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RESEARCH PAPER

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The impact of the factory of the exploitation of the baryta deposits on the quality of the waters of the township of ain Mimoun province of Khenchela N-E of Algeria

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Abstract

Our work is intended as a contribution to the analysis of the effect of barium factory discharges in the region of Ain Mimoun in the province of Khenchela, the latter has a semi-arid climate, the sampling of the groundwater was carried out on quaternary and cretaceous formations for the purpose of physicochemical analysis. The hydrochemical study revealed that the concentrations of barium and sulphate are high, particularly in the samples taken near the production unit. This means that the discharge of this barite unit has a pollution impact on the groundwater of our study area.

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Introduction

The study of ground waters chemistry or hydrochemistry brings its lot of information in the chemical tracing for the understanding of the functioning of the different aquifer systems and inter-nappes relations. A great deal of work has also been done on the study of the various effects of industrial and urban discharges on water quality trends and pollution (Reggam *et al*., 2015).

In Algeria, the exploitation of these resources is very intense with the growing needs related to the demographic boom and the accelerated development of economic activities, especially agriculture in Irrigation and industry (Mohammedi *et al.,* 2015). All over the world, clean water is essential for human comfort, health and survival (Bouziani, 2000).

To study the groundwater quality of Ain Mimoun, we carried out reconnaissance trips of the site during which we selected 10 points to study. The main interest of this study, is to better characterize the quality of the groundwaters of Ain Mimoun, these variations in space and time, in order to contribute to the knowledge of the system of point of view pollution.

It is very important to carry out controls and physicochemical analysis of water periodically. In view of the worrying state of water quality in the plain of Ain Mimoun and near the exploitation of the baryta deposits on the quality of thewaters of the township of ain Mimoun province of Khenchela N-E of Algeria

The usine exploitation of the baryta deposits on the quality of thewaters of the township of ain Mimoun province of Khenchela N-E of Algeria, the present study aims to indicate the main role of the industry in the deterioration of water quality by evaluating the physico-chemical characteristics of groundwater in this area.

Physical measurements were carried out in situ immediately after the sample was taken by ours elves in March 2015, using a HANNA HI 9025 multi parameter such as temperature, electrical conductivity and the hydrogen potential. The chemical analyses were performed at the Environmental Analysis and Chemical Testing Laboratory on Materials of AinM'Lila s using a 410-sherwood flame type atomic absorption spectrometer for cations, and using a scanner for the other parameters: the anions.

Materials and methods

Study Area

The unit of exploitation of the baryta deposits is located in the village called Ain Mimoun, which is in the township of Tamza, sub province of El Hamma, province of Khenchela; 25 km south-west of the capital of the province along the national road no. 88 linking Khenchela to Batna; departing from khenchela over a distance of 16 km where there is a roundabout and there, we take the left route, the south-west road that leads to the village of Ain Mimoun, the location of the baryta ore processing unit (SOMIBAR), which is 9 km away from the national road 88.

Part of Ain Mimoun township is located entirely in the lower cretaceous on the Khenchela anticline which presents a sandstone, marl-limestone and dolomite facies; the rest is completely settled in the upper cretaceous on the flanks of the Chelia and Khenchela anticlines and in the heart of the DjebelAurès syncline with marly, limestone facies.

The climate of the township is continental Mediterranean type semi-arid. It is characterized by a wet and cold season in the autumn and winter months and a hot, dry season during the spring and summer. Within the study area, permanent water points are rare, which can be explained by the nature of very permeable terrain formed by limestone and limestone-marl.

The only sources that flow in the summer are located at the bottom of Oueds Tamza, Issouel, Khefadj, Mellagou, Azreg, where the presence of clay soil allows the formation of groundwater. (Fig. 1)

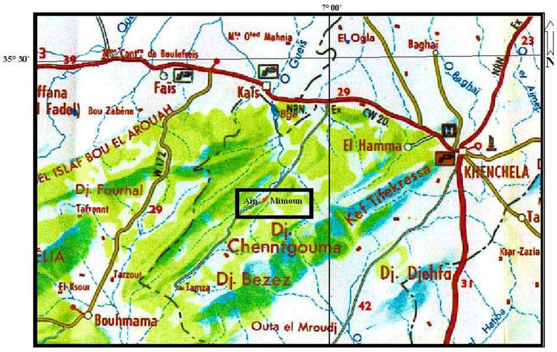

Fig. 1. Geographical localization of Ain Mimoun (according to tourist map of Algeria).

