

## STUDY OF THE PHYSICO-CHEMICAL QUALITY OF THE GROUNDWATER OF THE LOWER DEVONIAN AQUIFER IN THE ILLIZI REGION (ALGERIA)

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Received: 08 November 2019/ Accepted: 27 December 2019 / Published online: 01 January 2020

### ABSTRACT

This study's main objective is to diagnose groundwater quality in the Illizi region. The physical-chemical quality analysis included 10 samples from various Devonian aquifers mined in the area, used for human consumption. The results obtained showed that the water in the limestone aquifer has a better quality than that of the other aquifers (Devonian). This relates more specifically to pH, conductivity (mineralization), total hardness and the concentration of major elements, and that there was an excess of nitrate, manganese, and ammonia. This can probably be due to the proximity of agricultural land as well as industrial areas in the case of a few boreholes. To this end, ongoing assessment of water quality is imperative and treatment to reduce the deterioration of water quality and eliminate health problems may be necessary.

**Key Words:** Diagnostics, groundwater, physico-chemical quality, pollution, Illizi area.

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doi: <http://dx.doi.org/10.4314/jfas.v12i1S.27>



## 1. INTRODUCTION

The issue of water is inseparable from sustainable development in that water must meet the needs of current generations without mortgaging the ability of future generations to meet their own needs [1] In Algeria, water resources come from renewable and non-renewable surface water and groundwater. The exploitation of these resources is very intense with the growing need for population growth and the accelerated development of economic activities, including irrigated agriculture and industry [2]. The management of water resources, both in quantity and quality, remains at the centre of the country's concerns, given the shortage of resources, which is often aggravated by drought. The degree of water quality required obviously depends on these uses, and particular attention is paid to the quality of water intended for human consumption, The main objective of this study is to determine the physical quality of the European Commission has published an annual report on groundwater pollution and groundwater pollution in the region, as well as the extent to which groundwater is polluted by sampling the waters of different aquifers [3].

### I.1. Situation of the study area

The wilaya of Illizi is located in the extreme South East of Algeria. It covers an area of 284,618 km<sup>2</sup>, with a population estimated at 33,767 [4], spread over 06 municipalities. It is bordering with three countries on a border of nearly 1256 Km , as follows:

- TUNISIA to the north-east, on 37,43 Km
- LIBYA to the east, on near 1006 Km.
- The NIGER in the south, over nearly 213 km

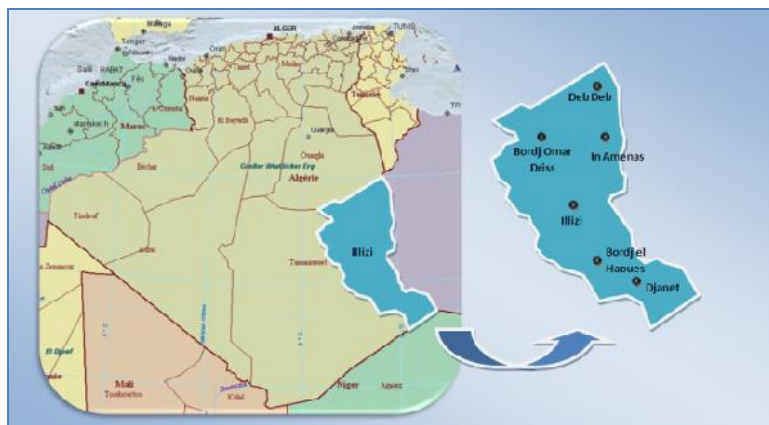
In the interior of the country, the wilaya is limited by 02 wilayas:

- The wilaya of TAMANRASSET in the west
- The wilaya of OUARGLA in the north, the nearest administrative center which is about 1052 km from the chiefplace of ILLIZI

It is divided into six municipalities (see Figure 01), namely:

- BORDJ OMAR DRISS
- DEB DEB
- IN AMENAS
- ILLIZI

- NET
- BORDJ EL HOUES



**Fig.1.** localization of ILLIZI County

## **I.2. Water supply in the town of Illizi**

The city of Illizi is totally dependent on groundwater resources.

These are extracted through drilling from the aquifer, which extends beyond the Algerian borders and drains the Lower Devonian greso-clay formations.

The works in and around the area have produced good results and show that this aquifer holds enormous amounts of water.

Other more or less important resources exist in the Illizi region.

Drilling capturing the Devonian aquifer feeding the town of Illizi.

