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Desalinated Seawater for Phosphate Processing as a Key to Maintaining the Sustainability of the Mountain Oases of Tamerza, Chebika, and Mides in Southwestern Tunisia

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ABSTRACT

The mountain oases of Tamerza, Chebika, and Mides in southwestern Tunisia rely on perennial springs fed by fossil groundwater from the Continental Intercalaire and Complex Terminal aquifers, including the Miocene Beglia Formation, which support both traditional gravity irrigation and high-value Deglet Nour date production. Since the 1950s, extensive groundwater abstraction for phosphate extraction and washing in the Moularès–Redeyef basin, along with agricultural expansion and climate-driven aridification, has caused a significant decline in piezometric levels, spring discharge, and water quality, accelerating soil salinization, biodiversity loss, and the emergence of new date palm pests. This work argues that a strategic, large-scale shift from fossil groundwater to desalinated seawater for mining and industrial uses is the most effective solution to reduce pressure on the aquifers that supply the oases, thereby preserving natural springs and the ecological services they provide.

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Study Area

Chebika is the closest to the city of Tozeur and the smallest of the three. It is famous for its lush vegetation, date palm groves, natural springs, and scenic waterfalls forming natural pools. The oasis lies in a gorge offering dramatic views of mountains and cliffs, contrasting with the surrounding desert.

Tamerza is the largest mountain oasis in Tunisia, known for its impressive waterfalls and an abandoned old Berber village that was deserted in 1969 after deadly floods. The ruins provide a glimpse into the region's history and cultural heritage amid palm groves and fertile land nourished by spring water.

Mides, similar to Chebika and Tamerza, offers beautiful gorges, waterfalls, and lush vegetation that create an oasis environment in this arid terrain. It is also part of the trio of mountain oases frequented by tourists for its natural beauty and serene atmosphere.

Objective of the Study

The oasis ecosystems in southwest Tunisia, particularly around inTamerza, face major challenges related to the overexploitation of water resources, climate change, and anarchic urbanization, threatening their ecological and economic sustainability. These agro-ecosystems, centered on palm groves and phreatic aquifers, are subjected to increased anthropogenic pressure that alters their biodiversity and agricultural productivity The present study aims to determine whether anthropogenic activities have affected the sustainability of natural springs feeding the mountain oases with freshwater.

Results

Figure 1: The Tamerza, Chebika, and Mides Oases are Three Remarkable Mountain Oases Located in South-West Tunisia near the Algerian Border, about 450 km from the Capital Tunis

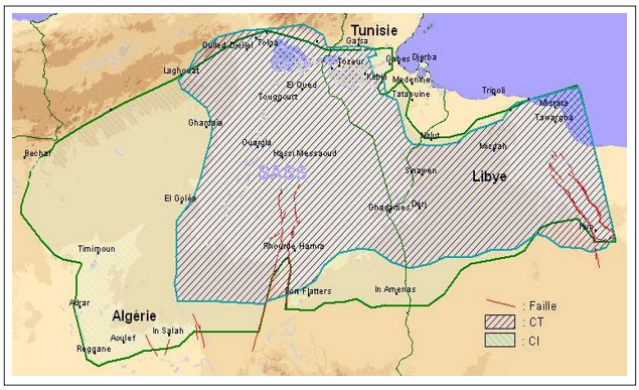


Figure 2: The map depicts the Northern Sahara Aquifer System (SASS), a vast underground aquifer shared by Algeria, Tunisia, and Libya.The SASS covers more than one million square kilometers, with 70% of its area located in Algeria. It comprises two main water reservoirs: the Continental Intercalaire (CI) and the Complex Terminal (CT).This aquifer is a crucial water resource for the populations and economic development of these arid regions [1-3].

The Major Challenges Facing the Oases in the Context of Advanced Water Scarcity

The oasis ecosystems in southwest Tunisia, particularly around in Tamerza, face major challenges related to the overexploitation of water resources, climate change, and anarchic urbanization, threatening their ecological and economic sustainability [3,4].

