

Hydrogeological study of the lower Devonian aquifer in The Illizi region

Omar BAKELLI⁽¹⁾, Moussa CHALIALI, and Prof. Aziez ZEDDOURI⁽²⁾

⁽¹⁾⁽²⁾ Laboratory of underground reservoirs oils, gas & aquifers

E-Mails: bakelliomar9@gmail.com, zeddouriaziez@yahoo.fr

Abstract— Groundwater is the main source of water in the Algerian desert, the hyper arid climate in Illizi area with low precipitations and very high temperatures is the origin of the scarcity of surface water, hence the need to exploit groundwater. Our work consists in the hydrogeological study of the lower Devonian groundwater in the Illizi region, a land company was carried out to determine the water levels and the flow directions of the lower Devonian aquifer. The realization and study of the piezometric map shows two flow directions N-SE and SE-NW. The hydrochemistry study shows good characteristics and groundwater is composed of two chemical facies that are: Chlorinated calcium facies and Bicarbonate calcium facies.

Key-Words: *Illizi, groundwater, lower Devonian, flow direction, hydrochemistry, chemical facies.*

I. INTRODUCTION

Groundwater is a precious resource with limited availability. Groundwater plays an important role in sustaining development, environment, and standard of living. It is not only the main source for water supply for domestic uses, but also is the largest and most productive source of irrigation water.

The state of Illizi, as almost all regions in the Algerian desert, use groundwater as main resource for domestic and agricultural needs, which gives a strong importance for the quantitative and qualitative study of this groundwater.

This study aims to: to group and exploit the data of the previous geological and hydrogeological studies carried out at the region, to make initial description of the hydrogeological model of the Lower Devonian aquifer on the town of Illizi, to determine and interpret the physicochemical characteristics of the groundwater and the

dominant facies and to qualify this groundwater for domestic uses and for irrigation.

II. MATERIELS AND METHODS

A. Study area:

The Illizi basin is located in the south east of the Algerian Sahara, It covers an area of about 110000 km², and it is between 26.30 ° and 29 ° of North latitude and between 6 ° and 10 ° east longitude.

The Illizi basin composed by sedimentary cover mainly detrital ages from the Cambrian to the Paleocene, superposed in major discordance at Infra-Tassilian surface that levels a pleated base composed of metamorphic, sedimentary, Cristalloyphyllian and volcanic rocks.

On the hydrogeological plan, six aquifer systems are exploited on the Illizi watershed: the Ordovician, the Devonian (at Illizi state), the intercalary Continental (CI) and the alluvial aquifer, our study is based on the Lower Devonian aquifer, the main used for domestic and irrigation needs in the state of Illizi.

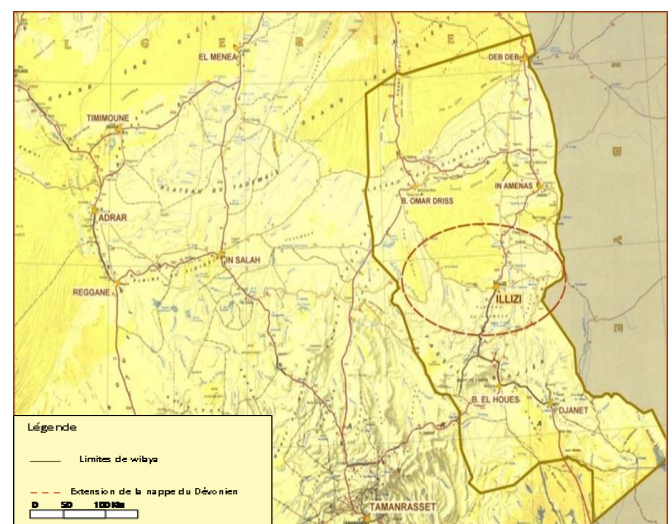


Figure I: Geographic situation of the state of Illizi (ANRH Ouargla)

B. Climate and rainfall:

The Illizi region is located in a saharian deserted bioclimatic hot climate and is characterized by extreme temperatures between day and night basically in the period from October to April.

This severe climate in addition to the rainfall almost negligible during all the year associated with very varied relief has a big impacts on the biodiversity of the region.