## **2. PHYSICO-CHEMICAL QUALITY OF ILLIZI EPA WATERS**

### **2.1. Sampling**

The extraction of the water from the boreholes was carried out between January 2015 and December 2015 and concerns the aquifers of the complex terminal and the water table. These samples are manual and are taken at the top of the drill. The samples are taken in plastic bottles of 1000 cm<sup>3</sup> capacity. Prior to sampling, the bottle is thoroughly rinsed with drilling water. Conductivity and temperature were measured on site. For each sample, the vial must bear the drill code, date of sampling, depth and level of the aquifer.

**Table 1.** Characteristic of water wells exploited in the city of Illizi

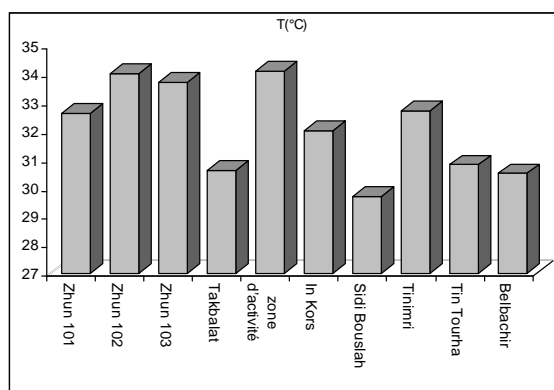
| N°         | Désignation        | Coordinates |          |     | tablecloth | prof | N.S<br>(m) | N.D<br>(m) | Observation |
|------------|--------------------|-------------|----------|-----|------------|------|------------|------------|-------------|
|            |                    | long        | latit    | alt |            |      |            |            |             |
| <b>F1</b>  | Zhun 102           | 8°28 59     | 26°30 51 | 588 | Dévonien   | 400  | 46         | 70         | Exploits    |
| <b>F2</b>  | ZONE<br>d'activité | 8°28 36     | 26°30 58 | 571 | Dévonien   | 355  | 17         | 35         | Exploits    |
| <b>F3</b>  | Zhun 101           | 8°28 26     | 26°30 18 | 591 | Dévonien   | 400  | 44         | 80         | Exploits    |
| <b>F4</b>  | Ain kors           | 8°30 10     | 26°30 13 | 575 | Dévonien   | 400  | 34         | 90         | Exploits    |
| <b>F5</b>  | Takbalat           | 8°28 03     | 26°27 47 | 562 | Dévonien   | 375  | 47         | 95         | Exploits    |
| <b>F6</b>  | Tintourha          | 8°26 16     | 26°30 34 | 567 | Dévonien   | 250  | 10         | 95         | Exploits    |
| <b>F7</b>  | Sidi Bouslah       | 8°28 03     | 26°27 46 | 572 | Dévonien   | 372  | 10         | 20         | Exploits    |
| <b>F8</b>  | Tinemri            | 8°26 19     | 26°29 29 | 556 | Dévonien   | 348  | 9          | 8          | Exploits    |
| <b>F9</b>  | Belbachir          | 8°28 36     | 26°27 43 | 557 | Dévonien   | 312  | 41         | 87         | Exploits    |
| <b>F10</b> | Zhun 103           | 8°29 09     | 26°30 48 | 584 | Dévonien   | 440  | 45         | 72         | Exploits    |

### 3. RESULTS AND DISCUSSION

The results of the physico-chemical analyses and all the pollution parameters tested are presented in histograms of which we propose some examples and this for the various aquifer levels exploited in the region.

#### 3.1.1. Temperature

Water temperature is an important factor in organic production. This is because it affects its physical and chemical properties; in particular its density, viscosity, solubility of its gases (including oxygen) and the rate of chemical and biochemical reactions [5]. In the study area, the results show that the degree of this temperature does not vary significantly from well to well (Figure 1), with a minimum of 29°C (Sidi Bouslah well) and a maximum of 34.1°C (well area of activity).

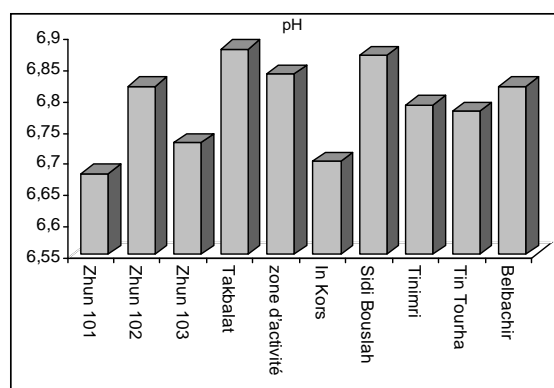


**Fig.2.** Spatial variation of average temperature values

### 3.1.2. The pH

The pH depends on the origin of the water, the geological nature of the substrate and the watershed being crossed [6,7]. This parameter conditions a large number of physico-chemical equilibria between water, dissolved carbon dioxide, carbonates and bicarbonates which constitute buffered solutions which confer a favourable development on aquatic life. In most natural waters, the pH is usually between 6 and 8.5, whereas in warm waters it is between 5 and 9 [8].

