

# Hydrogeochemistry of Groundwaters of the Area of Oulmes

O. Akkaoui, M. Najy, H. Ech-chafay, M. El qryefy, M. Lachhab, O. El Rhaouat, K. El Kharrim and D. Belghyti\*

Laboratory of Agro physiology, Biotechnology, Environment and Quality. University Ibn Tofail, Faculty of Science, B.P: 133.14000, Kenitra-Morocco; omar.akkaoui1@gmail.com, hamman.mohamed9@gmail.com, el-omo@hotmail.com, hassanfes98@gmail.com, elqryefy@gmail.com, salah-825@hotmail.com, k\_elkharrim@yahoo.fr, belghyti@hotmail.com

## Abstract

**Objectives:** The work is to evaluate and control the physicochemical quality of the groundwater in the medium Oulmes plate, to protect human health. **Methods/Analysis:** We have evaluated the quality of seven wells of the area of the plate of oulmes of the Moroccan Atlas during the year 2016; vary by carrying out the analysis for 16 physic-chemical and chemical parameters in the laboratory and "in situ". These parameters are pH, T, electric conductivity, salinity, potential of oxydoreduction, turbidity, dissolved oxygen,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{CO}_3^{2-}$  and  $\text{HCO}_3^-$ . These parameters are measured by the apparatus Hanna Instruments HI 98280 and Hach 2100 NTU, the anions and cations are measured by the atomic absorption. **Findings:** Electric conductivity 4110  $\mu\text{S}/\text{cm}$ , salinity is worth 1 mg/l, turbidity 9 TNU, dissolved oxygen 6.63 mg/l, potential of oxydoreduction 118.9 mV, the concentration of calcium 300.7 mg/l, the potassium concentration 39.04 mg/l, the magnesium concentration 65.61 mg/l, the sulphate concentration 102.01 mg/l, nitrate concentration 10.34 mg/l, and bicarbonate concentration 1068 mg/l. Indeed, these got results reveal that the degree of pollution exceeds the threshold of the national and international standards of potability. **Application:** In front of this situation, this requires a control and a treatment to preserve the natural environment.

**Keywords:** Groundwaters, Morocco, Oulmes, Physic-chemistry, Quality

## 1. Introduction

Water is much more than one simple human need. It represents an essential component to ensure the continuity of the life. The ground waters are all water present in the basement except for boiler feed waters. In Morocco, the ground waters constitute a significant portion of the hydraulic her it age exploited in the country<sup>1</sup>. The ground waters, although often geologically protected, age sometimes exposed with pollution agricultural, industrial or urban. The pollution of ground waters represents one of the most worrying aspects and their use at food ends represents a danger to health<sup>2</sup>. The ground

waters age traditionally the water resources privileged for drinking water, because safe from pollutants that the surface water<sup>3</sup>.

The deterioration of the quality of the water resources by proliferation of the various sources of pollution (solid rejections of not controlled waste, mining, urbanization...) constitute a threat as important as that related to quantitative imbalance. In the zone of Oulmes which belongs Moroccan of Meseta central, the ground waters constitute a vital resource for the economy for the region and the state. This work is interested under investigation of the quality of ground waters of Oulmes. A follow-up physic-chemical of parameters of water of

\*Author for correspondence

seven of traditional wells representative of the zone of study is carried out in order to specify the importance of pollution and to determine the origin of it.

## 2. Materials and Methods

### 2.1 Overview of the Study Area

The plate of Oulmes is located in Meseta Moroccan power station at 150 km at the southeast of Reduction. The annual average of the maximum temperatures varying between 22.8 with Oulmes and 22.2°C with Mouly bouazza. The minimal temperatures lie between 9.4 with Mouly Bouazza and 10 °C with Oulmes. As for pluviometry, Meseta of Oulmes receives approximately 773 mm/an<sup>4,5</sup> (Figure 1).