The study of climatic measurements series between 2008 and 2017 shows that the hottest season extends from the month of May to September, with maximum values attend 47°C, The cold season extends from the month of October to April with minimum values attend 5°C. The Illizi region is characterized by high values of the evaporation, attend 647mm in the month of July and minimum values attend 195mm in the month of January.

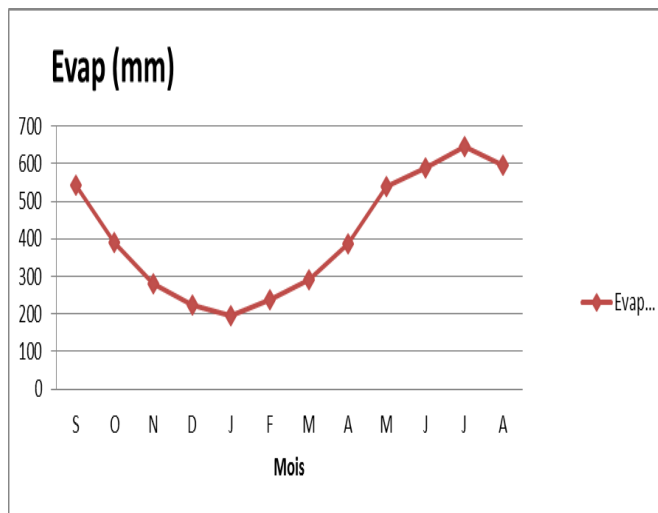


Figure II: Monthly mean evaporation (2008_2017), ONM Ouargla

C. Methods used:

Four ways were used to study the hydrogeology of the watershed: a bibliographic research to analyze the work carried out on the region, then a field company which enabled the acquisition of piezometric, Chemical and electrical conductivity data, a chemical analysis of the major ions to identify the facies generated by ground water circulations and graphical representations of the

results for better establish an interpretation of the chemical facies and the origin of waters.

Some analysis were established onsite by a multi-parameter kit: Temperature, pH, Electrical conductivity and resistivity and total dissolved solids, other analysis were done in laboratory by:

1. Titrimetric for TH, Calcium (Ca^{+2}), magnésium (Mg^{+2}), bicarbonates (HCO_3^-) and chlorides (Cl^-),
2. Flare Spectrophotometer for sodium (Na^+) and potassium (K^+).

3. Atomic Spectrophotometer: for sulfates (SO_4^{-2}). The results were treated by software such as: surfer, PhreeqC, Diagramme.

III. RESULTS AND DISCUSSION

A. Piezometric map:

From the piezometric map established we concluded that the groundwater of lower Devonian aquifer has as upstream the Tin Tourha, town center and Ain El Cours, and converge to the downstream zone in Sidi Bouslah as the principal flow direction, with sever hydraulic gradient 2.03%, Otherwise, secondary flow directions can be noted such as from south west of Oued Innaten to Sidi Bouslah zone, with a small hydraulic gradient of 0.47%, with the presence of depression cone in Sidi Bouslah related to over exploitation which can be resulted by the big number of wells in this zone.

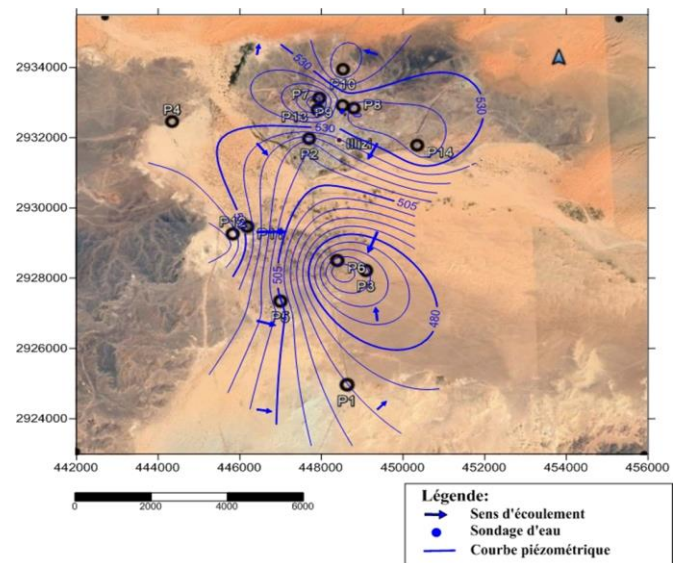


Figure III. Piezometric map of the lower Devonian aquifer in the state of Illizi

B. Hydrochemistry:

The physico-chemical analysis results shows that the lower Devonian aquifer in the state of Illizi is characterized by a good values of pH and electrical conductivity and a good concentration of chemical elements,