In the case of the study area, the pH values of the aquifers do not show Significant variations, with a minimum of 6.68 at the Zhun 101 well and a maximum of 6.88 at the Takbalat well (Figure 3), indicating a slight alkalinity of the environment.

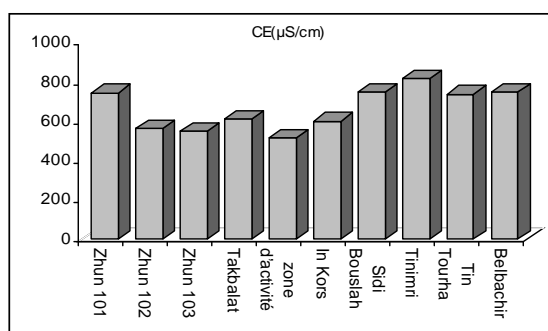


**Fig.3.** Spatial variation of mean pH values

### 3.1.3. Electrical conductivity

The electrical conductivity of water is the conductivity of a water column between two metal electrodes (Platinum) of 1cm<sup>2</sup> of surface and separated from each other of 1cm. It is the

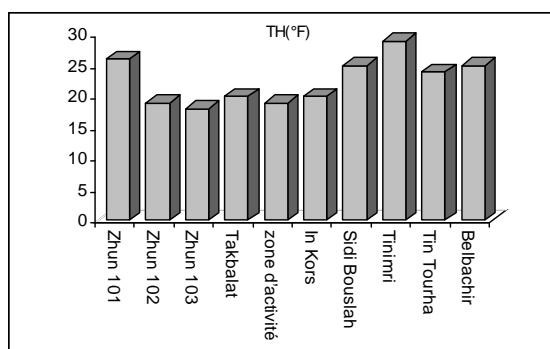
opposite of electrical resistivity. The unit of conductivity is Siemens per metre (S/m):  $1\text{S/m} = 10^4 \mu\text{S/cm} = 10^3 \text{S/m}$ . Conductivity provides an indication of the mineralization of water and is a good marker of the Origin of water [7]. In fact, the conductivity measurement makes it possible to assess the quantity of salts dissolved in the water, and thus its mineralization. The values recorded during the study period range from 511 to 814, the minimum recorded at the well in the area of activity and the maximum recorded at the Tinimri well (Figure 4). Electrical conductivity depends on the loads of endogenous and exogenous organic matter, generating salts after decomposition and mineralization and also with the evaporation phenomenon that concentrates these salts in water, It also varies according to the geological substrate.



**Fig.4.** Spatial variation of mean values of electrical conductivity

### 3.1.4. Total hardness

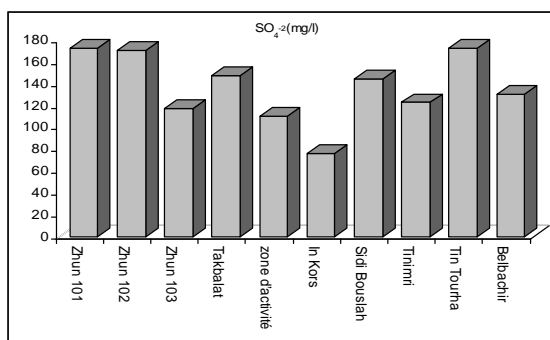
The total hardness of a water is produced by the calcium and magnesium salts it contains. A carbonate hardness corresponding to the carbonate and bicarbonate content of Ca and Mg and a non-carbonate hardness produced by the other salts are distinguished. Hardness is measured by the hydrotimetric titre expressed in °F (French degree); 1°F is 10 mg of calcium carbonate in 1 litre of water. It results mainly from the contact of groundwater with rock formations: Calcium derives from the attack of dissolved CO<sub>2</sub> by calcareous rocks (dolomites) or from the dissolution in the form of sulphate in gypsum. The hardness of natural water depends on the geological structure of the soils traversed. In the samples analyzed (Figure 5), this parameter presents a large variation from one well to another that would be related to the lithological nature of the geological formation of the groundwater table and in particular its composition in magnesium and calcium.