The water reserve was about 60,000 billion m3 (CI and CT), the renewal rate was about 1 billion m3/year, and the exploitation rate was 2.2 billion m3/year (Algeria: 1.33; Tunisia: 0.55; Libya: 0.33). The planned 2050 drawdown of 30-50 m (OSS, 2003) will result in serious problems by 2100. Following the radical upheavals (population growth in North Africa, expansion of irrigated areas, tourism in "marine, mountain and desert" areas, and industrial activities), in 2050 soil subsidence is likely. Nowadays, this phenomenon has already started (Ouergla and El Eulma regions, Algeria, with a 10-m drawdown, as well as in Libya) [1,5,6].

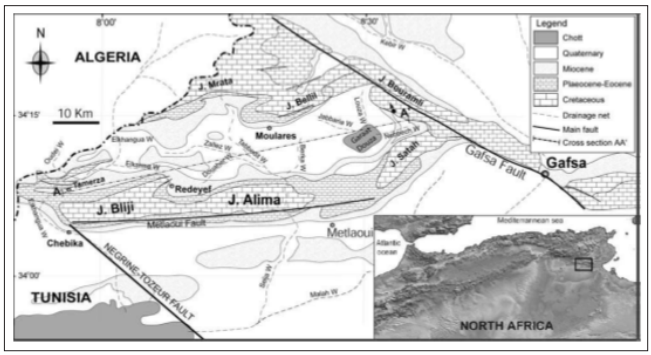


Figure 3: Geological map of the Moulares-Redayef basin. Hamed el al. 2008 (Geochemical and Isotopic Study of the Multilayer Aquifer System in the Moulares-Redayef basin, southern Tunisia) [6].

Overexploiatation of Water Resources

The main component of the fossil water resources containing clayey sand formations of Beglia is the Miocene aquifer of Moulares-Redayef-Tamerza. The facies type and sedimentary structure of the Beglia formations in several outcrops from the middle Miocene (about 11 to 13 million years ago). The groundwater flows from the hills of the Moulares Mountains to the Tamerza springs and forms the natural drainage system of this aquifer [7,8].

In the Moulares-Redayef basin (Gafsa-Gouvenorat), near the Tamerza region, the number of deep wells increased from 50 in the 1980s to more than 250 in 2007, while the number of dug wells has increased from 85 in 1975 to 765 in 2007. This increase is primarily due to the expansion of phosphate mining and, to a lesser extent, demographic and agricultural development in the area. Currently, total annual abstraction accounts for 70% of the region's total groundwater extraction. Consequently, increased groundwater abstraction for mining and agriculture in Moulares and Redayef has caused a decline in the water table and a reduction in artesian conditions, threatening both the quantity and quality of dreshwater feeding the oases [3,9].

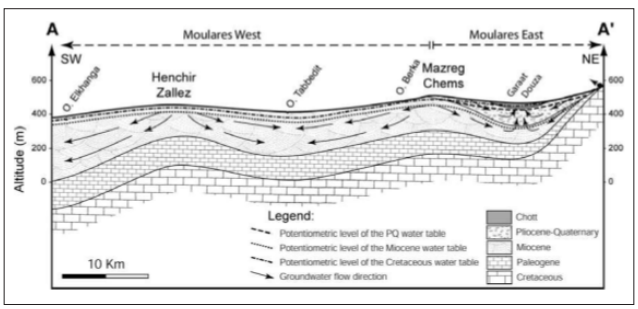
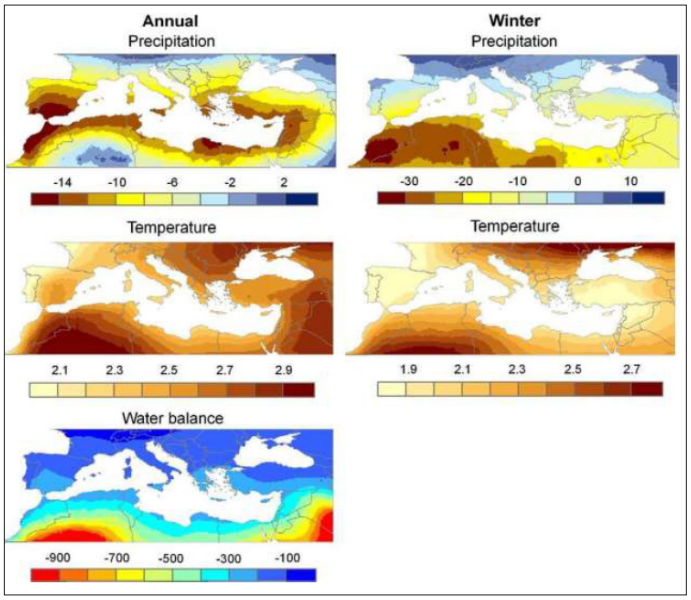


