Contribution of Geostatistical Estimation Techniques to the Characterization of the Water Quality of the Albian Groundwater in the Mzab Region (South Algerian)

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Abstract

The Ghardaïa region in the Sahara is characterized by an arid climate with severely limited surface and sub-surface water resources. In this challenging environment, the Continental Intercalary (CI) aquifer system serves as the primary source for drinking water, agriculture, and industry. This extensive groundwater formation is heavily exploited by over 750 wells, yet it is considered a non-renewable resource due to minimal recharge, necessitating careful management and regular monitoring. This study aims to comprehensively assess the current state of the CI system in the Ghardaïa region by examining its exploitation patterns, piezometric changes, and chemical quality. We analyzed piezometric data from 2010 to 2018 and conducted chemical analyses on more than 120 water samples collected across the study area. Advanced geostatistical methods, including kriging and variogram analysis, were employed to develop detailed maps of hydrogeological and hydrochemical parameters. Additionally, we produced variance maps of the estimation error to enhance the accuracy of our findings. Results reveal a significant groundwater level decline across the M'zab region, particularly in major urban centers such as Ghardaïa, Berriane, Metlili, and Zelfana, where water table drops exceeding 8 meters have been observed. Chemical analyses indicate a predominance of evaporite facies, including calcium sulphate, sodium sulphate, sodium chloride, and calcium chloride. While water quality generally meets Algerian Standards for Drinking Water, its suitability for irrigation varies across the region, ranging from poor to good based on the Richards diagram classification. The CI aquifer is naturally protected from anthropogenic pollution by a confining Cenomanian aquitard layer. Water mineralization primarily results from the dissolution of evaporites, particularly gypsum and halite, coupled with base-exchange processes. This comprehensive study highlights the critical state of the CI aquifer in the Ghardaïa region, emphasizing the urgent need for sustainable management practices. The observed groundwater depletion, coupled with the aquifer's non-renewable nature, underscores the importance of developing targeted conservation strategies and optimizing water use efficiency. Our findings provide a crucial foundation for future research and policy decisions aimed at safeguarding this invaluable groundwater resource for current and future generations in this arid environment.

Keywords

Continental Intercalary Aquifer, Arid Hydrogeology, Geostatistical Analysis, Groundwater Depletion, Hydrochemical Facies, Piezometry, Water Quality Assessment