**Figure 1.** Central Hercynian solid mass of Morocco (Elbataoussi D et al, 2005), structural Map of Morocco to the 1/4.000.000 of the Mésétien fields and Atlasique).

### 2.2 Equipment and Methods

For the qualitative study of ground waters of Oulmes samplings were carried out during the period of 2016/2017. The analyses physic-chemical were carried out “in situ” and at the laboratory of Agrophysiology, Biotechnology, Environment and Quality of the University, Faculty of Science ibn Tofail Kenitra.

The temperature, potential pH, the potential redox, electric conductivity, dissolved salinity and oxygen are measured “in situ” using a multi-parameter of the type Consort C535 and Hanna Instruments HI 98280. Turbidity is measured by an optical turbidimeter Hach2100N. the chemical analyses of the major elements (cations and anions) were carried out by atomic absorption. For in situ analyses, the conservation of the

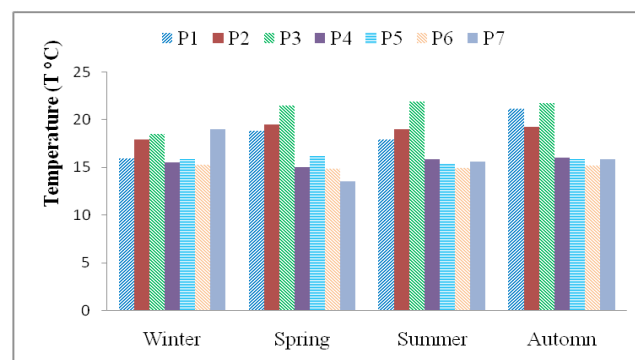
taking away of water was made according to the general guide for the conservation and the handling of the samples<sup>6,7</sup>. The physic-chemical follow-up of the parameters is carried out according of the technique of Rodier<sup>8,9</sup>.

## 3. Results and discussion

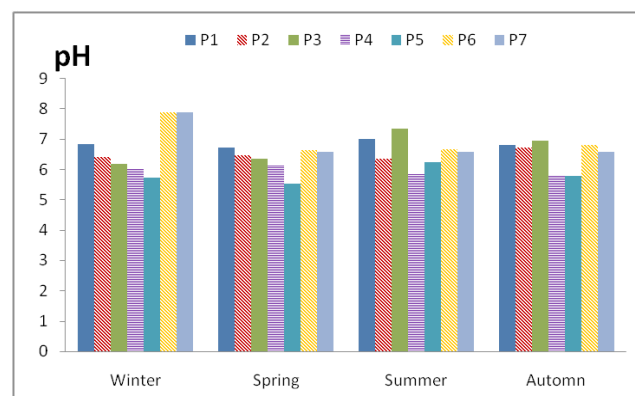
### 3.1 Temperature (T)

The temperature of water is an ecological factor very important in the study of the environmental phenomena. In effect, this one plays its part in the solubility of gases the dissociation of dissolved salts and determination of the pH the knowledge of the origin of water and the mixtures possible. Generally, the temperature of water is influenced by the origin of which they come (surface or deep)<sup>8,9</sup>.

In the zone of study, we noticed that the temperature does not present a notable variation in the wells P4, P5, P6 and P7, with a minimum of 13,53°C with the well P7 and the 15 maximum, 9°C with the P4 well except the wells P1, P2 and P3 which are registered of the values exceeding the norm admissible one (Figure 2).



**Figure 2.** Annual variations of the temperature.



**Figure 3.** Annual variations of the hydrogen potential.

### 3.2 Hydrogen potential (pH)

The hydrogen potential measures the concentration in ion  $H^+$  of the water, which translates also the balance between acid and bases. This parameter conditions a great of number physic- chemical balances between water, dissolved carbonic gas, carbonates and bicarbonates which constitute plugged solutions conferring on the aquatic life a favorable development. It depends also on geological nature distrains<sup>10</sup>. In most natural water, the values of pH range between 6 and 8.5<sup>11</sup>.