Figure 4: Hydrogeological Cross-Section of the Moulares-Redayef (between Moulares and Tamerza). Hamed et al. 2008 [6].

Fossile Aquifer Shared between Tamerza Region and the Mining Areas in the Vicinity

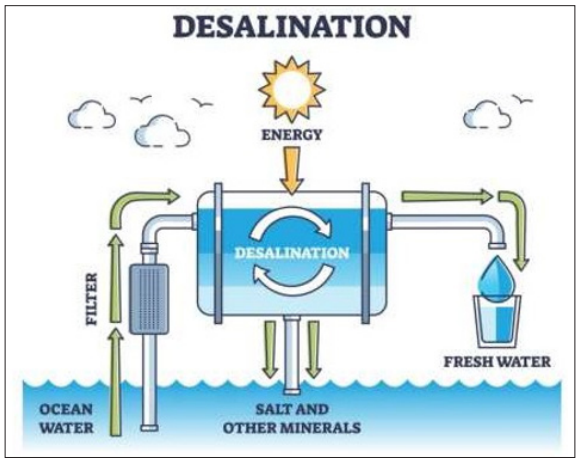
Tamerza and Moulares (mining region in vicinity) are closely connected by the Miocene aquifer system of the Moulares-Redayef-Tamerza basin in south-west Tunisia, which confined within the sandy layers alternating with clay of the Beglia Formation, constitutes the most important aquifer in the region, extending over an area of 575 km². In this system, the groundwater flow is NE-SW, from the hills of Moulares range towards the Tamerza springs which represent the natural drainage system of this aquifer [6,9].

This means that the sustainability of the springs and the ecosystem of the Tamerza oasis depends directly on groundwater recharge and the exploitation and use of water in the Moulares-Redayef areas.



The figure summarizes the average climate change for the Mediterranean region for the period 2040-2070. A marked decrease in annual precipitation and increase in temperature are evident, affecting the entire Mediterranean basin [10].

Long Term Solution: Desalinated Seawater



Conclusion

The mountain oases of Tamerza, Chebika, and Mides face existential threats from groundwater overexploitation, salinization, climate change, and pests, jeopardizing their fossil aquifers, springs, agriculture, and biodiversity. In the long term, the most effective solution is to abandon local fossil groundwater use for phosphate processing by substituting desalinated seawater at regional and national scales. This critical shift will relieve pressure on aquifers that feed the springs and ensure the viability of the oases.

Local actions remain essential complements: enhance irrigation efficiency, preserve traditional systems, regulate fossil aquifer access to favor renewables, conserve biodiversity, reduce plastic use, strengthen governance, and boost product value through quality schemes. Education and research will foster a shared vision of sustainability. Without swift action – especially seawater desalination – these oases risk transforming from lush palm groves into desertified steppes, as evidenced by Tamerza farmers reporting that two-thirds of their springs have dried up in recent decades.

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