Assessing the Impact of Treated Wastewater Recharge on Groundwater Using Piezometric, Isotopic, and Emerging Contaminant Tracers

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ABSTRACT

In semi-arid and Mediterranean regions such as Tunisia, groundwater resources are intensively exploited to meet increasing human demands. This overpumping has led to a significant decline in groundwater levels, degradation of water quality, and disruption of the natural groundwater balance. Artificial recharge has therefore become a key strategy for aquifer restoration and adaptation to global and climate change pressures. Due to the limited availability, or even scarcity, of conventional water resources such as surface water, treated wastewater (TWW) represents a valuable alternative source for groundwater recharge. To monitor and assess the impacts of artificial recharge, various methods are commonly used, including piezometric, chemical, isotopic, and geophysical techniques. However, relying solely on piezometric data is often insufficient, as aquifer responses may be affected by uncontrolled pumping and uncertainties related to the complexity of groundwater dynamics.

This study aims to develop an improved and integrated methodology that combines piezometric monitoring with isotopic analysis and emerging contaminants. This approach provides a novel framework for assessing aquifer recharge using TWW. The methodology was applied to two selected case studies in Tunisia: the Kairouan and Korba regions.

In both study areas, the hydrodynamic survey and the total mineralisation of groundwater did not provide a clear vision of the recharge impact, especially in the site strongly disturbed by agricultural pumping. The stable isotopes showed an evaporative uptake only at the site where the water is transferred over a long distance and spread on the surface. The emerging compounds provided a much finer definition of the extension of the recharge plumes, especially carbamazepine. Results of the non-target analysis were consistent with the history of the site and the relocation of the discharge point. These approaches also highlighted the hydrogeological heterogeneity in sedimentary aquifers that were supposed relatively uniform. Their combination allowed to go much further in understanding the dynamics of these two sites than previous studies.

Keywords: Groundwater; Artificial Recharge; Wastewater; Carbamazepine; Non-Target Analysis