**Fig.5.** Spatial variation of mean values of total hardness

### 3.1.5. Sulphates

Sulphates ( $\text{SO}_4^{2-}$ ) result from runoff or infiltration into gypsum soils. They also result from the activity of certain bacteria (chlorothiobacteria, rhodothiobacteria, etc.). This activity can oxidize toxic hydrogen sulphide ( $\text{H}_2\text{S}$ ) into sulphate [7]. Based on the results of the samples analysed (Figure 6), the recorded values remain below the guide value ( $\text{VG} = 200 \text{ mg/l}$ ) of the Algerian standard for the quality of water intended for the production of drinking water.



**Fig.6.** Spatial variation of mean values of sulphates

### 3.1.6. Dissolved oxygen

Dissolved oxygen ( $\text{O}_2$ ) is very important because it determines the condition of several mineral salts, the degradation of organic matter and the life of aquatic animals [8]. It plays a crucial role in maintaining aquatic life and in self-purification. Its presence in natural waters is mainly determined by the respiration of organisms, by the photosynthetic activity of the flora, by the oxidation and degradation of pollutants and finally by the air-water exchanges. For all samples, dissolved oxygen varies significantly from point to point, ranging from 3.97 to 4.98 during the study period, with results showing that the wells are slightly under oxygen (Figure

7). Dissolved oxygen is an important parameter to consider because it provides information on the condition of the well and promotes the growth of micro-organisms that degrade organic matter. In general, low dissolved oxygen values promote the development of pathogenic germs.

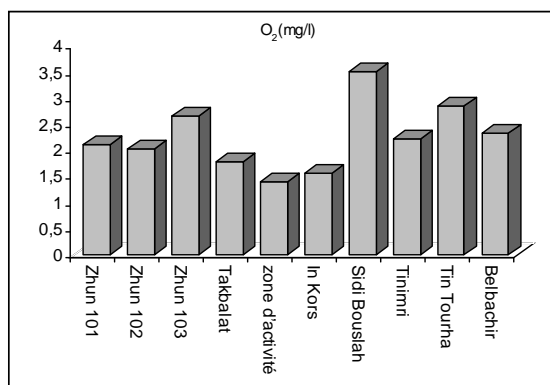


Fig.7. Spatial variation of mean values of oxygen

### 3.1.7. Hydrotimetric Titre

On all the samples taken, the hydrotimetric titre (TH) does not exceed in the majority 50° F, or even 19°F, and thus the standards of the O.M.S.

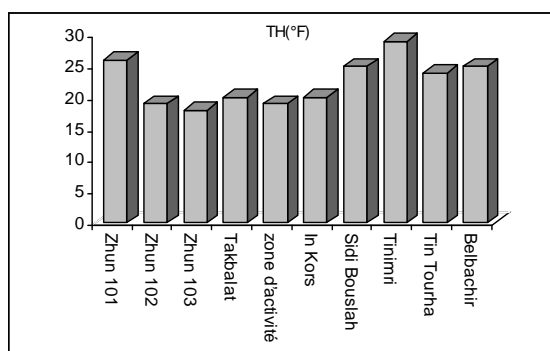
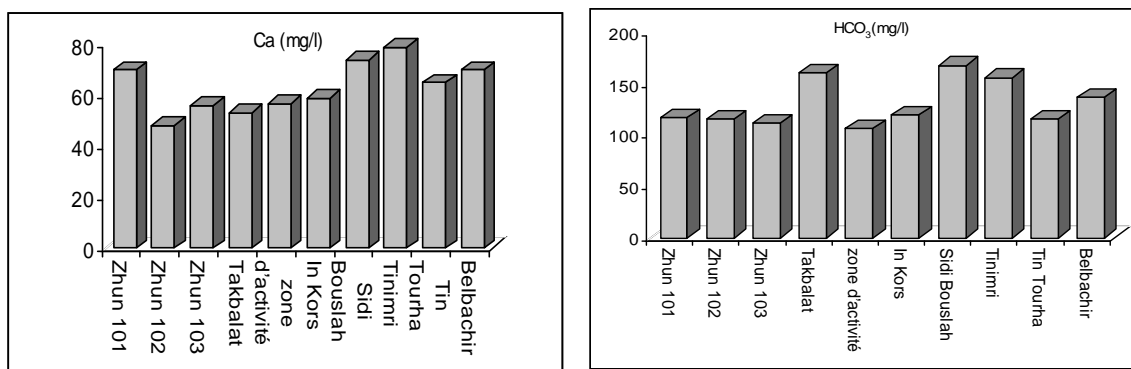


