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EDITORIAL MESSAGE: Special Issue: Hydrogeology in Tunisia

Guest Editors:

Dr. Anis Chekirbane, *National Agronomic Institute of Tunisia, University of Carthage, Tunisia*
Dr. Samia Khadhar, *Water Research and Technologies Center, Borj Cedria Technopark, Tunisia*
Dr. Soumaya Hajji, *Faculty of Sciences of Sfax, Sfax University, Tunisia*
Dr. Imen Ayadi, *Higher Institute of Sciences and Technologies of Water, Gabes University, Tunisiaa*

Introduction

Water is the most critical resource in Tunisia, a country characterized by an arid to semi-arid climate along the Mediterranean Sea. With an irregular distribution of rainfall both spatially and temporally, Tunisia's water resources are highly vulnerable to climate change (Hamed et al., 2018). According to the Sixth Assessment Report (AR6) by the Intergovernmental Panel on Climate Change, water scarcity in the region is expected to intensify due to projected decrease in precipitation driven by global warming (Asadnabizadeh, 2022). Surface water and groundwater serve as the primary sources of water for agriculture and drinking supply, making it crucial to understand their distribution, variability, and interaction. Tunisia's total renewable water resources consist of 56% surface water (2.7 billion m^3/year) and 44% groundwater (2.1 billion m^3/year) (BPEH, 2023). Despite a relatively balanced distribution, groundwater remains the primary water source, supplying approximately 75% of total water use. The agricultural sector alone consumes more than three-quarters of the country's water resources. This heavy reliance on groundwater is driven by the significant spatio-temporal variability of surface water, which is strictly dependent on rainfall, whereas groundwater offers a more consistent year-round supply.

Aquifer systems in Tunisia and their exploitation

Due to its geological structure and climatic conditions, Tunisia features three major hydrogeological systems with distinct characteristics: the northern, central, and southern aquifer systems. These systems encompass a variety of aquifers that overlap and interact across the country, covering approximately 73% of Tunisia's land area. More than 212 shallow aquifers and 267 deep aquifers have been identified within these systems (DGRE, 2023).

Northern aquifer system

In northern Tunisia, aquifers are primarily hosted in detrital, sandy, and gravelly formations, as well as alluvial and carbonate layers. Large alluvial aquifers, such as those in the Ghardimaou, Kalaa Khasba, and Fahs plains, are composed of Plio-Quaternary sediments and can reach thicknesses of up to 100 meters (Hachani et al., 2020). These aquifers recharge mainly through precipitation and river floodwaters, providing high-quality water with a total dissolved solids (TDS) content generally below 1.5 g/L. Groundwater extraction is typically conducted via large-diameter wells (3 to 5 m) or deeper boreholes, reaching depths of 100 to 200 meters. In contrast, carbonate aquifers, found in the Eocene limestones of Jebel Sra Ouertane, the Aptian limestones of Jebel Bargou, and Jurassic formations in the Djouggar and Zaghouan Mountains, have limited spatial distribution. These aquifers are primarily recharged by rainfall through karstic fissures and dissolution networks, which support abundant underground flow and the emergence of natural springs. Due to the relatively high precipitation in northern Tunisia (550–1500 mm/year), these aquifers maintain high renewal rates.

Central aquifer system

Central Tunisia features multi-layered aquifer systems within Miocene and Mio-Plio-Quaternary formations, with sediment thicknesses exceeding 600 meters in some areas. The predominant reservoir is the Miocene sandstone aquifer, found in structures such as Kasserine, Sbeitla, Hajeb El Ayoun, and Oum Ali Thelepte. These geological formations are affected by tectonic structures that create hydraulic thresholds, leading to permanent groundwater discharge in rivers such as Oued Derb in Kasserine. Groundwater recharge in these aquifers occurs through direct infiltration of precipitation on outcropping formations and floodwaters from river systems. However, in the eastern Sahel region, groundwater quality is often poor due to the presence of gypsum-rich reservoirs and the release of saline water from sebkhas and seawater intrusion along coastal areas. Water from Miocene aquifers generally has a salinity below 1.5 g/L, and groundwater is extracted through boreholes ranging from 200 to 500 meters in depth, as well as from natural springs (Elloumi, 2016).