Result and discussion

The physicochemical analyzes of the waters of Ain Mimoun during the year 2015 indicate a variation of the concentrations of certain chemical elements. This explains the presence of the variations in the standards of drinkability in certain points of measures. The following map represents the different water points taken from this study. (fig. 2)

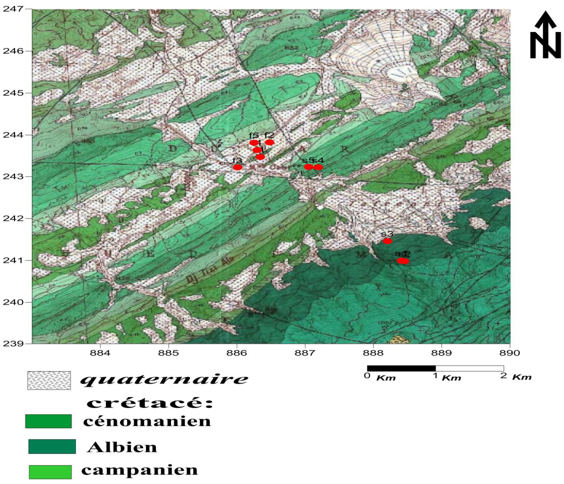

Fig. 2. Inventory map of water points 2015.

Physical Parameters

The Temperature of the Water

Temperature is a very important factor because it conditions evaporation. Water temperature is a useful physical parameter in understanding power sources that should not exceed 25 ° C. It is important to know the water temperature with good accuracy. Indeed it plays a role in the solubility of salts and especially gases, in the dissociation of dissolved salts so the electrical conductivity in the determination of pH.

The temperature values observed in the study area are below the standard of drinkability set by WHO which is 25 °C, it varies between 17 °C and 20 °C. We notice that the average annual air temperature is 16.52 ° C. These values reflect the presence of a shallow alluvial aquifer fed by meteoric waters.

The Hydrogen Potential the (pH)

Ph measures the chemical activity of hydrogen ions (H^+) in solution. In particular, in aqueous solution, these ions are present in the form of the oxonium ion H_3O^+ (also called hydronium ion). More commonly, pH measures the acidity or basicity of a solution. It is related to changes in temperature, salinity, dissolved oxygen, CO_2 levels and crossed lands.

The pH of the study area varies between 7.22 and 7.61. with an average of 7.46, the waters of AinMimoun are in adequacy with the WHO standard (6.5 and 9.5) for drinking water. The region has an alkaline character as Fig. 03 indicates.

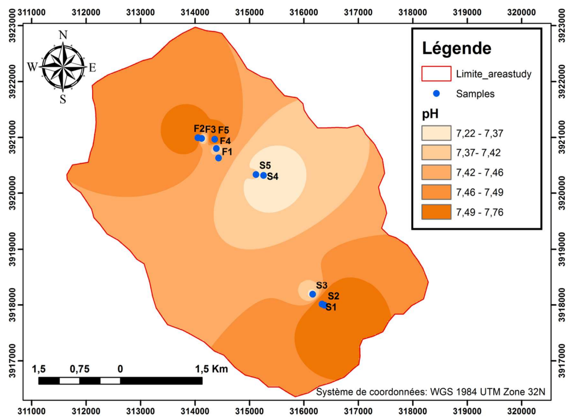

Fig. 3. Map of the spatial pH distribution of AinMimoun underground waters.

