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Research Article

ASSESSMENT OF IRRIGATIONAL QUALITY OF SURFACE WATERS IN EL TARF AREA, ALGERIA

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ABSTRACT

During two seasons (winter and summer), the sampling of surface waters of nine stations along wadi Bounamoussa located in El Tarf which has an agricultural vacation (the extreme Northeast Algerian), is analyzed in order to evaluate preliminarily the pollution of surface water, the study methodology carried out in order to check the current state of water chemistry, its evolution over time and in space depending on the variation of the physicochemical parameters of water.

The results of the physicochemical analyses of the waters samples shows that are very poor in soluble and moderately mineralized and accentuated, which can reduce the yield of sensitive plants and cause slow salinization of the soil hence the need for this research. We got the same order of abundance decreasing for both seasons as follows: $Na^{+} > Ca^{+2} > Mg^{+2} > K^{+}$ and $Cl^{-} > SO_4^{-2} > NO_3^{-} > NO_2^{-}$ and show that it is appropriate to irrigation and agriculture.

Keywords: Wadi Bounamoussa; physicochemical parameters; irrigation; mineralization.

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1. INTRODUCTION

Worldwide water quality has deteriorated in recent years due to uncontrolled industrial discharges, the intensive use of chemical fertilizers in agriculture and the disorganized exploitation of water resources. These produce a chemical modification of the water and make it unsuitable for the desired uses [1].

Among these cases, was the site of the plain of Bounamoussa located in the wilaya of El Tarf (NE Algerian). The El Tarf area is a predominantly rural area where water resources heavily used for agricultural activities. The burden of these discharges is growing with the socio-economic development of study area [2]. In the low plain of Bounamoussa, the chemistry of water resources (surface water at wadi Bounamoussa level, surface water and deep aquifer) often influenced by the effect of the dissolution of geological formations, domestic, industrial and agricultural activity.

Natural water is one of the most precious natural resources in the North-eastern of Algeria, as it is the principal source of irrigation and drinking water for the majority of the population.

The surface and ground waters of Annaba-El-Tarf region is extremely susceptible to surface-derived contamination because of the high permeability of sands and gravels that compose the soil profile of West El-Tarf region.

Several studies in El-Tarf region reported various degradations levels of surface and ground waters as one of the major concerns among the public and governmental decision makers [3], but these studies did not include an evolution of inorganic pollution of the surface waters especially Bounamoussa river.

The main objectives of this study were to determine the average levels and distribution of the physicochemical parameters in surface water of the Bounamoussa River and can contributed to classify the surface water quality and their allocation under both intense urban development and agricultural activities in two periods of the season (winter and summer).Suitability of water for irrigation can assessed not only from the total concentration of salt, but also from the type of salt and ions constituting it. It is then essential to study the parameters defining the characteristics of waters intended to irrigation [4].

2. MATERIALS AND METHODS

The development of agriculture and the fertility of the plain soils have created dense human settlements in the studied area particularly in the North. Research has indicated that agricultural practices may cause nitrate, chlorides and sulfates contamination to be high to exceed the maximum acceptable level for drinking water [5].

The experimental study carried out on surface water. The work donewas the broadest possible physicochemical characterization of the waters. The objective was to arrive at a thorough knowledge of the environment for allowing a good understanding and a relevant analysis of the results.

To achieve this objective, two (02) campaigns of sampling and analysis periods were carried out, the first related to the month of April 2016 (end of the wet season, beginning of the irrigation season) and the other concerned the month of September 2016 (end of the dry season, after the release of the Chaffiadam). Nine (09) stations spread across the Bounamoussa plain have been chemically analysed in the laboratory.

2.1. Presentation of study area

The area of El Tarf is along the littoral and fact part of the most sprinkled areas the Algerian Northeast. The climate of El Tarf is of the wet Mediterranean type, characterized by two six months seasons each one [6].The region of study subjected to a Mediterranean climate characterized by two different seasons: one wet, marked by high rainfall and low temperatures from October to May, and other dry and warm with high temperatures reaching their maximum in August with low rainfall. Prevailing southerlywinds blow off the sea during the winter; and in summer, the hot Sirocco blows in a south-south-westerly direction, carrying with it a drying effect that is strongly felt during a one month period of time [7].

A plan adopted to achieve this objective; it consists in the beginning of carrying out a sampling grid with a complete analysis of the physicochemical parameters of waters.