Southern aquifer system

In southern Tunisia, surface water resources are minimal, contributing only about 20% of total water availability and displaying significant interannual variability. Consequently, groundwater, particularly from deep aquifers, serves as the dominant water source, with 10% of groundwater use coming from shallow aquifers and 70% from deep aquifers (Mamou & Kassah, 2002). The principal deep aquifers in the region include the Complex Terminal (CT), the Jeffara aquifer, and the Continental Intercalaire (CI). Jurassic aquifers are also present, particularly in the Zeus Koutine region and along the eastern foothills of the Dahar mountains between Ghoumrassen and Dhiba. While the CI and CT aquifers contain vast fossil reserves estimated at 30 billion m^3, only a fraction around 10 billion m^3 is considered exploitable with an annual rate of 2.2 billion m^3. Tunisia shares these transboundary aquifers with Algeria and Libya, with an estimated 550 million m^3/year allocated for use within Tunisian territory (Besbes et al., 2010).

Groundwater utilization and overexploitation

Groundwater resources are distributed across nearly the entire Tunisian territory, allowing for decentralized management. However, despite their widespread availability, many aquifers suffer from overexploitation, particularly shallow aquifers, which have been heavily utilized since the early 2000s.

The reliance on groundwater steadily increased, reaching a point where almost all mobilizable groundwater resources are being extracted. This overuse has led to declining water levels, particularly in deep aquifers in central Tunisia, where the exploitation rate exceeds 100% of natural recharge (DGRE, 2023) (Fig. 1). In northern Tunisia, intensive groundwater extraction began in the 1980s, particularly in Greater Tunis and the Cap Bon region, before expanding into central and southern Tunisia. Initially, withdrawals focused on shallow aquifers, but as these resources became depleted, extraction efforts shifted towards deep aquifers, particularly in the south, despite their largely non-renewable nature (Closas et al., 2018).

Additionally, groundwater quality remains a concern, particularly in shallow aquifers, where only 12% of the resources contain less than 3 g/L of TDS. Pollution from nitrates and other contaminants further deteriorates water quality, rendering some groundwater sources unsuitable for drinking purposes. Conversely, deep aquifers exhibit relatively better water quality, with over 80% containing a salinity below 3 g/L TDS, making them suitable for agricultural and non-agricultural uses.

Main challenges and role of scientific research

Groundwater issues in Tunisia are compounded by inadequate regulation and the widespread drilling of illegal wells. Climate variability further exacerbates the problem, reducing recharge rates and increasing stress on already overburdened aquifers.

To address these challenges, hydrogeological research must be strengthened using advanced methodologies such as numerical simulation and geophysical and geochemical investigations. These tools can improve the assessment of groundwater resources, providing critical insights into recharge mechanisms and sustainable extraction limits. Additionally, nature-based solutions such as Managed Aquifer Recharge offer promising strategies to enhance groundwater sustainability and mitigate overexploitation. Strengthening legal frameworks and improving enforcement mechanisms are also essential for protecting and managing groundwater resources effectively.

This Special Issue of the *Italian Journal of Groundwater*, titled "Hydrogeology in Tunisia" aims to highlight current research on groundwater resources in Tunisia, showcasing innovative approaches and best practices for sustainable management. The issue seeks to foster collaboration among scientists, policymakers, and water resource managers to address critical groundwater challenges by providing a platform for advancing hydrogeological knowledge and developing solutions that balance economic development with environmental conservation.

Kraiem et al. (2025a) found high salinity in the western part of the Sidi Mansour aquifer, with machine learning effectively predicting salinity for groundwater management.

