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# Climate and human impact on the Karstic environment in the semi-arid zone of the Chéria plateau (Northeast of Algeria)

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**Abstract**

The region of Chéria from a geographical point of view is located more than fifty kilometers from the main square of the wilaya of Tébessa and is located on a plateau culminating at more than 1000m of altitude. Due to the importance of its aquifer system and in particular the Eocene level, which provides sufficient water resources to meet the populations' drinking water needs, their growth and the extension of urbanization. This extension is conditional on the availability of low vulnerability areas to avoid any geotechnical hazards causing variable damage. The karstic regions characterized by carbonate geological formations marked by the presence of cavities and cracks constitute risky terrain and a particular danger in inhabited areas. This approach is necessary for a better knowledge of this karstic aquifer and in particular the climate aspect and its variability, an indisputable impact on the water resources of the Chéria region, the last decades of which have been marked by a rainfall deficit, favoring Thus a high level of demand on groundwater resources and a sharp decrease in aquifer recharge. The worsening of the lower water level in the wells and boreholes of the Eocene karst aquifer accentuates the risk of collapse in the town of Chéria and its periphery. Analyzing the results of the survey and identifying the current state of the aquifer provides an understanding of the respective effects of climatic and anthropogenic factors on an integrated approach to water resources management, A rational implementation of urban infrastructures.

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## Introduction

Among the effects of climate and in particular deficit years, the GCM offers an overall increase in temperature of about 0.7 °C to 1 °C for 2020 (Alibou, 2002) with an impact on groundwater. The latter is aggravated by an increasing exploitation of the Eocene aquifer (Benhammadi *et al.*, 2015).

The limestone soils of this region are the site of an accelerated dissolution phenomenon by the fluctuation of the piezometric levels (Chaffai *et al.*, 2003) favoring the appearance of voids and cavities, characteristic of the karsts landscapes (Fehdi *et al.*, 2011). The Karsts is a special and little-known environment, often requiring accurate monitoring and studies to understand the risks to existing and future infrastructure.

Although the tectonic faults initially result in cracks and allow decoding of a hydrochemical phenomenon that degrades the rock by dissolution in lattices, which are morphologically characterized as karst landscapes by the presence of wells, valleys and springs. Hydrologically speaking, there are two zones, one vertical and one loss of rapid flow (wells), coupled with a slow flow through the cracks (Chamekh *et al.*, 2014).

The karstic environments are complex and heterogeneous, marked by a permeability contrast between the pipes and the surrounding rock. It is vulnerability and it presents a constraint in urban expansion which represents a very difficult situation for the managers of the region.

To this end, the work carried out helped to better understand the development process of these structures and to estimate the area's most exposed to them. It should be noted that the emergence of these phenomena has blocked urban expansion projects because of the risks involved and the increasing pressure of demand for drinking water to meet the different needs of the Chéria region (Chaffai *et al.*, 2006). The approach taken to address this issue is to carry out a one-time piezometric monitoring and delineation of vulnerable and risky areas.

## Material and methods

The Chéria Plateau is a complex aquifer system, composed mainly of carbonate formations. The Eocene level is the most important, which explains our interest in this limestone aquifer. The first step is to identify the factors that have an impact on the evolution of the water supply of the Eocene Formation (Fig. 1).