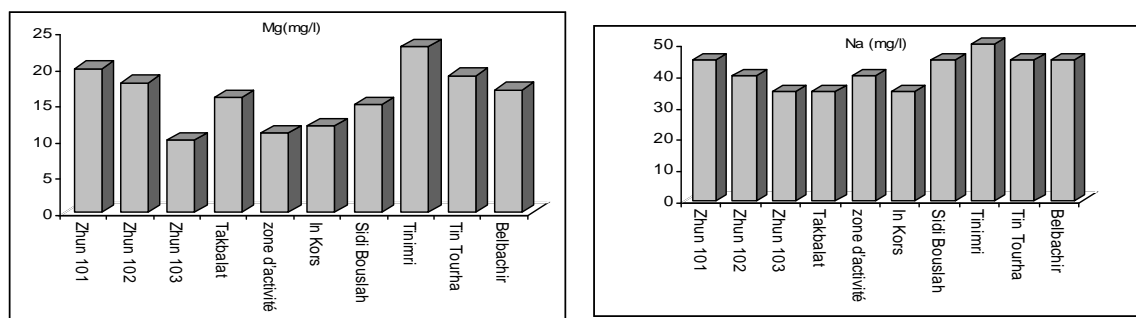
Fig.8. Spatial variation of mean values of total hardness

### 3.1.8. Other major elements

Figure 9 shows the sodium, chloride, sulphate and bicarbonate contents.



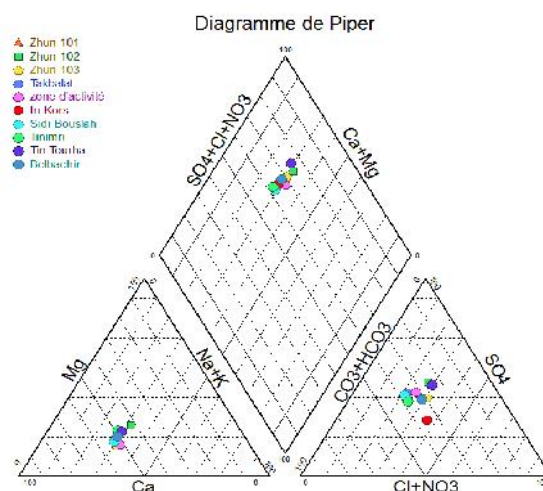




**Fig.9.** Concentrations of Major Mineral Elements at Drilling different tablecloths

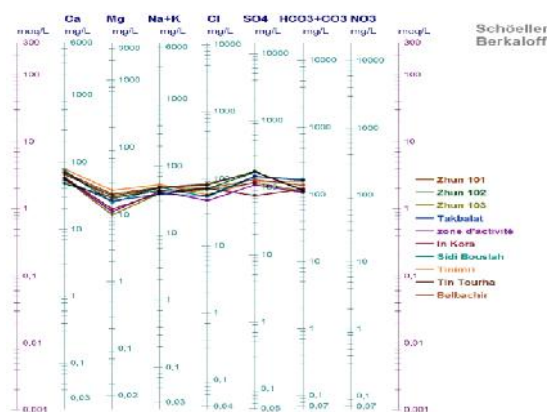
### 3.1.9. Chemical facies of water tested

We used the Piper diagram (Figure 8) to represent the chemical facies of a set of water samples. It is composed of two triangles to represent cationic facies and anionic facies and a rhombus synthesizing the global facies.



**Fig.10.** Piper diagram of the waters tested in the illizi region

Schoeller-Berkaloff diagram (Figure 9) allows to represent the chemical facies of several waters. Each sample is represented by a broken line. The concentration of each chemical element is represented by a vertical line in a logarithmic scale. , Broken line is formed by connecting all points of the different chemical elements. When the lines intersect, a change of chemical face is highlighted.