Nine (09) sites or stations were selected across the study area from upstream to downstream of Bounamoussa wadi; according to their good accessibility even in winter, their locations in the plain, their types of use (agricultural land, residential or fields etc ...), and the nature of the pollution that affects them and especially depending on the presence superficial water.

The surface waters were sampled in nine (09) stations spread out in the space between Ben M'Hidi and the Cheffia dam: Six at the level of agricultural lands crossed or near the wadi of Bounamoussa, two stations at the bridges crossing the wadi (Ben M'Hidi Bridge and Zerizer Bridge) and the last distance from the Cheffia dam.

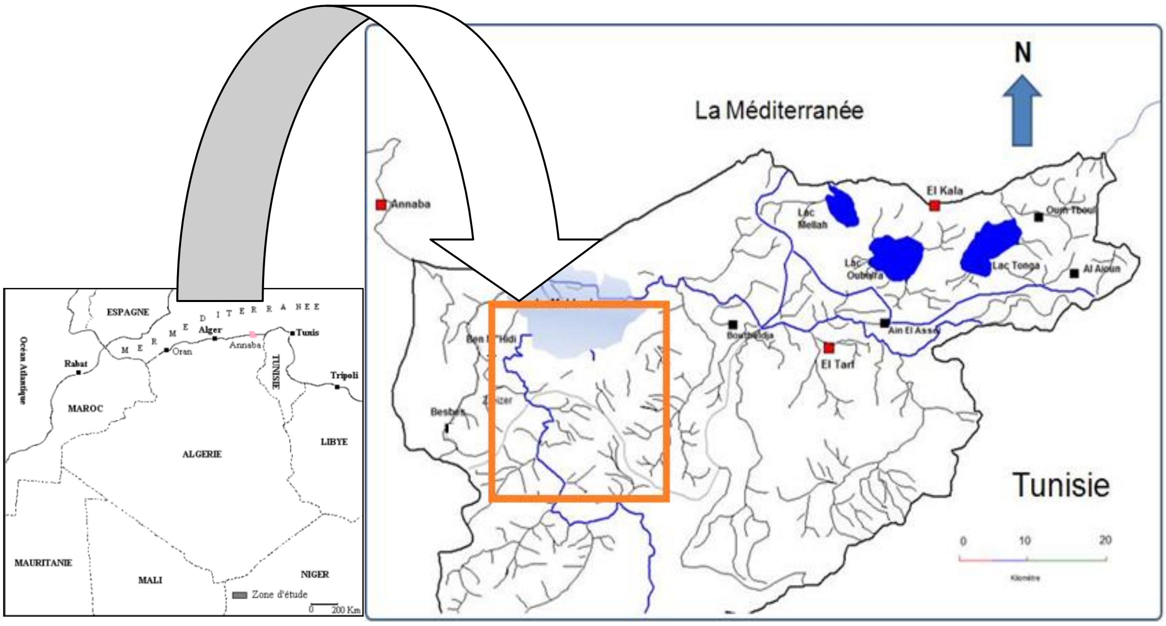

Fig.1. Map of the location of the study area [8]

2.2. Sampling and analysis protocol

The samples taken from the running water, that is to say, the most at the centre of the canal, about 10cm below the surface, using the seal and the rope according to the places. Until overflow in 1.5 L polyethylene bottles (at least for each sampling station) rinsed before filling with the water to be analysed and corked.

Upon return to the laboratory, samples were immediately stored in a refrigerator at a temperature below 4 ° C protected from light. Due to lack of time in the field, filtering done in the laboratory the day after the sampling campaign. The samples filtered to a porosity of 0.45µm, in order to eliminate as much as possible the colloids, which increase the apparent solubility of certain ions.

The study concerned the analysis of physicochemical parameters, namely: pH, EC, SM, DR, DE, Ca^{+}, Mg^{+}, CO_3^{-2}, HCO_3^{-}, Cl^{-}, SO_4^{-2},NO_2^{-}, NO_3^{-}, NH_4^{-},K^{+}, Na^{+}[9] along the wadi Bounamoussa in order to establish a diagnosis of the state of surface water pollution in the study area. These analyses performed at the laboratory level by colorimetric method. Thus, water samples taken at 09 study stations.

3. RESULTS AND DISCUSSION

The results of the physicochemical analyses showed that all the surface waters of our study area were free of carbonates (CO_3^{-}) and bicarbonates (HCO_3^{-}).

The statistical results of the other physicochemical parameters of the 09 stations for the dry period and the wet period were show in Table 1.

The statistical study of the spatial distribution of chemical elements presented the minimum, average and maximum values, as well as the standard deviation (Tables 1).

