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An integrated hydrogeochemical approach to identify multiple salinization sources of a coastal aquifer (Rhodope, Northern Greece)

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The coastal aquifer of the Rhodope region (NE Greece) is a complex groundwater system characterized by locally increased salinity. Identifying the exact nature and spatial orientation of the multi-induced salinization sources and their functioning processes is a major step towards sustainable groundwater management. An integrated methodology has been employed to this aim, which included a toolbox of methods such as classical hydrogeochemical approaches, multivariate statistics, environmental isotopes, and hydrogeochemical modelling.

A set of over 100 samples collected in two periods (beginning and end of the irrigation season) from surface and groundwater resources have been processed with a combination of multivariate statistical methods (Q-mode Hierarchical Cluster Analysis – HCA and R-mode Factor Analysis – FA) for the initial classification, grouping and spatial orientation of the samples. Accordingly, the data was processed with classical hydrogeochemical molar ratios of major and minor ions to perform a preliminary assessment of the potential salinization sources. Outcomes were coupled with a combo multi-isotopic assessment, which included ^{18}O, ^{2}H, ^{3}H, ^{13}C, ^{14}C, CFCs, SF6, ^{15}N, ^{87}Sr and ^{11}B that defined the different salinization sources and processes. Finally, hydrogeochemical modelling with the aid of the PHREEQC code further supported assessments and provided an overview of the spatiotemporal variability of factors and processes affecting groundwater chemistry in both periods.

Results outlined the occurrence of cascading factors that drive groundwater salinization, including seawater intrusion, upconing of deep brines, irrigation water return and geothermal fluid impact. The extent and intensity of the salinization processes are temporally dependent on and affected by the irrigation schemes applied and the local hydrostratigraphic conditions. The integrated methodology applied in this work could provide a robust methodological framework for assessing and characterizing coastal aquifers with similar conditions; thus, providing a versatile ensemble of tools that can significantly facilitate integrated groundwater resources management.

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