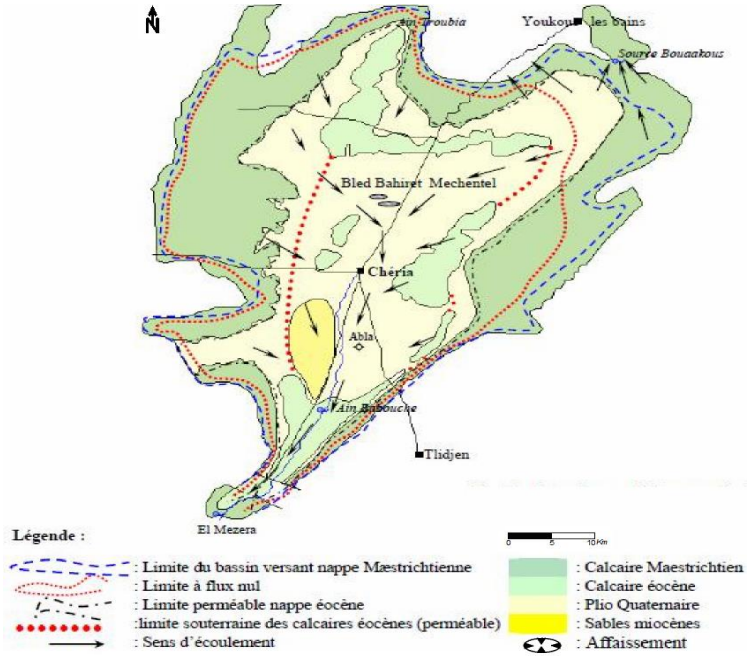


**Fig. 1.** Geological and hydrogeological situation of the Chéria Plateau.

*Identification of impact factors*

The climatic factor is essential to (anthropogenic) exploitation. For this purpose and from a practical point of view, the approach was to evaluate the operating rates during the previous period (more than 10 years). This increase is a consequence of the demographic factor (Fig. 2). In this operation, we combined the chronic piezometric water levels of the Eocene aquifer (Fig. 3). The objective were to see that the evolution and lowering of water levels in wells and boreholes has the effect of exploitation and climatic degradation. The precipitation chronicles have highlighted the impact of climatic factors on the recharge of groundwater and the evolution from an environmental and geotechnical point of view in the region which has seen phenomena of collapse (Fehdi *et al.*, 2011; Benhammadi *et al.*, 2015). This is a consequence of the dissolving of the limestones, which creates a vacuum and reduces the force of the rock under the pressure of the quaternary cover. The collapse is a real environmental and geotechnical constraint for the region and especially in the city of Chéria, urban area.

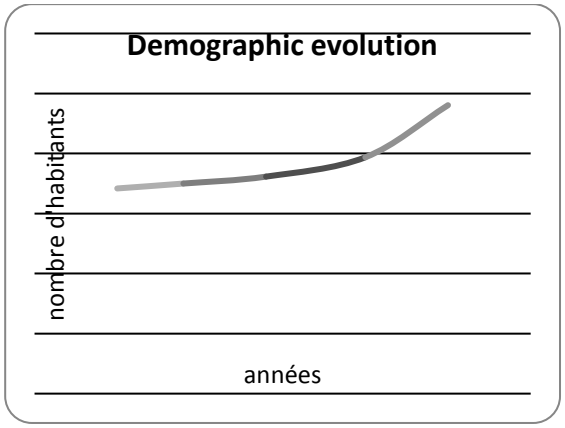


**Fig. 2.** Demographic evolution of Chéria City.

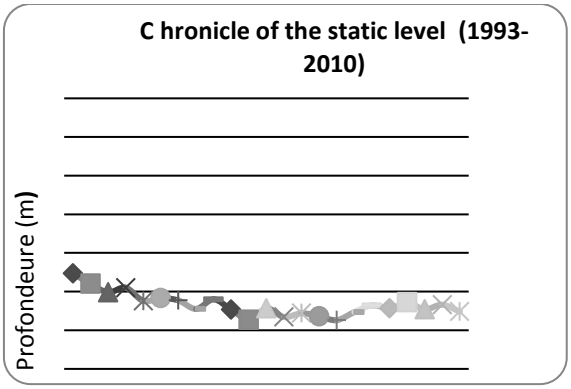


**Fig. 3.** Chronicle of the static level (1993-2010).

*Geophysical survey*

To remedy this problem, a geophysical companion (resistivity profile) was carried out. The objective was to delineate the vulnerable zones (void and cavity). The results allow a more rational urban expansion.