Table 1. Descriptive statistics for water chemistry

	wet season				**dry season**				
Variables	**Minimum**	**Maximum**	**Average**	**SD**	**Minimum**	**Maximum**	**Average**	**SD**	**Standards**
pH	7,20	7,80	**7,548**	0,177	7,72	8,39	**7,924**	0,190	**6 – 8,5**
EC (µS/cm)	212	631	**347,333**	128,540	245	523	**314,444**	87,414	
DR (mg/l)	0,13	0,33	**0,230**	0,065	0,07	0,40	**0,230**	0,109	**1500**
SM (mg/l)	0,027	0,110	**0,059**	0,032	0,001	0,020	**0,010**	0,005	**25**
DE (mg/l)	0,051	0,104	**0,066**	0,019	0,010	0,017	**0,013**	0,003	**50**
Ca^{++} (mg/l)	13,067	27,733	**19,644**	5,166	13,867	33,333	**24,741**	5,549	**200**
Mg^{++} (mg/l)	11,858	21,384	**14,785**	3,374	14,483	25,855	**19,818**	3,459	**50**
TH (mg/l)	24,925	47,517	**34,430**	7,927	31,071	53,843	**44,559**	7,692	**150 à 200**
Na^+ (mg/l)	27,49	107,80	**51,407**	22,417	27,50	93,32	**40,50**	21,394	**200**
K^+ (mg/l)	2,42	6,98	**3,712**	1,381	2,350	10,27	**4,192**	2,447	**12**
NH_4^+ (mg/l)	0,005	0,041	**0,020**	0,015	0,007	0,060	**0,029**	0,019	**0,5**
Cl^- (mg/l)	24,815	332,048	**139,043**	89,604	11,817	177,250	**73,526**	55,039	**250**
SO_4^- (mg/l)	39,529	87,569	**57,373**	14,149	47,255	68,235	**54,314**	7,030	**250**
NO_3^- (mg/l)	3,708	18,958	**11,148**	4,758	5	43,75	**15,694**	11,624	**50**
NO_2^- (mg/l)	0,033	0,153	**0,071**	0,048	0,023	0,349	**0,080**	0,103	**0,1**

SD : Standard Deviation, DR : Dry Residue, DE : Dry Extract, SM: suspended matter

Our study area has waters that are very poor in soluble salts and presents no immediate risk for its use in irrigation.

The surface waters characterized by the evolution of the contents of the cations and anions which present the same order of decreasing abundance for the two seasons as follows:

$Na^+ > Ca^{+2} > Mg^{+2} > K^+$: for cations and $Cl^- > SO_4^{-2} > NO_3^- > NO_2^-$:for anions.

Certain parameters like nitrates, nitrite and SM inform us about the organic pollution of water. Contamination by these elements mainly related to soil leaching and anthropogenic activities (waste releases).

The Na^{+} ions exchangeable can replace alkaline earth ions (Ca^{2+} and Mg^{2+}) clays, thus causing clogging of soil pores and thus waterproofing [10].

Calcium and magnesium can be tolerated, even in relatively great amounts in irrigation waters. High values of these parameters indicate that sodium is not in excess in the dam waters and that the hazard of defoliating sensitive crops by a sprinkling system is very low [4].

During high water mark, the low chloride content explained by dilution by rainwater's. Since chloride ions have a high concentration in low water levels periods, where the sources of this element were essentially constituted by wastewater discharge, notably urban waste [5].

In spite of efforts made to raise awareness to nitrate surface water pollution, nitrate fertilizer use has not decreased, but has increased due to surface tilling practices linked to increased crop production and progressive agricultural development [3].

The measured values of nitrates and nitrites through wadi Bounamoussa were low. Slim et al. [11] found that a trace amount of nitrate in surface water related to either algal growth in these sites, or the joint phenomenon of denitrification, which transforms nitratesNO_3^- into nitrogen N2 thanks to the presence of organic matter.

The increase in winter levels linked to the increase of the soil-leaching phenomenon and their decrease in summer contents could explained by the decrease in diffuse pollution [12].These seasonal changes are consistent with those recorded in the rivers [13].

According Medjani [3] results shown that the degree of pollution varies by zone, as well as by month to month with contents often exceeding recommendations made by the World Health Organization (WHO). The protection of water quality and the reduction of the risk contamination are of great importance in the region to a reliable and sustainable development.