The case of the area of study, the values of the pH of ground waters of Oulmes do not show variations notables, with a minimum of 5.53 with the well P5 (Winter) and a maximum of 7.86 with the wells P6 and P7 (Winter). These results show that the area of oulmes is characterized by water slightly alkaline (Figure 3).

### 3.3 Electric Conductivity (EC)

Electric conductivity measures the capacity of water to lead the electric current between two metal electrodes. Most dissolved matters in water are in the form of electrically charged ions. The measurement of conductivity thus makes it possible to appreciate the quantity of dissolved in water. Conductivity is also a function of the temperature of water, it is very important when the temperature increases<sup>8</sup>.

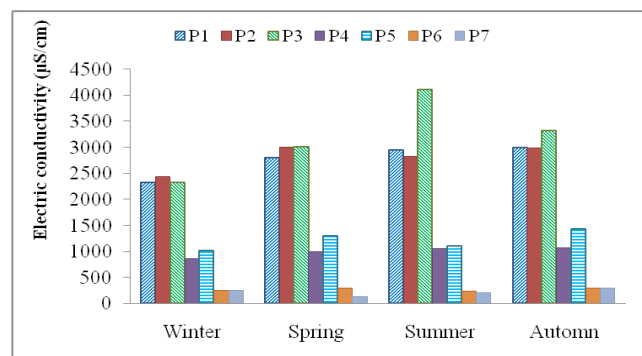


Figure 4. Annual variations of electric conductivity.

The values of conductivity recorded during the period of the analyses show that most water well meets the Moroccan standards except for the wells P1, P2 and P3 exceeding the standards (2330  $\mu S/cm$  with the P1 Well and 4110  $\mu S/cm$  with the P3 well). This increase can be due to the substrate geological, mineralization, of the loads of the organic matter and exogenic<sup>12</sup> (Figure 4).

### 3.4 Salinity

It is the evaluation of the total salt concentration dissolved in water. In the case of the area of study, the values of the concentration of salinity lie between 0 to 1 g.L<sup>-1</sup>. The concentrations are slightly above thresholds of the concentrations recommended by the standards of the WHO which indicates like value guides from 0.1 to 0.5g/L<sup>13</sup> (Figure 5).

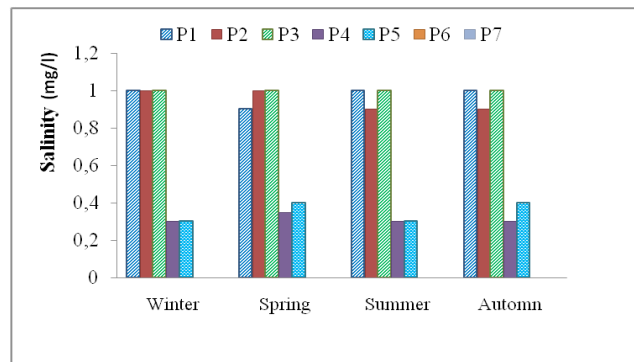


Figure 5. Annual variations of salinity.

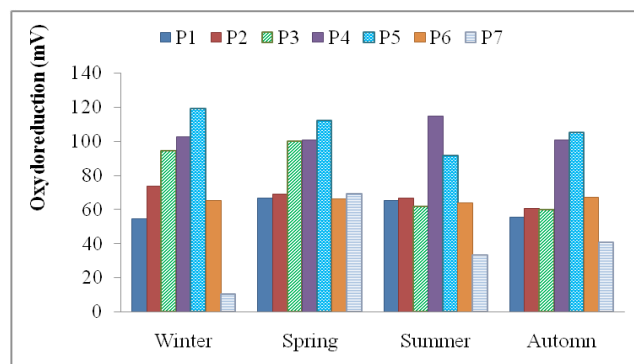


Figure 6. Annual variations of oxydoreduction.

