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STUDY OF WATER QUALITY OF THE UPPER CHELIFF VALLEY

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Abstract

Surface water and Groundwater are important and crucial resource in many countries, and it commonly plays a key role as a water supply both for drinking and irrigation. In the last decades, water demand has dramatically increased, especially in developing countries, driven by population growth, improvements in living standards, development of industry, agriculture and urbanization. This has led to increasing pressures on groundwater resources.

Excessive abstractions of groundwater over the past decades to meet these demands have resulted in serious troubles: water table decline, groundwater quality degradation and damage to ecosystems. It is therefore essential to quantify and analyze the quantity and quality of water reserves and to find ways to manage this resource to ensure sustainability.

The main aim searched in this context is to get to study the quality of groundwater and surface water in the Upper Cheliff region.

The aims of our study are:

An overview of quality parameters and methodology study of underground and surface water is given. Location and presentation of the characteristics of the study area, and analysis of essential climate and hydrological conditions.

Focus on the study of geological and hydrogeological natural and piezometry related the chemical quality. Then evaluate the quality of surface water quality through the sheets made and their interpretations for each dam.

The study of chemical parameters evolution in the time and space, by addressing mechanisms of the acquisition of the mineralization of groundwater.

Our efforts will also focus on the dependencies and relationships between the various physico-chemical parameters of the water and their origins.

Keywords: hydrochemistry, mineralization, characteristic report, High Cheliff aquifer.

Introduction

Water can be scarce in some places, such as arid and semi-arid, or just of poor quality in other places. It is certain that the increase in water demand for human activities accentuate the stress on the resource. In addition, natural factors such as drought or geological constraints affect the drinking water supply and distribution.

In this context, the present study adds to earlier research, and to provide a scientific overview of the current state of the upper Cheliff area, qualitatively and quantitatively. The quality of waters of this region has in recent years undergone some deterioration because of uncontrolled urban waste, intensive use of chemical fertilizers and fertilizers in agriculture and its disorderly exploitation. These elements alter the chemistry of the water and make it unsuitable for desired uses. It is in this context that this study was conducted to analyze the quality of water at the said region.

I. Presentation of the study area

The study area corresponds to the Upper Cheliff basin, located 110 km South-West of Algiers, and is part of the Cheliff watershed (Figure 01)

The upper Cheliff area has an agricultural vocation requiring sprinkler irrigation due to a semi-arid continental climate with very dry summers (interannual temperature ranges from 13 to 19 ° C, with a monthly maximum of more than 30 ° C recorded in July) and rainy winter episodes sometimes causing dramatic flooding of Wadi Cheliff. The construction of dams (Ghrib, Deurdeur, Harreza and Sidi Mhamed Ben Taiba) has regulated the wadis flows and provides irrigation water from April to September.

Interannual average rainfall varies between 300 and 500 mm. It is more concentrated in altitudes on the southern slopes of Zaccar and on the northern slopes of the Ouarsenis. Across the Upper Cheliff basin, annual potential evapotranspiration ranges from 1200 to 1500 mm according to the map of potential evapotranspiration in northern Algeria

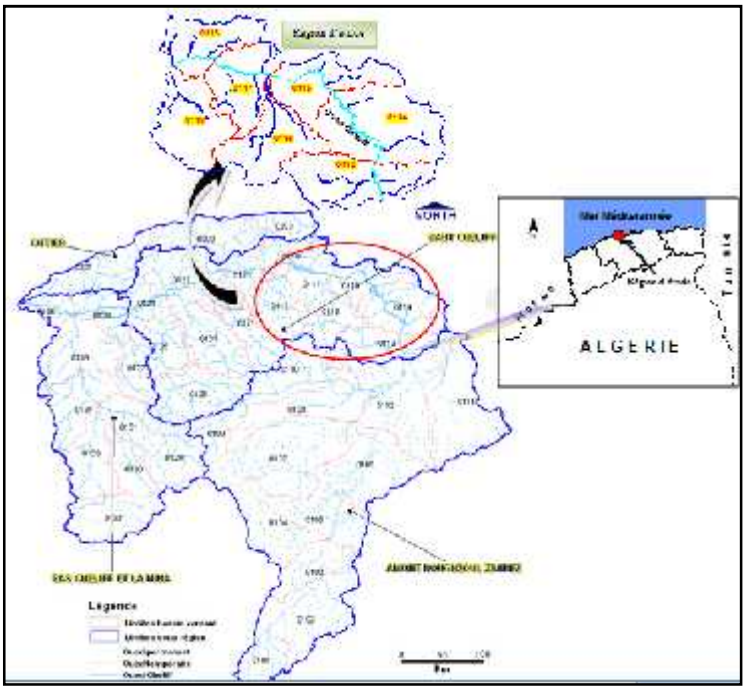


Figure 1: Location map of the Upper Cheliff Watershed.