*Geological and hydrogeological situation*

Chéria plateau which has a triangular shape is limited by limestone and marl edges. The structure of this system is characterized by marls of the Campanian whose thickness can reach 400m these are surmounted by the limestones of Maestrischien up to 250m thick. These formations succeed each margin of clay, black age and Danian (lower Eocene), with a thickness of 150m. These clayey marls are surmounted by limestone from the Middle Eocene (Fig. 4). The Mio-Pliocene transgressive unconformity is made of clay and sand lenses, over a thickness of 60m. Finally the Quaternary is mainly developed in the north (fluvial gravels). The aim is to check the current status of the aquifer and to measure the extent of the impact of climatic and anthropogenic factors on the development of the resource (Benhammadi and al. 2015).

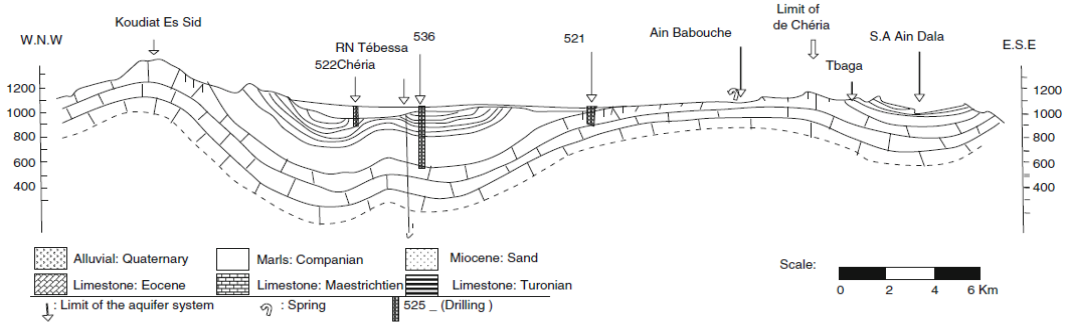


**Fig. 4.** Hydrogeological cross section.

The agglomeration of Chéria (south eastern Algeria); this town in terms of water resources, we meet four aquifers, with the level Eocene, most important. The Maestrischien level is still poorly known, and the level Mio-Pliocene and Quaternary saw their reserves significantly decrease until exhaustion in some places (Chaffai and *et al.,* 2003). The recharge of the aquifer occurs from the limestone borders. The flows are converging to the center (Chaffai *et al.* 2006; Benhammadi *et al.* 2012. 2013; 2014). This refill occurs also directly from losses (sinkholes). These flows are characterized by different modes, due to the variability and permeability contrast. This contrast is the result of the evolution of cracking. The source is the exit point of the karst water.

**Result and discussion**

The results obtained from the data from field studies made it possible to visualize the evolution of the geotechnical and hydrological situation. The graphs obtained from the various parameters (static level and recharge) and anthropogenic pressure (changes in the number of inhabitants) accelerates the deterioration of the equilibrium conditions of the surrounding environment and the increase in demand on the region's water resources.

The geophysical study and in particular the tomography, allows a better visualization of the structure; this technique can also help to identify areas of risk (Fig. 5).