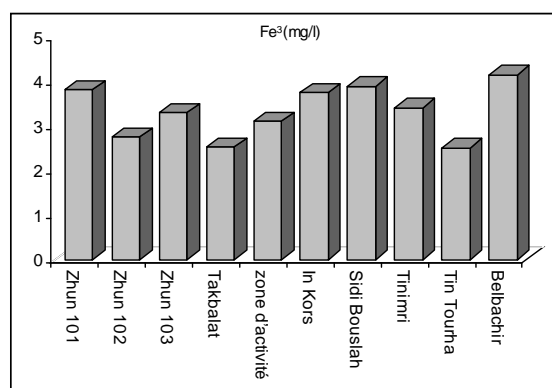
**Fig.11.** Schöeller-Berkaloff diagram of sampled boreholes

Through these representations, the water in the mined table shows a calcium and potassium sulfate facies. According to the Schöeller-Berkaloff diagram (Figure 9), the dominant ions are calcium and magnesium sulfate, the dominant cations are:  $\text{Ca}^{2+} > \text{Mg}^{2+} > \text{Na}^+$  and the dominant anions are:  $\text{SO}_4^{2-} > \text{HCO}_3^- > \text{Cl}^-$

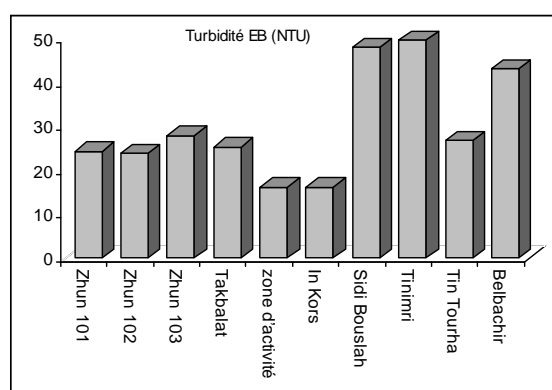
### 3.2. Undesired and toxic parameters

#### 3.2.1. Iron

Iron is a fairly abundant element in rocks (a few %) in the form of silicates, oxides and hydroxides, carbonates and sulphides. Chalk contains marcasite (sulphide) nodules; the Jurassic terrains currently a level of oolites made of iron oxides. Iron is soluble in the  $\text{Fe}^{2+}$  ion state (ferrous ion) but insoluble in the  $\text{Fe}^{3+}$  state (ferric ion). The value of the oxidation reduction potential (Eh) of the medium therefore determines its solubility and the iron content of the water. The underground aquifers isolated from the exchanges with the surface are in reductive conditions: their water is ferruginous. This dissolved iron precipitates in an oxidizing medium, especially at the source and at the outlet of the pipes. The presence of iron in water can promote the proliferation of certain strains of bacteria that precipitate iron where pipes corrode. Water is ferruginous especially in the ground water. Specific treatment is then necessary (precipitation in an oxidizing medium) [5]. Iron levels in the study area range from 2.51 mg/l to 4.16 mg/l (Figure 12), and the iron concentration in the region is below the recommended standard.



**Fig.12.** Spatial variation of mean iron values



**Fig.13.** Spatial variation of mean turbidity values

### The analyzes of samples taken at ILLIZI show

Salinization Water with low mineralization and good mineral quality.

Their mineral salt content ranges from 300 mg/l to 500 mg/l.

Presence of high turbidity up to 55 NTU due to oxidation of iron to ferric iron and forming a precipitate of a rusty colour.

### 2- Nitrogen, phosphorous and organic compounds:

The levels of organic, nitrogen and phosphorous compounds meet the standards of potability.

### 3- Undesirable and toxic elements:

Presence of very high levels of Iron which vary between 1.87 mg/l and 4.00 mg/l - (the accepted standard is 0.3 mg/l).

#### 4. CONCLUSIONS AND RECOMMENDATIONS

In conclusion, we can classify the waters of the ILLIZI borehole as fairly fresh waters, red with a high iron content. These physico-chemical characteristics define these waters as fairly fresh waters of red color requiring a specific treatment to clarify the drinking water of the municipality of Illizi. Iron concentrations, even if high, do not pose a risk to human health. The nuisances associated with the presence of iron in water are the rusty color, aesthetically not engaging for the consumer, and which can stain the linen and sanitary facilities as well as a "metallic" taste of water.

- Possible disposal techniques

Iron oxidation can be carried out by two processes:

- **1<sup>st</sup> variant:**

Removal by natural oxygenation consisting of the works: Cascade oxygenation tower – Settling basin - Filtration basin.

- **2<sup>nd</sup> variant:**

Removal by artificial oxygenation consisting of structures: Two-compartment basin or occurs oxygenation by artificial aeration and decantation – Filtration basin

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**How to cite this article:**

Mekhloufi N, Kateb S, Baouia K, Zegait R. Study of the physico-chemical quality of the groundwater of the lower Devonian aquifer in the illizi region (Algeria). *J. Fundam. Appl. Sci.*, 2020, *12(1S)*, 378-391.