### 3.5 Oxydoreduction

The reference of the potential of oxydoreduction is that of pure water, conventionally fixed at zero. The “oxi-dizing” bodies known as are the oxidants of the couples having a negative potential, thus that causes a reduction in oxygen what translates by the presence of an ascending polluting load is the increase in the reduction. The bodies known as “reducing” are the reducers of the couples having a potential positive which explains why oxygen oxidizes the solution. The values characteristic of the potentials is about a few millivolts (mV). We recorded in all wells. The study period of positive values the potential redox, which explains why oxygen oxidizes groundwaters (Figure 6).

### 3.6 Dissolved Oxygen

The dissolved oxygen concentration of water depends on several factors in particular the temperature, the atmospheric pressure and salinity. Dissolved oxygen comes either from the atmosphere by diffusion photosynthesis or of the photosynthesis of the autotrophic plants. It is consumed during breathing of the animals and plants, of the decomposition of the organic matters by the aerobic micro-organisms and the oxidation certain chemical substances<sup>14</sup>.

The values of the concentrations obtained at the level of the water wells P4, P5, P6 and P7 vary from 2.15 to 4.71 mg/l during the study period (Figure 7).

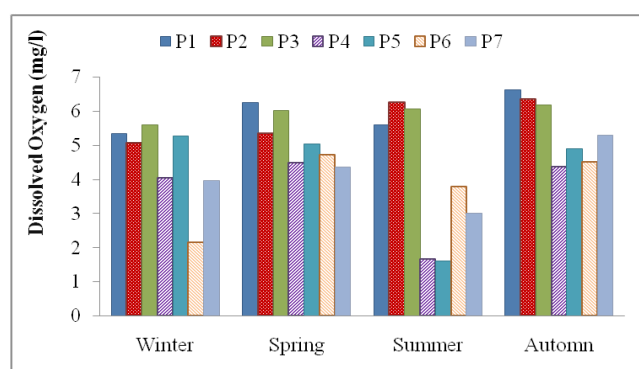


Figure 7. Annual variations of dissolved oxygen.

That shows that the wells are oxygenated on the other hand dissolved oxygen varies from 5.34 and 6.63 mg/l on the level of the wells P1, P2 and P3, with unveiled maximal variant between 5 and 8 mg/l according to the Moroccan standards of portability<sup>8</sup>.

### 3.7 Turbidity

Turbidity translates the presence of suspended particles in water (organic remains, microscopic clays, organizations). The measurement of turbidity makes it possible to specify the visual information on the water.

In the study area, the recorded turbidity values show that most of the water from the studied wells exceeds the maximum admissible value of groundwater compared to the Moroccan standard of potability. The turbidity values obtained at the water wells P1, P2 and P3 vary between 40.01 and 90 TNU (waters are turbid) whereas the turbidity at the level of the water wells P4, P5 and P6 varies between 9.5 and 30.7 TNU (waters are slightly turbid)<sup>2</sup> (Figure 8).

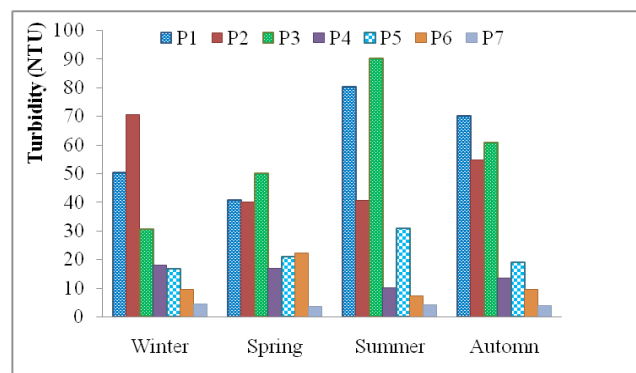


Figure 8. Annual variations of turbidity.

### 3.8 Nitrates ( $\text{NO}_3^-$ )

The nitrate content is shown (Figure 9) at the natural and soluble state in the ground. The nitrates also come from the oxidation of ammonia, organic matter and micro-organisms. They are also brought in a synthetic way by manures<sup>11</sup>.

