

Impacts of intensified water pumping on the aquifer and wetlands in a region of the Southern Mediterranean

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Introduction

In addition to the interest it represents for the water supply of populations, the dune massif of Bouteldja (Algeria) offers a place of wintering and nesting for many species of birds and for the development of flora of internationally recognized wealth. This site is today subject to progressive anthropogenic pressure which is becoming worrying. Indeed, the continuous exploitation of nearly fifty boreholes has led to a deterioration in water quality and has negatively influenced the hydrodynamic balance of the aquifer. It also resulted in a reduction in spring flows and the appearance of salty wedges, threatening even in the short term and the exploitation of the aquifer and the proper functioning of wetlands (Samraoui and de Belair 1998).

In this study, we attempted to use a hydrodynamic and hydrodispersive model:

- To assess the condition of water resources,
- identify sectors vulnerable to marine intrusion, and
- identify the factors responsible for the reduction in flow rates from the main sources and the reduction in the surface area of wetlands in the region.

Materials and methods

The Bouteldja region, located in the North-East of Algeria, is made up of Quaternary aeolian sands containing a free sheet of generally triangular shape with a thickness varying from 25 m in the east to 175 m in the west. To the south, the sands pass laterally to the gravels of the Bouteldja alluvial layer.

The climate of the study area is Mediterranean. The average annual rainfall is around 785 mm. The average annual temperature is 18°C. The average recharge of the aquifer is around 270 mm/year, or nearly 35% of rainfall.

Transmissivity values vary from 3.10^{-5} to $1.10^{-2} \text{ m}^2 \cdot \text{s}^{-1}$. The effective porosity ranges between 9 and 20%. The gravel layer located to the South and the Mediterranean Sea to the North constitute the two main outlets of the layer. Finally, the contact of the reservoir with the Numidian clays forms a watertight boundary in places. The infiltration of precipitation water is estimated at 0.272 m, or nearly $1550 \text{ l} \cdot \text{s}^{-1}$ passing through a dune surface of 180 km^2 . Evaporation at the numerous outcrop areas of the water table (Garâet Khroubzi, Gouréate, etc.), designated under the names of "Néchaât" and "Garâet", also constitutes an important element of the assessment given their extension (near 15 km^2).

MODFLOW (Harbaugh 2005) was used to describe the behavior of groundwater flows by solving the equations using the finite difference method. The aquifer was discretized into 720 active square grids of size 500 m, i.e., a study area of 180 km^2 . By combining MT3DMS, it was made possible to simulate the propagation of pollutants in the aquifer. To highlight the vulnerability of the coastal sectors of the aquifer to seawater intrusion, we chose chloride as the characteristic element, which does not undergo adsorption and degradation phenomena during its transport in water.

Results and concluding remarks

The intensification of pumping in the dune aquifer and the regularization of watercourses, via the construction of numerous hydraulic dams, have led to a significant reduction in the flow of springs, a drop in the water table level and a reduction in the surface areas of the wetlands (Figure 1).

The intensive pumping also had the corollary of the appearance of a marine intrusion which threatens the exploitation of this important reservoir, particularly in the western sector near Mafragh. The drop in the piezometric surface can reach up to -30 m and by a fairly significant drop in diffuse emergencies. The drop in spring flow rates goes from $360 \text{ L}\cdot\text{s}^{-1}$ in 2000 to less than $130 \text{ L}\cdot\text{s}^{-1}$ in 2014.

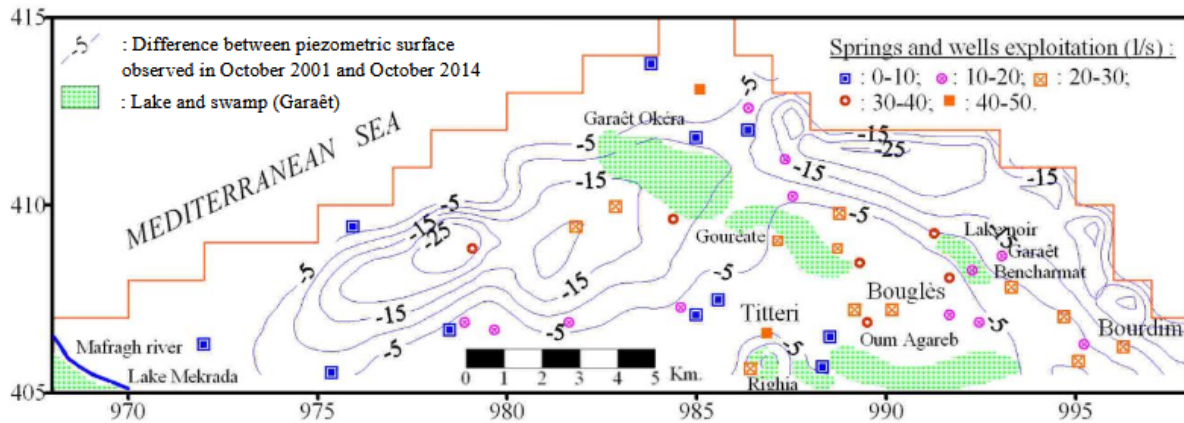


Figure 1. Map of the Bouteldja dune drawdowns.

The results of the hydrochemical balance show that the flow rates of marine waters entering the aquifer are of the order of $0.07 \text{ m}^3\cdot\text{s}^{-1}$ for all model meshes that are sensitive to seawater invasion. Concentrations vary from 0 to nearly 350 g/s for each of the coastal meshes.

The intensification of pumping has a direct consequence of a modification of the surface area and hydrological regime of wetlands and a deterioration of the water quality of wadis, alder groves and lakes.

References

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