Hamed et al. (2025) assessed the radiological impact of phosphate deposits in Southern Tunisia, revealing elevated uranium levels in groundwater near phosphate mines, exceeding safety standards and posing health risks.

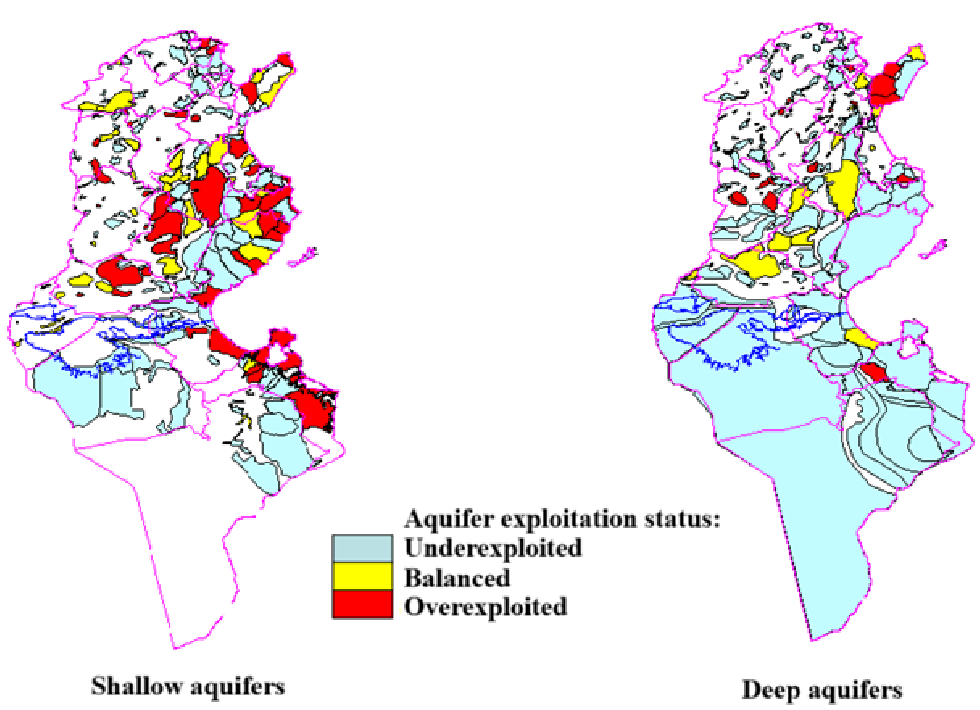

Fig. 1 - Exploitation rate of shallow (left) and deep (right) aquifers in Tunisia (Source: DGRE 2023).

Ben Brahim et al. (2025) evaluated groundwater quality in Maknassy, showing 53% of water is suitable for drinking and 92% for irrigation, but highlighting concerns over nitrate contamination and soil salinization due to over-extraction from the Upper Zebbag aquifer.

Ben Slimene et al. (2025) used GIS and statistical analyses to assess groundwater quality in Bou-Arada-El Arroussa, finding that high salinity in some areas challenges sustainable agricultural use.

Kraiem et al. (2025b) conducted isotope studies in Chott Djerid, showing that Saharan aquifers are recharged by precipitation and deep groundwater mixing, while oasis aquifers are influenced by irrigation return flow, with evaporite dissolution driving salinization.

The other papers in this issue. Besides the papers related to the Special Issue Hydrogeology in Tunisia, we feature three more papers.

Guechi and Beloulou (2025) present a study on the vulnerability of Seraidi's springs (Algeria) due to low flow rates and increasing pollution levels. They found the springs discharge become critically low during dry periods, and that the rising concentrations of pollutants, particularly heavy metals such as nickel and iron, emphasize the adverse impact of human activities on water quality. Alimonti et al. (2025) present a methodology to evaluate the sustainability of water resources in a watershed using a simplified water balance method. Applying their method to Mt. Lepini aquifer (Italy) they conclude the management of this water system should be conducted considering all the ecosystem services, not only provision one, but also sustaining water ecosystems downstream.

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