Electrical Conductivity (CE)

Electrical conductivity refers to the ability of water to conduct an electric current, it is determined by the content of dissolved substances. As a result, it provides information on the degree of mineralization of a water (Derwich *et al*, 2010). It depends on the nature of these dissolved ions and their concentrations. Temperature and viscosity also influence the conductivity because the mobility of ions increases with increasing temperature and decreases with that of viscosity (Franck, 2002). The standard electrical conductivity is generally expressed in millisiemens per meter (ms / m) at 20° C. The conductivity of a natural water is between 50 and 1500µS / cm. (IBGE, 2005).

The maximum values of the electrical conductivity are recorded in boreholes F1, F2, F3, F4 in the north-west of the study area, this strong mineralization reflects the influence of the recent alluvial quaternary formations, leached by the rainsfeeding this aquifer. While the minimum values of electrical conductivity are recorded in S1, S2, S3 whose minimum value is (319.7µS / cm) because of cretaceous formations. All values of electrical conductivity do not exceed the WHO standard. (Fig. 4)

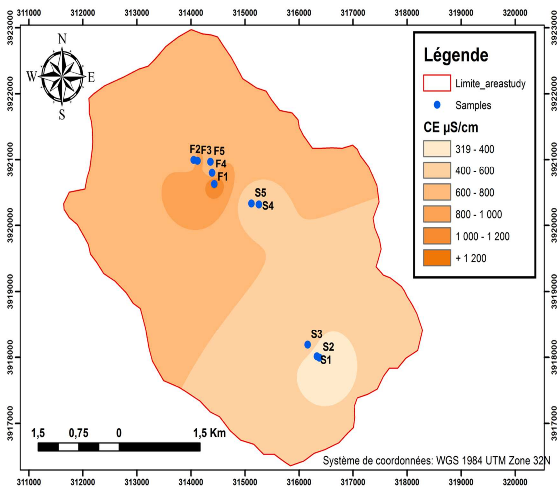

Fig. 4. Map of the spatial distribution of the electrical conductivity of Ain Mimoun underground waters.

Analytical study of Chemical Elements

Bicarbonates (HCO3-)

Bicarbonates are found in natural waters, their presence in water is due to the dissolution of carbonate formations such as limestones and dolomites. The bicarbonate ion reacts with a mineral acid and releases carbon dioxide into the solution (Rodier, 2009). The concentrations of bicarbonates in the various samples analyzed from the aquifer range from a minimum of 131.9mg/l to a maximum of 270.3mg/l.

The spatial evolution of the bicarbonates (Fig. 19) shows an increase in the concentrations of this element in the northwestern part and in the center of the study area at the water points F1, F4, F3, S4, S5. These high levels are probably due to the influence of carbonate formations of cretaceous and quaternary. Heading south-east, without forgetting the northern part of the study area where HCO3- concentrations decrease to reach the lowest grade at water points F2, F5. (fig. 5)

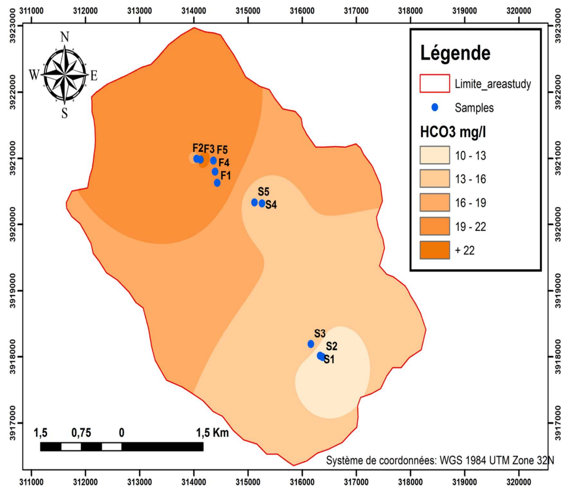

Fig. 5. Bicarbonate concentration map in the AinMimoun underground waters.

