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Use of stable isotopes in order to clarify complex interactions among various water bodies in a coastal aquifer system

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Isotopes of hydrogen and oxygen are commonly applied in groundwater research in order to investigate groundwater origin, movement or interactions with other water bodies and sources of salinity. The present work deals with the elucidation of the complex interactions among various water bodies in a Mediterranean coastal aquifer system i.e. the Neon Sidirochorion aquifer in Northeastern Greece, using their stable isotope composition. The study area comprises several important water bodies and ecosystems; Ismarida lake which is protected by the Ramsar Treaty and during the last 30 years is artificially connected via a channel to the sea, Vosvozis river which discharges into Ismarida lake and the Neon Sidirochorion aquifer which is the main source of irrigation water for this agricultural area and it is subject to saltwater intrusion. Within the present work, the d18O and d2H isotopic composition of seawater, lake water, river water and groundwater in combination with hydrogeological and hydrochemical data were studied in order to reveal the interactions of surface and groundwaters and the origins of salinity within the aquifer system. Additionally, the conceptual model in the study area was determined and is presented taking into account the existing hydrogeological information. Analysis of the seasonal and spatial trends of the isotope pattern showed that all water bodies in the study area interact. It was also shown that increased salinity of the aquifer is not due to relic water from past geological periods, but it is attributed to intrusion of the lake water into the aquifer, a process which is induced because of the extensive groundwater pumping for irrigation. Additionally, direct interaction of the sea was certified only in the case of Ismarida lake which is subject to seawater intrusion during summertime and a consequent increase of the Electrical Conductivity (EC) values its waters. Progressively, brackish lake water moves towards the aquifer with a time lag of approximately 3 months. Using the simple dilution equation, it was estimated that the aquifer is enriched annually by almost 4,5 million cubic meters of brackish water from the lake. From isotopic point of view for the various water bodies, several differences could be observed during different time periods. During winter all water bodies except seawater are plotted very close to the LMWL, indicating thus that precipitation is the main source of water for both surface and groundwaters. During summer, lake water moves clearly towards seawater composition, below the LMWL, indicating thus the seawater intrusion that is known to take place. Additionally the isotopic signatures of the seawater and the groundwaters are considerably different, so the possibility of direct seawater intrusion into the aquifer seems to be very low. Furthermore, the fact that the groundwater dependent ecosystem of Ismarida lake decreases constantly in size and volume, indicates that it cannot sustain the provision of water to the aquifer. Therefore, it is considered of urgent importance to control the pumping quantities from the aquifer so as to minimize water losses from the lake.