Table I: Statistical parameters of Physico-chemical variables

Variable	Unité	N	Moy	Min	Max	Ecarte type
Ca ⁺⁺	mg/l	12	62,11	44,74	141,36	25,86
Mg ⁺⁺	mg/l	12	24,93	16,80	40,00	7,32
Na ⁺	mg/l	12	31,60	21,65	49,21	9,13
K ⁺	mg/l	12	1,79	0,00	3,59	0,84
Cl ⁻	mg/l	12	89,65	53,20	252,50	56,15
SO ₄ ⁻	mg/l	12	20,46	18,23	32,61	3,92
HCO ₃ ⁻	mg/l	12	139,75	100,00	171,00	25,48
NO ₃ ⁻	mg/l	11	0,73	0,00	4,00	1,15
pH	-	12	7,23	6,82	8,20	0,49
CE	μS/cm	12	808,42	473,00	2230,00	468,38
TH	°F	12	25,58	19,00	52,00	8,89

Two chemical facies was identified: Chlorinated Calcium facies with 58.33%, and Bicarbonate Calcium facies with 41.67%.

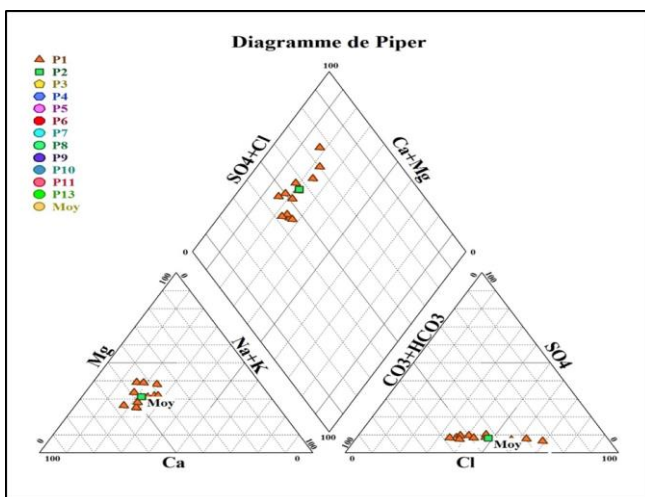


Figure IV. Piper Diagramme

C. Water quality for Irrigation:

The aptitude of using the lower Devonian water for Irrigation was evaluated by two ways: the sodium percentage (Na %) or Wilcox classification and the sodium adsorption ratio (S.A.R) or Riverside classification,

From the Wilcox classification, the lower Devonian water is generally in the C2-S1 class, which indicate that it can be used for irrigation without any particular controls, in soils with good permeability.

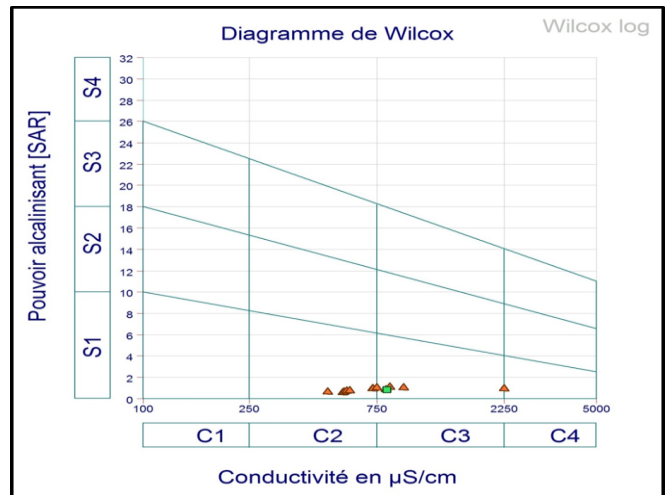


Figure V. Wilcox Diagramme

From the riverside classification, the S.A.R value for this water is lower than 2, which indicate that it can be used with less risks of alkalinity of soils.