Sulphates (SO_4^{-2})

They are present in natural waters at very variable levels and may come from the dissolution of gypsum. The latter may be triassic, as it may be associated with more recent formations such as Mio-Plio-Quaternary clays. They also depend on industrial discharges. The map shows that sulphates concentrations are elevated northwestern of the study area at drill holes F1, F2, F3, F4, F5, with a maximum value recorded at drill hole F1 (834mg / l).

This explains the influence of the discharges of the factory of the exploitation of the barytadeposit (BaSo4) which is very close to these water points. 20% of the samples exceeded the drinkability standards. These high levels are located in the quaternary, whereas the low concentrations of sulphates are at the cretaceous level. The presence of gypsiferous inclusion (CaSO4, 2H2O) and evaporitic salt rocks (Na2 SO4) would also be responsible for increasing the sulphate content (fig. 6)

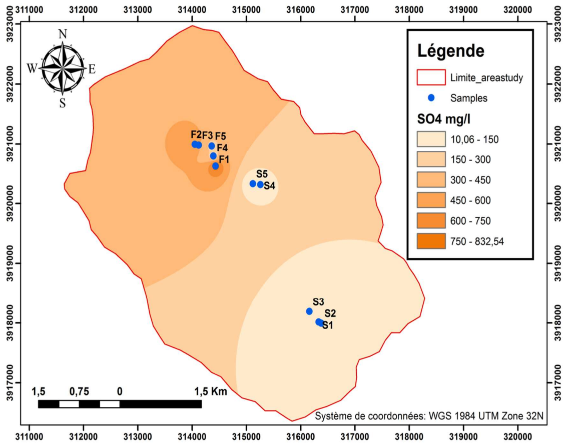

Fig. 6. Map of the distribution of sulphate levels in the underground waters.

Nitrates (NO_3^-)

Nitrate (or nitrate nitrogen) is the nitrogen form often found most in natural waters. Nitrates are the main component of inorganic or mineral nitrogen, which is mainly included in global nitrogen (NGL) or total nitrogen (NT) with another component, organic nitrogen. They represent the most oxygenated form of nitrogen, it is a very soluble form, its presence in groundwater is linked to the intensive use of chemical fertilizers.

The nitrate distribution map shows that high concentrations are found at the quaternary level in the northwest of the study area with a maximum recorded value in borehole F1 (20mg/l) which is below the standard of drinkability set by WHO (50mg/l)(Fig. 7).

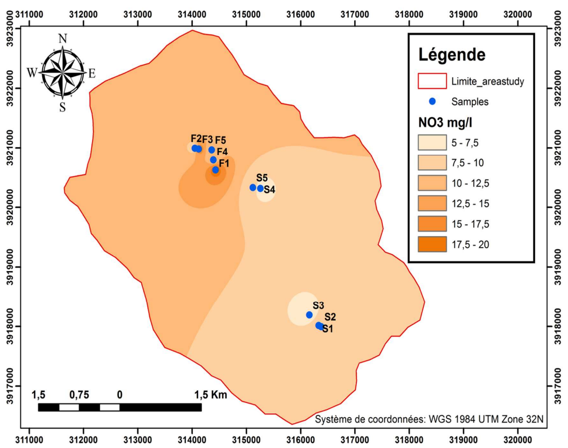

Fig. 7. Map of the distribution of nitrate levels in the underground water.

Chlorides (Cl^-)

Water almost always contains them, but in very variable proportions the chlorides content usually increase with the degree of mineralization of a water. The chlorides encountered come from:

• Discharges of industrial origin such as hydrochloric acid (HCL).

• Discharges of water of domestic origin.

• The dissolution of the natural soils of saliferous soils.

Thematic Map 23 indicates that the highest concentrations are northwesterly at the quaternary level. The maximum value is 56.1mg / l given by the F1 drilling. It should be noted that all results obtained in this parameter are higher than the concentration capped by the WHO (50mg / l).

The region of AinMimoun is semi-arid, it would be useful to attribute the high levels, the leaching of superficial salt concretions in case of heavy rain. In this zone, these high concentrations of chlorides can also be linked to the pollution of the groundwater by wastewater from the factory's waste (Fig. 8).

