemical composition and hydrogeochemical evolution. In the Marathon coastal plain, three different zones of the alluvial granular aquifer system have been detected, considering the geochemical processes and recharge, which affect its hydrochemical characteristics. The alluvial granular aquifer system is divided eastwards into three zones: a) the natural recharge zone, b) the reverse ion exchange zone and c) the diffusion sea water zone.  $\text{Cl}^-$  is the dominant anion and  $\text{Na}^+$  and  $\text{Ca}^{2+}$  are the dominant cations, as determined by plotting the analyses on the respective Piper diagram. Near the coastline high concentrations of  $\text{Na}^+$  and  $\text{Cl}^-$  were observed indicating a zone of seawater intrusion. On the other hand, westward there is increasing concentration of  $\text{HCO}_3^-$  with simultaneous decrease of  $\text{Na}^+$  is indication of a recharge zone from karstic aquifers of the study area. Between the aforementioned zones there is an intermediate one, where reverse ion exchange takes place due to high concentrations of dissolved  $\text{Na}^+$  and  $\text{Ca}^{2+}$  adsorption. The saturation indices (SI) were calculated using the geochemical modeling software PHREEQC. Mineral phases of halite, sylvite, gypsum and anhydrite were estimated to be undersaturated in the water samples, suggesting these phases are minor or absent in the host rock. On the other hand, calcite, aragonite and dolomite are close to equilibrium; these minerals are present in the host rocks or in the unsaturated zone, possibly increasing the  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$  and  $\text{HCO}_3^-$  concentrations when carbonates are dissolved. The analyses of the bivariate scatter plots, the ionic ratios, the Indices of Base Exchange (IBE), the Gibbs diagram and the dissolution/precipitation reactions show that evaporation and water-rock interaction mechanisms such as dissolution of carbonates, followed by reverse ion exchange, have affected the groundwater chemistry in the study area.

The results revealed that groundwater chemistry and therefore the origin of the solutes in the coastal alluvial granular aquifer system of the Marathon coastal plain is primarily affected by a number of factors such as groundwater and mineral equilibrium, seawater intrusion, reverse ion exchange and nitrate concentration. A possible future research could focus on the interaction among hydrogeochemistry, mineral phases and chemical thermodynamic modeling.