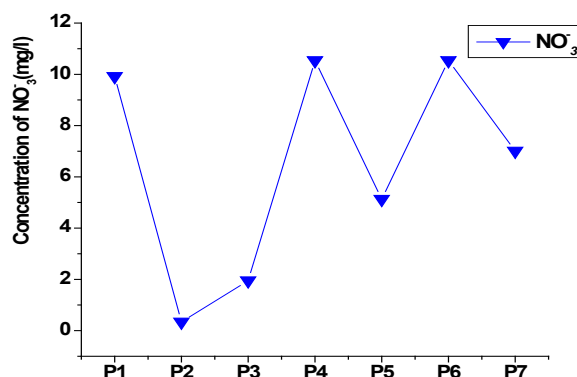


Figure 9. Variations of the median values of nitrates.

The Moroccan standard is fixed to 50 mg/l like acceptable value of nitrates in water of human nutrition. Thus all water of Oulmes answers the standards Moroccan and WHO<sup>2</sup>.

### 3.9 Sulphate ( $\text{SO}_4^{2-}$ )

The sulphate is present in the natural state in the ground and the rocks. In ground waters, most sulphates come from the dissolution of minerals like the gypsum and anhydrite<sup>15</sup>.

All the analyzed wells present a concentration lower than the acceptable maximum value (400mg/l) dictated by the Moroccan standard [7]. The content sulphates

in the wells vary between a minimal concentration of about 7.4 mg/l with the P2 well and a maximum concentration of about 102.01 mg/l with the P5 well (Figure 10).

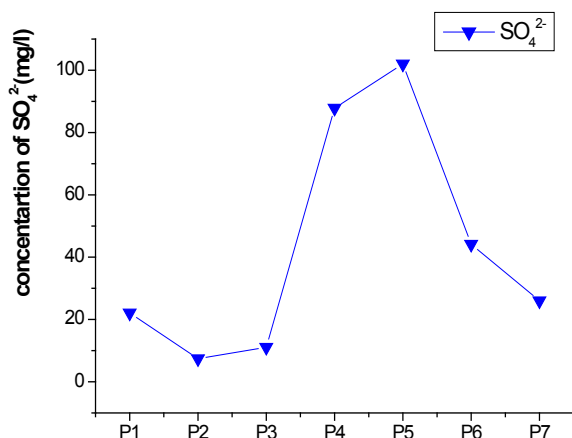


Figure 10. Variations of the median values of sulphate.

### 3.10 Magnesium ( $\text{Mg}^{2+}$ )

Under the conditions, magnesium comes from the dissolution of the carbonated formation ( $\text{CaCO}_3$ ) and bicarbonate<sup>16</sup>.

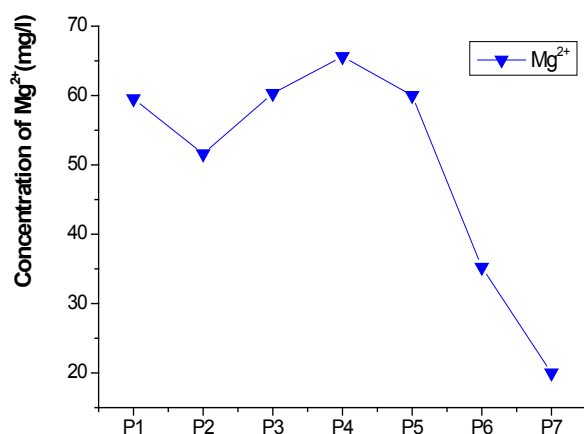


Figure 11. Variations of the median values of magnesium.

The manganese contents in the wells analyzed vary between minimal concentration of 20 mg/l recorded in the well P7 and a maximum concentration of 65.61 mg/l recorded in the well P4. Among the seven analyzed wells we found five-well do not meet the standards Moroccan<sup>7</sup> which are the wells P1, P2, P3, P4 and P5. The source of

magnesium seems to be dependent on contact with water with rocks lime stones and dolomitic (Figure 11).