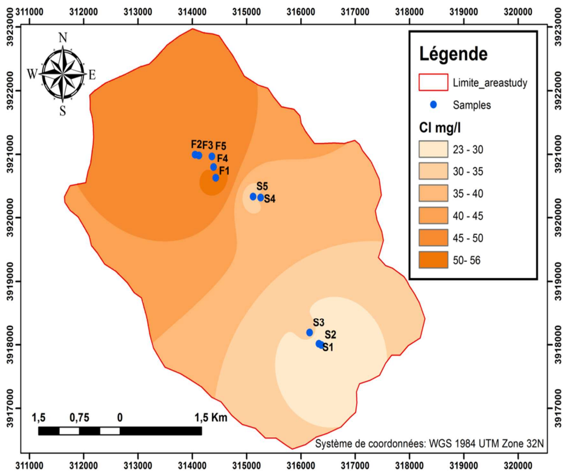

Fig. 8. Map of the distribution of chloride contents in the underground waters.

Calcium (Ca^{2+})

Calcium is an alkaline earth element, it is found in thermo-mineral waters circulating in calcareous medium and also in calcareous rocks in the form of carbonate. Calcium can also come from gypsiferous formations ($Ca\ SO_4$, $2H_2O$).

Measurement results from the laboratory and the calcium distribution map show that most water points in the study area have high calcium ion levels (maximum value is 610mg/l) with higher concentrations to the water drinkability standard (100mg/l), with the exception of a few points where concentrations are lower (minimum value is 09mg/l) where groundwater flow is very low (the curves spaced isopides), indicating that these waters are less influenced by the dissolution of carbonate and gypsum formations. (fig. 9)

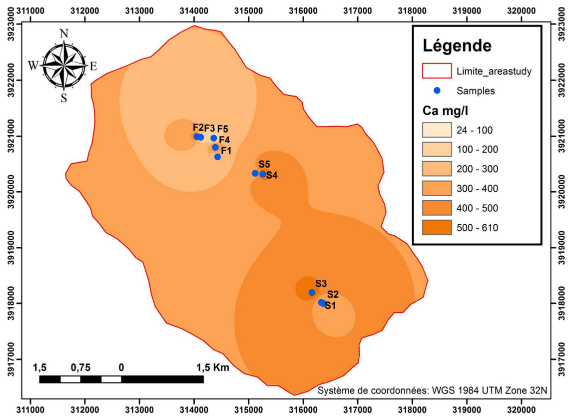

Fig. 9. Map of distribution of calcium levels in the underground waters.

Magnesium Map (Mg^{2+})

Magnesium originates in the geological formations crossed by water, either by the dissolution of dolomitic formations, which is only possible thanks to the presence of carbon dioxide, and also by the dissolution of magnesium sulphatemgSO_4 in gypsum soils. Finally, it is noted that the dissolution ofmg^{2+} is very difficult and requires a lot of contact time. The magnesium concentration map shows that the high concentrations are located in the north-west of the study area, at water points F3, F5, F4, S4 with a maximum value of 147.7mg / l, exceeding standards of drinkability. The high magnesium content can be attributed to the dissolution of dolomites of recent geological formations (quaternary)(Fig. 10).

Sodium map (Na^{+})

It is an element that exists in all waters because the solubility of its salts is very high. It comes from the leaching of geological formations rich in NaCl.

The spatial representation of sodium informs us that the high concentrations of sodium are localized in the boreholes F1, F2, F3, F4, in the North-West of the study area (the maximum value is 184mg/l), the corresponding geological formation at the high concentration is the quaternary, this high concentration is probably at the origin of the nature of the grounds of this region, even if this concentration is above the norm imposed by WHO (fig. 11)

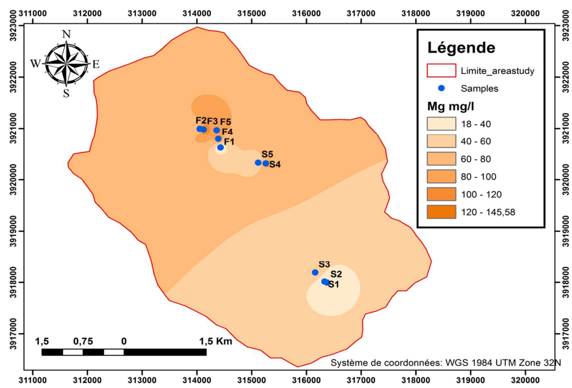

Fig. 10. Map of the distribution of magnesium levels in the underground waters.