The evaluation of physical chemical parameters measured in the surface waters of Wadi Bounamoussa shows a degraded water quality. Bahroun S et al. [2] and Boussaha S et al. [14] reached this conclusion, indicating the alteration of the waters of our study area whose has a very high organic pollution class.

3.1. The mineralization

The concentration of Total Dissolved Solids, salinity or total dissolved load [15]. This parameter represents the total concentration of substances dissolved in water. TDS is composed of inorganic salts and some organic matter. These elements can come from a number of natural sources as well as from human activities. *TDS* calculated by summing the main ionic

species (Na^{+},Ca^{+2}, Mg^{+2}, K^{+}, Cl^{-}, SO_4^{-2}, NO_3^{-} , NO_2^{-} and NH_4^{+}), [5].

It is more important from south to north of our study area. Figure 2A and 2B for the cations and Figure 3A and 3B for the anions illustrate the variations of the dissolved salts (TDS, or total concentration of the dissolved salts) of the two seasons. The rate of TDS in the surface waters of our study area generally increases during the dry season and decreases at the beginning of the winter season [16].

The spatial evolution of the average concentrations of the dissolved salts of the surface waters follows an increasing gradient upstream downstream of the study area, it is important in site S9 or it noted that the concentrations of sodium, chlorides and sulphates were also important.

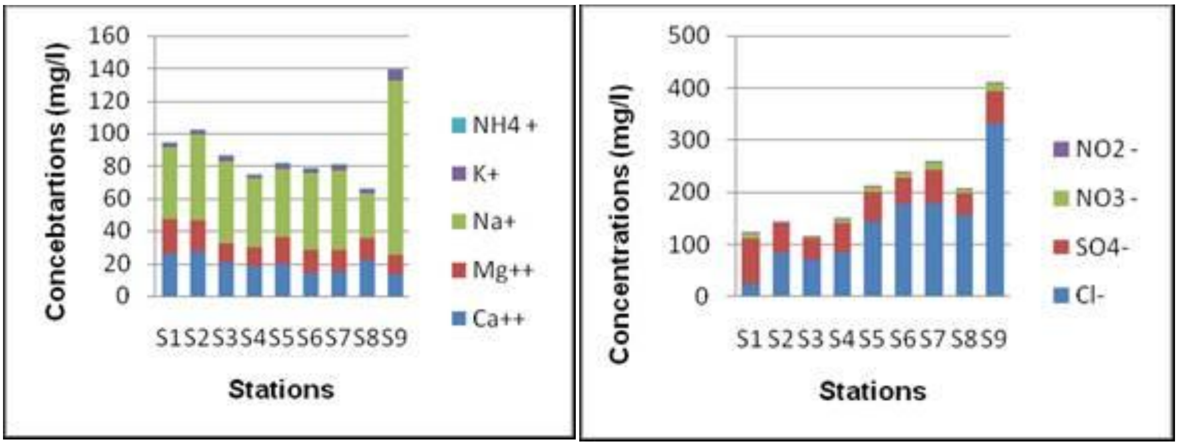

Fig.2A and 2B. Levels of cations and anions of water (wet season)

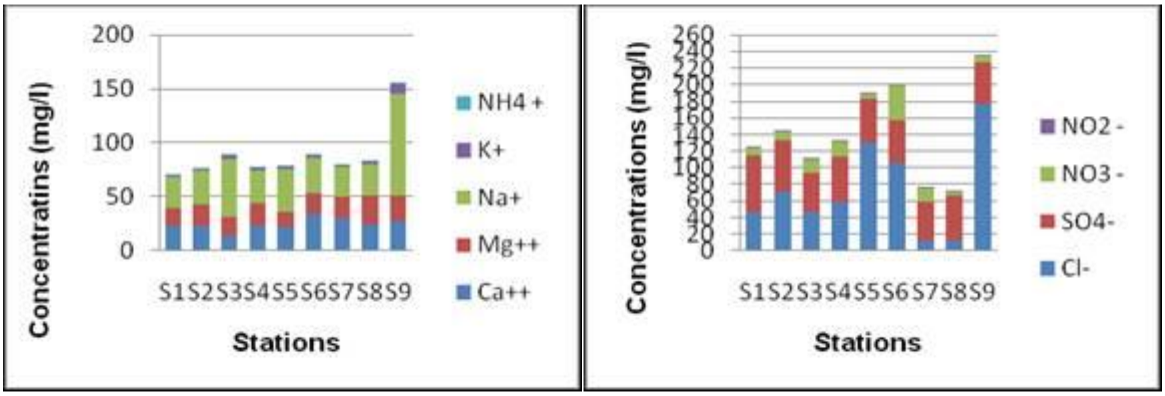

Fig.3A and 3B. Levels of cations and anions of water (dry season)

3.2. Chemical facies

In order to better identify the chemical facies and to have an indication of the qualitative aspect of the surface waters of our study area, the graphical representation of the analysis results is a valuable tool. To achieve this goal, the Piper, Riverside and Schoeller-Berkaloff diagrams were used. The realization of these diagrams made using the Diagram software, designed by Ronald S (hydrogeology laboratory, University of Avignon, 2004).