### 3.11 Sodium ( $\text{Na}^+$ )

Sodium is a constant element in water, (Figure 12) however, the concentrations can extremely variable. Normally groundwater without contact with evaporates the sodium content ranges between 1 and 20 mg /l16.

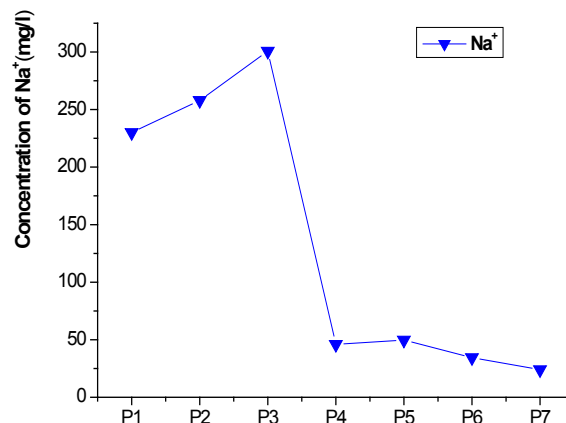


Figure 12. Variation of the median values of sodium.

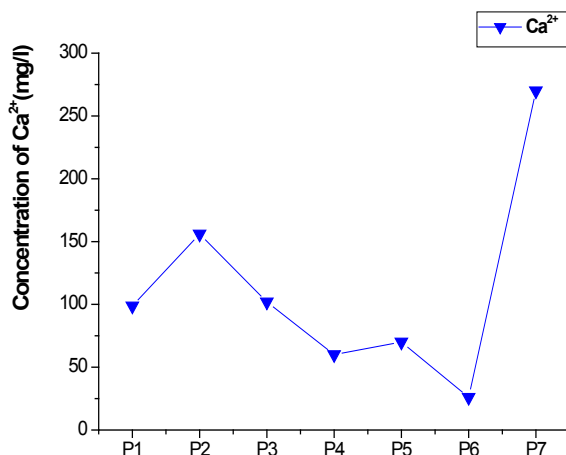


Figure 13. Variations of the median values of calcium.

In the zone of study, the wells study present concentrations varying between 24 mg/l recorded to the P7 well and 300, 7 mg/l recorded with the P3 well. All the values record during this study is in conformity with the Moroccan standards of potability<sup>7</sup>. What indicates to the



presence of a strong mineralization of water of the tablecloth of area of study?

### 3.12 Calcium ( $\text{Ca}^{2+}$ )

Calcium has generally dominated in drinking water. The presence of this element in water is related mainly either to the dissolution of the formations carbonates ( $\text{CaCO}_3$ ), or with the gypsum ( $\text{CaSO}_4$ ) (Figure 13).

Moreover, the concentration of calcium in the analyzed wells varies between 26 mg/l in the well P6 and 270mg/l in the well P7. Most recorded values do not exceed the Moroccan standard (200mg/l) with the exclusion of the well P7 which with recorded values exceeding the Moroccan standard of portability<sup>7</sup>.

### 3.13 Potassium ( $\text{K}^+$ )

Potassium is very high in the ground. Potassium is generally the major element the least abound in water after sodium, calcium and magnesium. According to standards of WHO relating the portability of water, the maximum concentration recommended for potassium is about 12 mg/l.

According to our results, the potassium levels are in the range of 3 mg / l to 39.06 mg / l. So, on the level of the area of study, the potassium content of groundwater meets Moroccan standards of potability<sup>7</sup> in wells P4, P5, P6, P7; on the other hand, wells P1, P2 and P3 do not meet the standard (Figure 14).