II. Geology and Hydrogeology of the Upper Cheliff area

The Upper Cheliff plain is located between 36° 120' and 36° 300' North latitude and 02° 20' and 2° 440' East longitude. It is bordered to the North by the dolomitic limestone of Jebel Zaccar (1578 m altitude) and the sandstones of Jebel Gantas, to the South by the first foothills of the clayey-marly and sandstone Ouarsenis massive (figure 02). One enters the plain at the East by the Djendel threshold at 308 m a.s.l. (above sea level) and comes out through the West by the Doui threshold at 248 m a.s.l. (Mania, 1990).

The plain of Upper Cheliff corresponds to a vast depressed area subsidente East-West orientation where Miocene sediments Pliocene and Quaternary have accumulated. The cross lithological cuts in the plain of Upper Cheliff, show the synclinal look different formations constituting the basement.

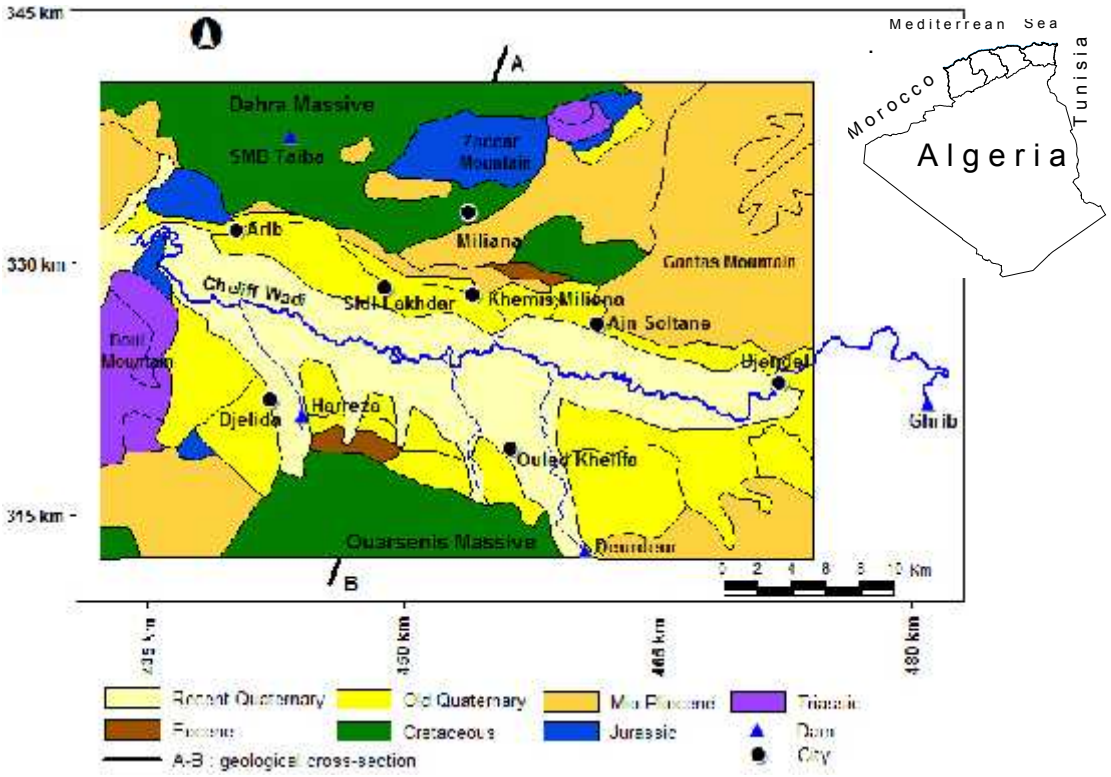


Figure 02: Simplified geological map According to the 1/50.000 of Miliana.

The main aquifer in the plain of Upper Cheliff is formed by alluvial formations. This aquifer is characterized mainly by coarse alluvia silt and pebbles in the center of the valley with a thickness of 50–145 m. A layer of clay and silt covers the coarse alluvia to the south-west with a thickness of 7–20 m. This aquifer overlies the Mio-Pliocene sandstones, which are observed at the East of the plain at Jebel Gantas and can reach 200 m thick in the North.