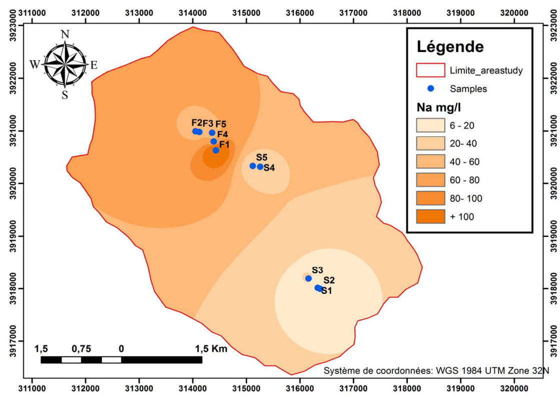

Fig. 11. Map of the distribution of sodium levels in the underground waters.

Barium (Ba)

Barite, or baryta, is a mineral species composed of barium sulfate of formula BaSO4 with traces of Sr, Ca and Pb. This mineral, of hydrothermal origin, has many varieties. Its density and the barium it contains are the main causes of its industrial uses and several million tons of baryta are extracted and produced each year.

Based on the spatial distribution of barium, the highest concentrations at this drill point F2 and

2.15mg/l at drilling level F3 are found in the northwest of the study area, which correspond to the geological formations of the quaternary. It should be pointed out that the concentrations of all the samples are alarming and far exceed the allowable value of WHO. These high levels of barium can be related to the pollution of the groundwater by the discharges of the exploitation unit of the baryta deposits ($BaSO_4$) which is in the vicinity of these water points. (fig. 12)

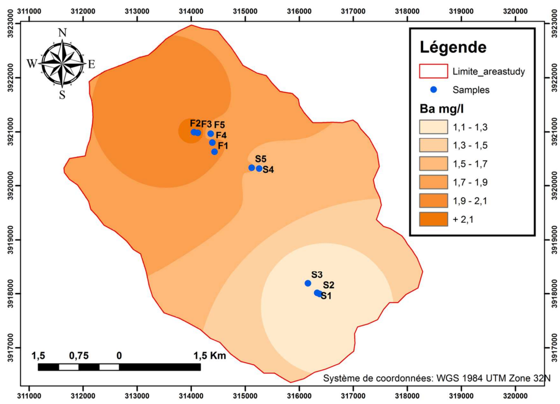

Fig. 12. Map of the distribution of Bryum contents in the underground waters.

Chemical Facies of Waters

Graphic Distribution

From the results of the chemical analyzes of the different water points, the Piper (1944) and SCHOELLER and BERKALOFF (1935-1938) diagrams give a global approach to the spatio-temporal composition of determining the chemical facies of waters.

Piper Diagram

The Piper diagram is composed of two triangles representing the distribution of the anions and that of the cations respectively, and a rhombus representing the synthetic distribution of the major elements.

The Piper diagram shows an evolution of the chemical facies from calcium sulphate water (F1, F2, F4, S3, S4, S5) to the northwest of the study area in plio-quaternary rich in gypsum ($CaSO_4$ $2H_2O$), towards an intermediate calcic chloride facies (S1, S2) in the southeast that correspond to the geological formations of the cretaceous to eventually lead to magnesium sulphate water (F2, F5) located in the quaternary (Fig. 13).