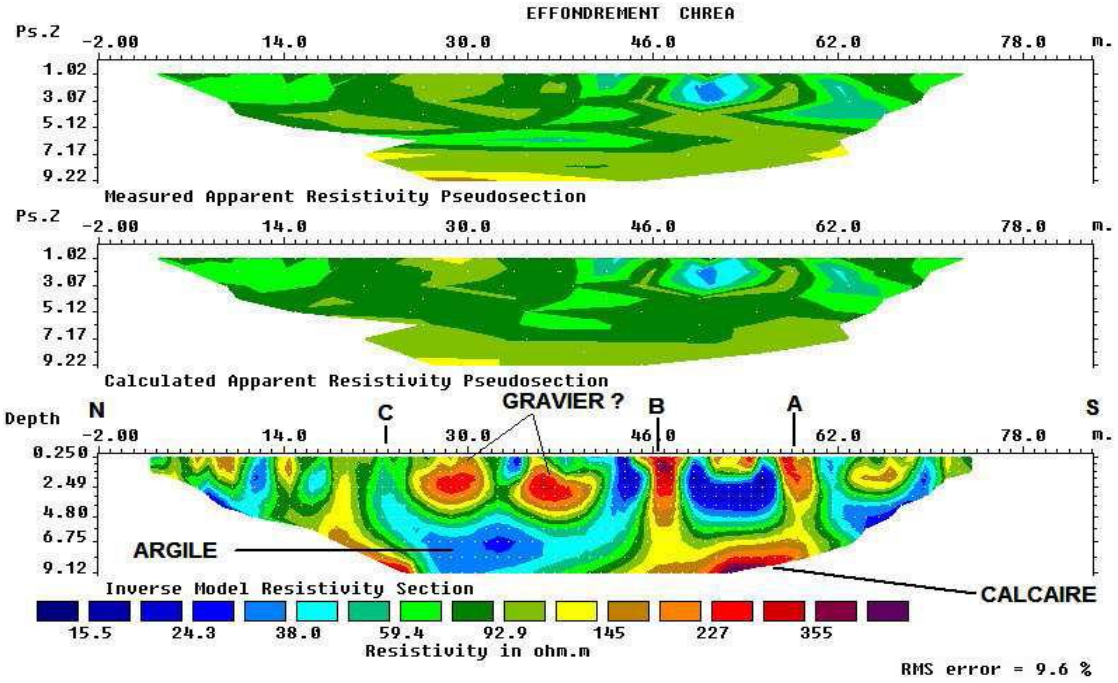


**Fig. 5.** Profiles resistivity tomography.

*Environmental impact*

The result in terms of environment is the phenomenon of collapse in the region. These structures are called dolines (wells) of circular shape and with a diameter of more than 20 meters and a depth that can exceed 4 meters (Fig. 6).

The phenomenon of dissolution of carbonated water on the rock is changing the dimensions cavities. This increases the risk of instability of these lands.

**Fig. 6.** Type of collapse in Chéria Plateau.

*Hydrological impact*

The appearance of the collapse is not the only effect on the region; this effect is geotechnical (Fehdi and al. 2011). There is also another effect of a hydrological that one. The decline of the resource and a significant decrease in the water table reflects this impact. Level tracking drillings allowed viewing a continuous decline in this level, despite some rainy periods. The human factor (exploitation) aggravates this situation.

The identification of impact factors requires a better understanding of the hydrological phenomenon of the lower levels and the resulting environmental phenomena (collapses). The approach undertaken is based on an investigation and data collection work; we analyzed and correlated the various parameters measured. Based on the results of various research, hydrology and geotechnical aspects from the point of view of data collection and analysis, the following should be noted:

The significant decrease in the groundwater level is the result of a shortage of aquifer recharge. Overexploitation of aquifer water results from an anthropogenic effect. The impact of this factor has accelerated the phenomenon of the reduction of the groundwater level.

The Eocene limestone cavities are pathways for any type of pollutant to the water table and increase its vulnerability. In urban areas, the weight of buildings has aggravated the phenomenon of collapse. In the field of study and in particular in the urban area, the geophysical approach made it possible to verify the existence and the location of other cavities as well as their geometrical characteristics. The multiplication of the geo-electric profiles makes it possible to realize a risk map in this zone.

**Conclusion**

We can say that this is the effect of the two combined climate and anthropogenic factors; they had a direct impact on the reduction of water resources and indirectly on the stability of karsitics land. We can suggest a rational exploitation with rigorous monitoring of the management of the aquifer, allows mitigation of this situation. Regarding the geotechnical aspect, a good field by consulting the appropriate geophysical methods, avoids the unstable land for urban expansion. To mitigate the alarming decline in groundwater level of the aquifer, a method can be used; it is proceed to artificial recharge of the aquifer. This can be done from cavities and collapses that exist in the region.

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