3.2.1. Piper diagram: this diagram has the particularity to represent several samples on the same plane. It is composed of two triangles, to determine the chemical facies (cationic and anionic). The global facies obtained by intersection on a rhombus synthesizing the chemical facies of the sample considered.

The Piper diagram established by the surface waters of our study area (Fig 6) shows three families of faciesduring both wet and dry seasons:

 A chlorinated and sulphated calcium and magnesian family.

 A sodium chloride family.

 A sulphated calcium and magnesian family.

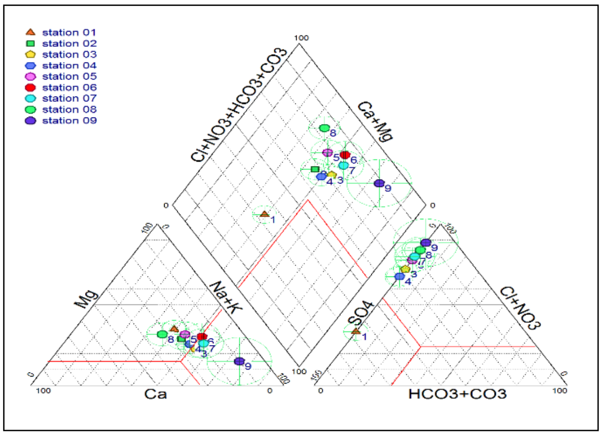

Fig.6A. Piper Diagram of Waters Season

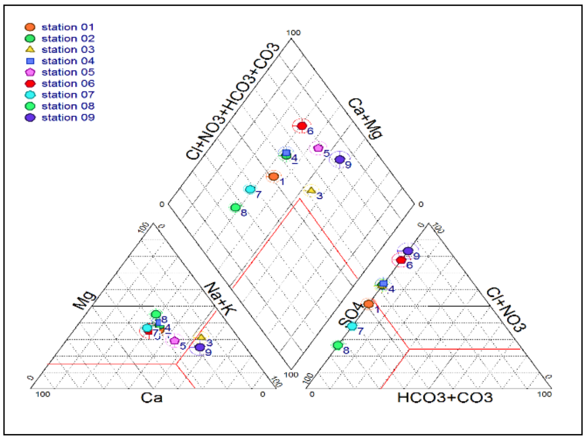

Fig.6B. Piper Diagram of Waters of Wet Dry Season

Figures 6A and 6B illustrated the predominance of Na^{+} ions with respect to Ca^{2+} and Mg^{2+}among the cations, as well as the abundance of Cl^{-} and SO_4^{2-} ions among the anions in the waters of this period. This explains the predominance of sodium chloride facies observed on both diagrams.

3.2.2. Riverside Diagram

The Riverside diagram, which based on electrical conductivity (EC) and Sodium Absorption Ration (SAR), taken into account the balance between these two variables, one of which influences the other. . The risk of sodicity due to SAR attenuated in the presence of high salinity [17].

According to Riverside diagram established by the surface waters of our study area collected during April Companion (Fig 7A) which shown that they belong to classes (C2-S1) and (C3-S1). These classes classified as medium to good, poor quality and water used with caution in poorly drained soils and only for irrigation of salt-tolerant crops. Drainage is necessary and during the companion of September (Fig 7B) which shown that they belong to classes (C1-

S1) and (C2-S1). These classes were as medium to good quality for irrigation and as water for use with sensitive plants and in poorly drained soils and for sensitive plants (fruit trees).