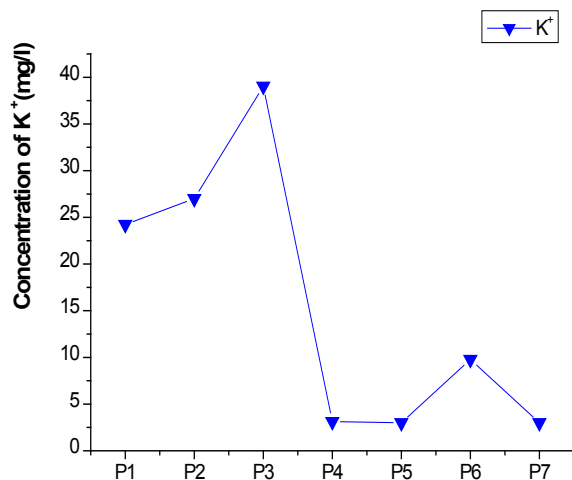


Figure 14. Variations of the median values of potassium.

### 3.14 Chloride ( $\text{Cl}^-$ )

The chloride contents of natural water extremely varied and bound mainly to the nature of the ground<sup>9</sup>, and generally in the form of salts of sodium ( $\text{NaCl}$ ) and potassium ( $\text{KCl}$ ) (Figure 15).

The results obtained in all the wells analyzed during study, answer the Moroccan norm set at 750 mg/l<sup>7</sup>.

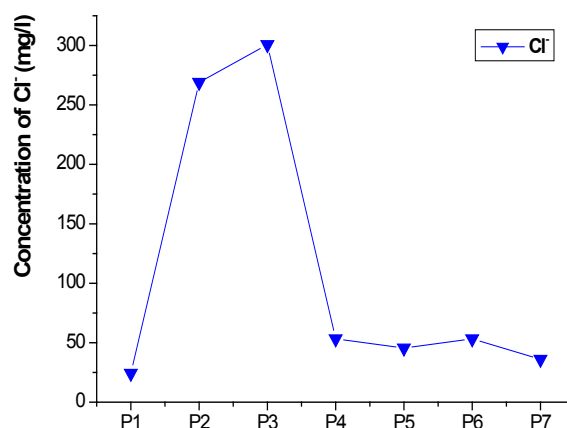


Figure 15. Variations of the median values of chlorides.

### 3.15 Bicarbonates ( $\text{HCO}_3^-$ )

The presence of bicarbonate in ground waters depends on dissolution on the formation carbonate and the  $\text{CO}_2$  content on the air. The bicarbonate content in non-polluted ground waters is of the order 302 mg/l<sup>16</sup>.

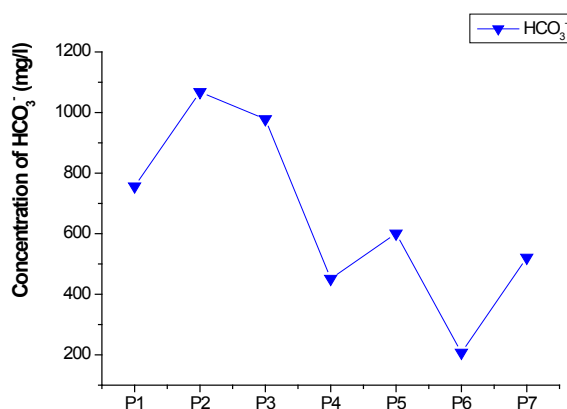


Figure 16. Variations of the median values bicarbonate.

Most value recorded during the study period exceeds the value of not polluted ground waters (302mg/l). The concentration of bicarbonates in the analyzed wells varies between 207,4 mg/l recorded in the well P6 and 1068 mg/l recorded in the well P3 (Figure 16).

## 4. Conclusions

The results obtained show that the water parameters (EC, Turbidity) exceed the standards of Marocaines par report. This pollution comes primarily from the degradation of the organic matter present in the medium and possibly of the compounds of industrial origin.