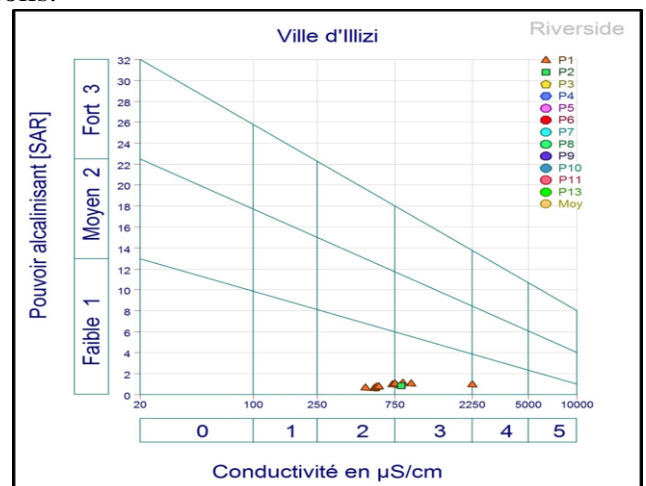


Figure VI. Riverside Diagram

C. Water quality for potability:

The world health organization has established a standard defining the good waters quality for potability, the lower Devonian water was examined, comparing it with the Algerian standards of potability, which correspond to the World Health Organization standards, the results showed that: in the state of Illizi, waters has a good quality in almost all the wells, however, in the service station of Belbachir, there is a bed quality water characterized by high electrical conductivity that attempt the max value of World Health Organization standards (2500 μ S) which need for treatments before being delivered to human consumption.

Table II: Water potability classification according to Algerian standards

NOM	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	Cl ⁻	SO ₄ ⁻	pH	Cd	remarque
NORME	200	150	250	15	500	400	6,5-8,5	2500	
Station de service	141,36	40	49,21	3,59	252,5	32,61	6,9	2230	Mauvais
ZHUN 101	60,89	17,6	29,65	2	121,5	20,8	6,98	783	Potable
ZHUN 102	49,71	16,8	23,8	1,5	70	18,23	6,92	568	Potable
ZHUN 103	53,44	22,4	21,65	1,5	60,2	19,17	7	555	Potable
ZHUN 104	50,95	20	25,95	1,6	78,4	19,1	8,18	581	Potable
Pépinière siège forêt	46	21,6	34,55	1,9	69,2	18,75	6,82	732	Potable
Zone d'activité Illizi	54,68	28,8	21,65	1,5	53,2	18,32	6,9	552	Potable
Centrale électrique	44,74	24,8	21,65	1,3	62,6	18,66	8,2	473	Potable
Tin Tourha 101	55,92	25,6	38,86	2	65,5	19,94	7,38	839	Potable
Tin Emri	62,14	37,6	43,16	2,6	121,5	20,71	7,53	943	Potable
Takbalt 101	57,17	24	34,56	2	62,1	19,69	7,07	721	Potable
Siège forêt	68,35	20	34,56	0	59,1	19,52	6,91	724	Potable

IV. CONCLUSION

The objective of this hydrogeological and hydrochemical study was the recognition of groundwater resources and their quality in the Illizi region.

Indeed, our contribution to achieve according to the data available to us, that the arid climate with low precipitation (10.9mm/year), and high temperatures (34°C), and a potential

evapotranspiration of more than 4920 mm/year, which translates Water deficit throughout the year.

The hydrogeological study highlighted the existence of a lower Devonian aquifer, of significant hydrogeological interest. The exploitation of the Lower Devonian aquifer in the town of Illizi is rational according to our observations on the ground during the field companion where we found the existing surveys contribute enormously to the protection of this underground wealth.

In a final stage, the hydrochemical study, based on the results of laboratory analyses, show that these waters are of a single dominant type, a good quality water of potability and irrigation.

It is noteworthy, that the total fer concentration is too high in this aquifer in the town of Illizi, which led to the installation of a Deferrisation station (the only one in Algeria) operational which treat the waters of this aquifer before its exploitation.

However, our study leads to the identification of a contaminated well noticed by its high conductivity which requires some treatment before being exploited.

The hydrochemical study shows two types of water facies, a Calcium Chlorinated facies and Calcium Bicarbonated facies.

The limitation of the methods used and the well points available in our study, strongly calls for a more extensive and expanded study to better recognize and characterize this aquifer.

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