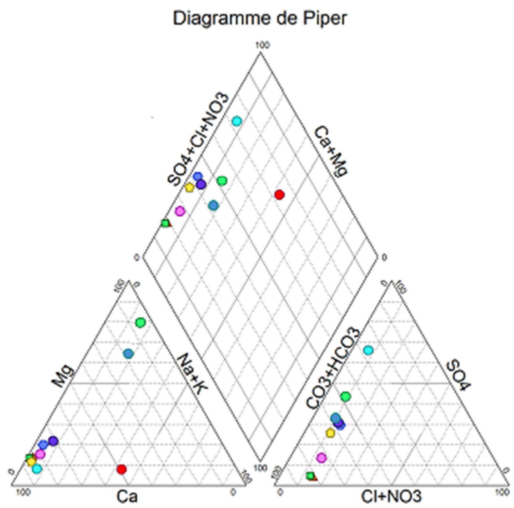

Fig. 13. Piper diagram of AinMimoun underground waters analyses.

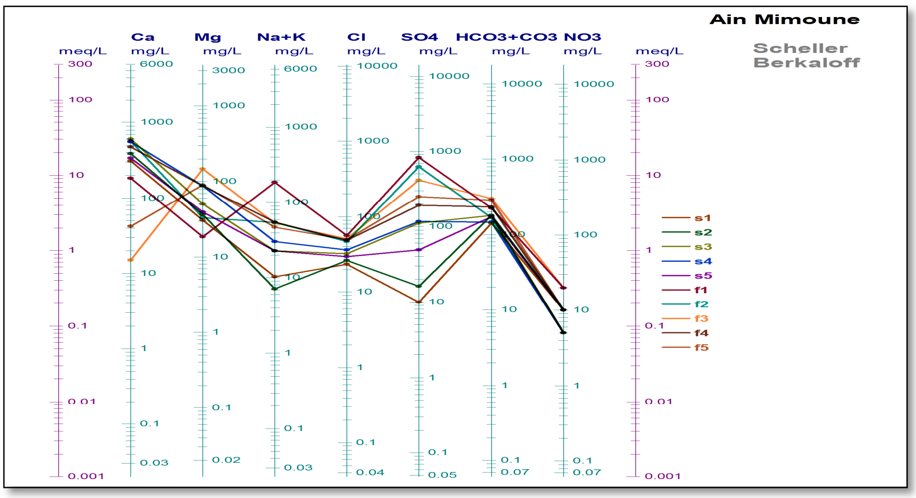

Fig. 14. Diagram of Schoeler Berkaloff.

Schoeler Berkaloff Diagram

The diagram was established by H. SCHOELLER in 1932, and revised by BERKALOFF in 1952,it is composed of seven vertical logarithmic scales corresponding to the main ions analyzed in water. The Schoeller Berkaloff diagram allows the representation of several analyses on the same graph. There is superposition of the straight lines obtained if the concentrations are identical and relative shift of the lines one above the other in the opposite case.

From Fig. 29 it is noted that there is a large variation in water content from wells in the water table, but in general there are three predominant water families, Calcium Chloride, Calcium Sulfate and Magnesium Sulphate. 60 % of the facies of the samples are calcium sulphate.

According to Schoeller Berkaloff we can say that the waters of the study area are marked by the calcium that is sometimes accompanied by sulfate or chloride; this is in direct connection with the dominant presence of clays, saline soils, and carbonate and gypsiferous formations.

Conclusions

The hydrochemical study, allowed us to highlight the physicochemical parameters having a direct influence on the water quality; these parameters are related to existing aquifer systems or the influence of geology.

At the end of this chapter, it was found that the physicochemical analyses revealed that the highest concentrations in this area are found in the recent geological formations of the quaternary.

Concerning the classification of waters, according to the piper and Schoeller Berkaloff diagrams we have made it possible to classify the waters into three families.

• Chlorinated calcium family;
• Magnesium sulfated family;
• Sulfated calcium family (this is the most dominant chemical facies) in our study area

It should be said that the majority of the elements whose concentrations exceeded the admissible standards, which affects the waters quality of our study area. These waters are very hard, which causes disadvantages of cooking and laundry and can also lead to soil salinization risks.

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