Further to the piezometric campaigns conducted in high and low water in 2002 and 2008, we found that piezometric maps show the same morphology and the same rate of piezometric curves. The groundwater flows are from the North and South of Upper Cheliff basin to the main East–West drainage axis, which coincides with the course of Wadi Cheliff. Groundwater generally supplies wadi Cheliff, in particular, over the downstream half of the plain where the wadi is in direct contact with the coarse alluvium.

However, there is a certain local disturbance at the central and southern plains in 2008, due to overexploitation of the water table to ensure irrigation.

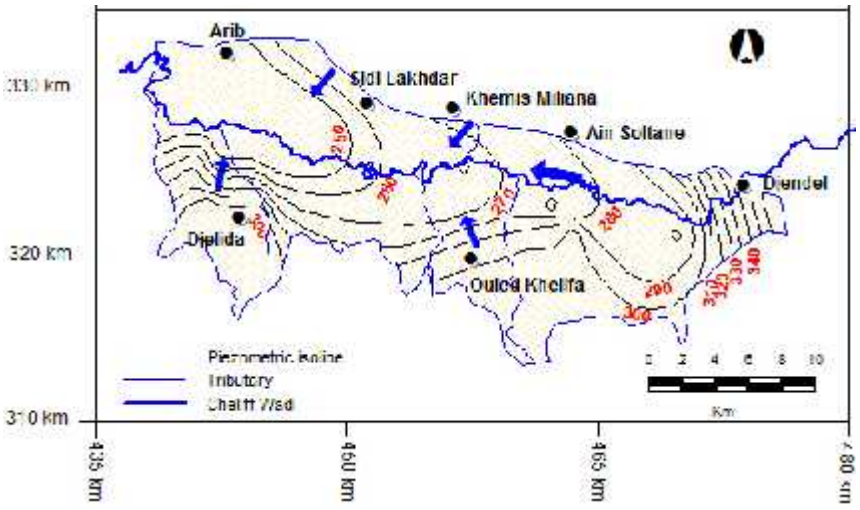


Figure 3: Piezometric map in high water 2008.

III. Quality of surface water

This work was the subject of a quality assessment study of dam waters on the basis of the monitoring of physical-chemical parameters by the National Agency for Water Resources (ANRH) for a period of ten years (1999-2008).

We give the state of the quality of water when the dam is equipped with a surveillance network then, the origin and the amount of pollution that receives each dam watershed.

Surveillance and evaluation of the qualitative status of water require a measurement network of water quality, regular analysis, interpretation of these analyzes and the comparison of results with accepted quality standards.

The study of the quality of Upper Cheliff dam waters concerne the 04 dams in operation Ghrib, Deurdeur, Harreza and Ouled Mellouk. These dams are monitored for water quality by the existence of ANRH monitoring stations.

The importance and severity of pollution is confirmed by the results observed in the study of the quality of surface waters in the region of Upper Cheliff, namely:

• Water quality sheets show a degradation of the quality for all dams (organic pollution expressed in COD MO over time. Indeed, the amount of recorded COD often exceeds 50 mg / l, and that of the MO also exceeds 15 mg / l. The contamination is due to discharges of wastewater and eutrophication.

• Water dams show a very high salinity (dry residue = 2574 mg / l in 2008 for the waters of the dam Ghrib, standard = 1500 mg / l). The content of water in substances containing nitrogen (NH_4^+, NO_2^-) in 2008 is high in the dam O. Mellouk. This pollution is caused by oxidation of the nitrogenous organic material.

• The pollution load reaching watershed dams is characterized by the pollution load of breeding in the first place because of its high value in almost all watersheds.

IV. Hydrogeochemical groundwater characterization

This chapter deals with the chemistry of groundwater, and we will try to explain the behavior, the origin and evolution of chemical elements described to explain the hydraulic functioning of the aquifer system.

The study is based mainly on information from four sampling campaigns from 47 water samples in 2002 and 50 water samples in 2008, spread over the ground. As the plain of Upper Cheliff is agricultural, special attention will be given to this effect.

The correlation matrix of Pearson (Swan and Sandilands 1995) was used to find relationships between two or more elements. The analysis of the correlation matrix (Table 01) can retain the correlated elements in pairs with a correlation coefficient (r) significant. It is noted that the R.sec is perfectly correlated with calcium (R = 0.78), magnesium (R = 0.75), sodium (R = 0.85), chlorides (R = 0.94) and sulphate (R = 0.69) in 2002. There was a slight increase in correlation coefficients in 2008 for calcium and magnesium ions.