The results also show that the concentrations of the physicochemical parameters such as  $\text{Ca}^{2+}$ ,  $\text{Na}^+$ ,  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$  and  $\text{NO}_3^-$  are generally low at the level of the majority of analyzes water samples. On the other hand, the concentrations of  $\text{Mg}^{2+}$ ,  $\text{K}^+$  and  $\text{HCO}_3^-$  exceeded the acceptable value. These waters are not balanced in minerals and afterwards their use then requires an adequate treatment to reduce any excess in concentration while conserving these natural resources.

## 5. References

1. Belghiti ML, Chahlaoui A, Bengoumi D, El moustaine R. Etude de la qualité physico- chimique et bactériologique des eaux souterraines de la nappe plio-quaternaire dans la région de Meknès (Maroc). Larhyss Journal. 2013;21–36.
2. L'industrie porcine: les risques reliés à la santé humaine [Internet]. [cited 1995]. Available from: <http://www.santecom.qc.ca/Bibliothequevirtuelle/santecom/3556700046018.pdf>.
3. Guergazi S, Achour S. Caractéristiques physico-chimiques des eaux d'alimentation de la ville de Biskra. Pratique de la chloration. Larhyss Journal. 2005;119–27.
4. Caractérisation isotopique des eaux du granite et de l'auréole métamorphique d'Oulmès [Internet]. [cited 2006]. Available from: <https://orbi.uliege.be/handle/2268/3459>.
5. Elbataoussi D, Cheddad M, Dadi S, Ruthy I, Orban ph, Dassargues A. Carte géologique du plateau d'Oulmès (MAROC). Département de Géologie, Ecole National de l'Industrie Minérale Raba –Maroc; 2005. p. 1–49.
6. Boutayeb M, Bouzidi A. Optimisation du dimensionnement des bassins d'épuration par lagunage naturel dans la région de la Chaouia Ouardigha-Maroc. Nature and Technologie; 2014. p. 15–20.
7. El Asslouj J, Kholtei S, El Amrani-Paaza N, Hilali A. Impact des activités anthropiques sur la qualité des eaux souterraines de la communauté Mzamza (Chaouia, Maroc). Revue des sciences de l'eau/Journal of Water Science. 2007; 20(3):309–21.
8. Rodier J, Bernard L. L'analyse de l'eau. Dunod. 2009, pp. 15-26.
9. Ghazali, D, Zaid A. Etude de la qualité physico-chimique et bactériologique des eaux de la source Ain Salama-Jerri (Région de Meknès-Maroc). Larhyss Journal. 2013; 12:25–36.
10. Azami Hassani T. Contribution à l'étude de la pollution des eaux continentales au Maroc « Evolution d'impact des effluents d'une raffinerie (S.C.P) sur un oued en zone semi continentale R' dom». Faculté des sciences-Semlalia, Marrakech; 1996.
11. Abboudi A, Tabyaoui H, El Hamichi F, Benaabidate L, Lahrach A. Etude de la qualité physico-chimique et contamination métallique des eaux de surface du bassin versant de guigou, maroc. European Scientific Journal (ESJ). 2014; 10(23):1–11.
12. Bouchelaghem S, Djaballah I. Contribution to the study of groundwater quality Contribution to the study of groundwater quality in the region of el Oued (South-east of Algeria). Advances in Environmental Biology. 2015; 9(18):37–53.
13. Chaïeb A, Khattach D. Evaluation de la qualité physico-chimique des eaux souterraines dans le voisinage de la décharge contrôlée de Berkane (Maroc). Journal of Materials and Environmental Science. 2016; 7(11):3973–983.
14. Rodier J. Analysis of water. Wiley; 1975. p. 176–7.
15. Ben abbou M, Fadel F, El Haji M, Zemzami M. Impact anthropique sur la qualitedes eaux souterraines du bassin versant de l'oued taza (MAROC). European Scientific Journal. 2014; 10(5):1–21.
16. Nouayti N, Khattach D, Hilali M. Evaluation de la qualité physico-chimique des eaux souterraines des nappes du Jurassique du haut bassin de Ziz (Haut Atlas central, Maroc). Journal of Materials and Environmental Science. 2015; 6(4):1068–81.