The highest concentrations of these elements are found south of the plain, on the left bank of the wadi Cheliff, near the towns of Djendel, Bir Ouled Khelifa and Djelida. Indeed, the discharge of domestic waste water from agglomerations which are situated in the plain (17 discharge points) and estimated at 15 000 m3 / d, without being pretreated, affecting the quality of groundwater. The location of high concentrations may be related in some way to these spills.

Tableau 01: Correlation matrix between variables.

Variables	Ca^{2+}	Mg^{2+}	$Na^{+}+K^{+}$	Cl^{-}	SO_4^{-2}	HCO_3^{-}	NO_3^{-}	R.Sec
Ca^{2+}	**1**							
Mg^{2+}	**0,76**	**1**						
$Na^{+}+K^{+}$	0,35	0,51	**1**					
Cl^{-}	**0,72**	**0,81**	**0,82**	**1**				
SO_4^{-2}	0,53	0,59	**0,66**	0,57	**1**			
HCO_3^{-}	0,10	0,13	0,18	0,05	0,23	**1**		
NO_3^{-}	-0,21	-0,23	-0,24	-0,22	-0,43	-0,34	**1**	
R.Sec	**0,78**	**0,84**	**0,79**	**0,93**	**0,73**	0,18	-0,24	**1**

The nitrate distribution is very different. The highest concentrations are found in the east, near Djendel south near Bir Ouled Khelifa, north to Sidi lakhdar and west at Djelida. These very high levels are due to the activity of orchards occupying a large part of the area benefiting from the improper use of fertilizers, pesticides and manure and communities releases.

The projection of individuals on the F1-F2 plane revealed (Figure 04):

- ✓ The axis F1 opposes highly mineralized samples to weakly mineralized samples .The weakly mineral waters located to the northwest and west of the aquifer (in borders of the massif Doui Zaccar in particular). The highly mineralized waters which are located to the south of the groundwater on the left bank of Cheliff wadi and this for the two years 2002 and 2008.
- ✓ The axis F2 also shows an opposition between the rich waters bicarbonates and weakly loaded water in this element. The first are located on the right bank of Cheliff Wadi in the North and the Northwest of the groundwater near the the borders of the massive Zaccar and Doui. The seconds are located in the South of the groundwater.

Waters heavily loaded with nitrates located in the East and South of the groundwater close to the cities of Djendel, Ouled Khelifa and Djelida.

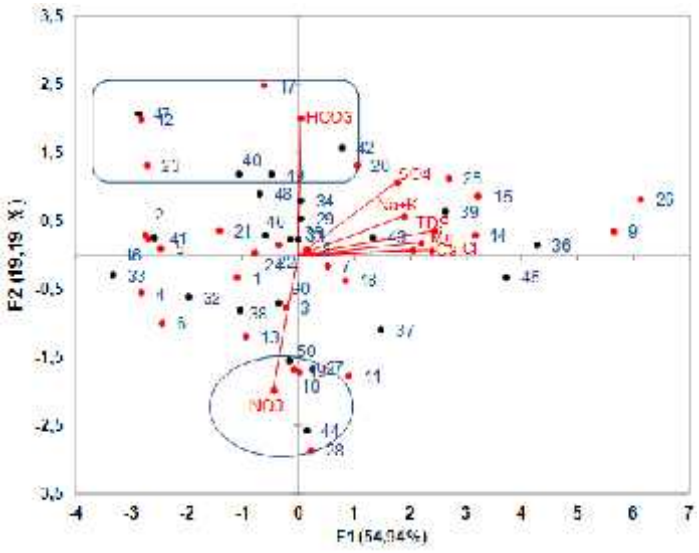
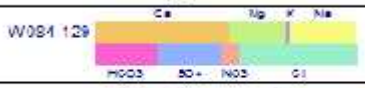
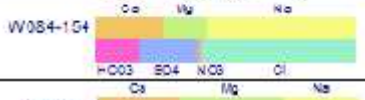
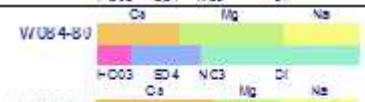
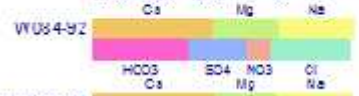
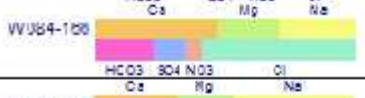
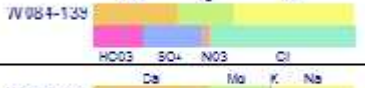


Figure 4: variables and individuals projection on the factorial plane (F1-F2)

Examination of Table 2 shows that dominant chemical facies for 2002 are of the type Calcium chloride; 17 samples of 28 or 61% in periods of high water and 08 samples of 19 or 42% in periods of low water. Followed by sodium chloride facies with 10 samples of 28 or 36% in high water and 6 samples of 22 or 27% in low water.

The calcium bicarbonate facies represents 11% (3 samples) and 11% (2 samples), respectively, in high and low water. Finally, it shows the presence of a chloride magnesium facies (4%) over the period of high water and a sulfated calcium facies (3% and10% for the period of high and low water).

Table 2: groundwater chemical facies in the Upper Cheliff aquifer.

period	Waters family	chemical facies	(%)	(%)
April 2008	Chloride	calcium chloride	50	
		sodium chloride	36	
	Bicarbonate	magnesium chloride	3	
		calcium bicarbonate	11	
October 2008	Chloride	calcium chloride	61	
		sodium chloride	27	
	Bicarbonate	calcium bicarbonate	9	

A noticeable feature of the groundwater in the Upper Cheliff is, however, the enrichment in Cl^- relative to Na^+ (figure 08d). The excess of Cl- can be explained by the combined effect of another source for this ion than the dissolution of halite and the Na^+ losses due to the phenomenon of Base Exchange, as clays bedrock can release Ca^{2+} after setting the Na^+. The excess of Cl^- may also have an anthropogenic origin. Indeed, as stated above, urban wastewater are discharged untreated in the

environment and can reach groundwater by infiltration. On the other hand, as the region is agricultural, fertilizers can also contribute to Cl^-.
The relationship Ca^{2+} vs SO_4^{2-}, Ca^{2+} vs HCO_3^- and Ca^{2+} vs Mg^{2+}, however, show a large excess of Ca^{2+}, this indicates that the source of Ca^{2+} is not only the dissolution of the calcite and gypsum, and thereby confirms the hypothesis of an entry of Ca^{2+} by ion exchange.
The calculation of the saturation index of carbonates minerals and gypsiferous showed that the former tend to precipitate before the latter, this has allowed the chemicals from the dissolution of gypsum to acquire significant levels.

Groundwater potability assessment
The Upper Cheliff groundwater potability was assessed according to international standards (World Health Organization 2008) and to the water hardness.
In the plain of Upper Cheliff, the majority of chemical elements analyzed exceed the standards set by WHO.
All the analyzed samples are very hard in both periods, with total hardness greater than 54°F (French degrees). The contents of magnesium and calcium that exceed the threshold set by WHO cause such high hardness. These results show that the groundwater in the study area is of poor to bad quality for drinking purpose.
The results of this study have significantly improved understanding of the aquifer which is an important resource for the development of this region. Urgent action must be taken quickly by the authorities to deal with the serious degradation of this resource.

Conclusion
Understanding the groundwater hydrochemistry and quality is vital to preserve this resource so that it can meet the present and future water needs in many countries. In North
West Algeria, groundwater resources in the Upper Cheliff plain play a vital role in supplying water for drinking and agricultural purposes. However, there is an increase in degradation of this valuable resource reflecting a lack of knowledge of the groundwater mineralization processes and a lack of rational management.
This study allowed first for a geological and hydrogeological synthesis of the aquifer of the Upper Cheliff plain. This system is mainly composed of Mio-Pliocene-Quaternary formations. Quaternary formations are represented by alluvium. The Miocene and Pliocene consist mainly of sandstone. All these formations have a hydraulic continuity and form a single aquifer system. The carbonate formations bordering the plain are of Secondary age (Zaccar and Doui massives). Groundwater flow is generally in a East–West direction, with a drainage axis which coincides with the course of the wadi Cheliff.
The hydrogeochemical study of the groundwater was conducted using several methods (Piper and Stabler diagrams, multivariate statistics, ions exchanges, saturation indices of various minerals). This study showed the presence of several hydrochemical facies: chloride-calcium, chloride-sodium and bicarbonate-calcium. Mineralization of groundwater is due to the process of dissolution of carbonate and evaporite formations. The exchange of ions significantly affects the chemical composition of groundwater. Human activities (urban waste, fertilizers) also contribute to the mineralization of the water.
In the plain of Upper Cheliff, the majority of chemical elements analyzed exceed the standards set by WHO. The groundwater is accordingly unfit for human consumption. The results of this study helped to significantly improve the understanding of the aquifer which is an important resource for the development of this region. Urgent action must be taken promptly by the authorities to address the serious deterioration of the resource.