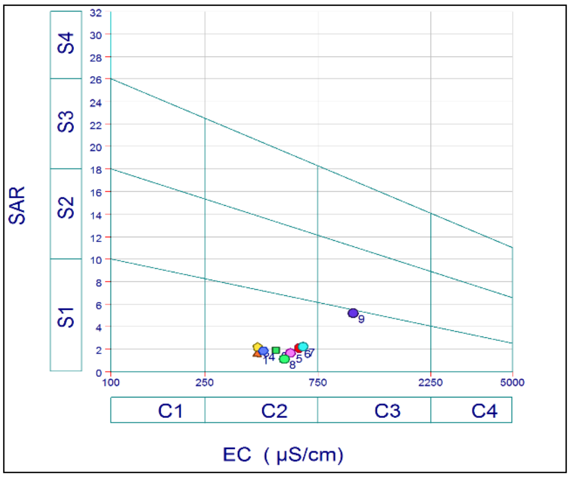

Fig.7A: Wet season

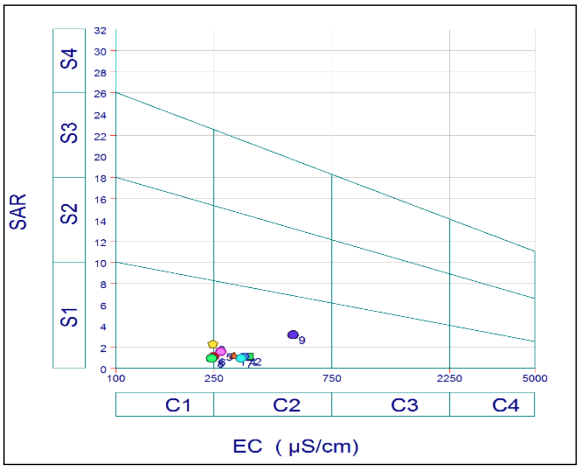

Fig.7B: Dry season

Fig.7A and 7B. Salinity diagram for classification of irrigation waters

3.2.3. Representation on the Schoeller-Berkaloff diagram

A semi-logarithmic diagram gives indications on certain chemical parameters of water.

The representation of the chemical content of the water points on the Schoeller-Berkaloff diagram has the same appearance as the Piper diagram, and it is constant that the dominant facies is the sodium chloride facies.

It reported that the content of bicarbonates and / or carbonates were absents, compared to that of the other anions, which explained the very low distribution of the bicarbonate facies.

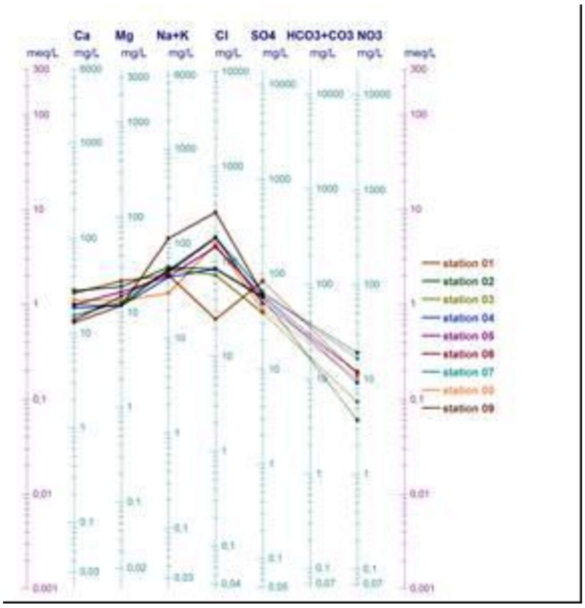

Fig.8A. Schoeller-Berkaloff diagram season)

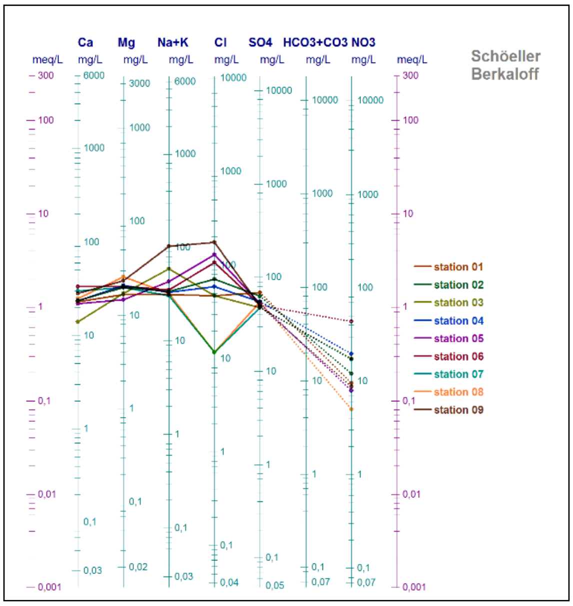

Fig.8B. Schoeller- Berkaloff diagram (wet (dry season)

4. CONCLUSION

Often confronted with a deficit of water, farmers are moving towards the use of different water sources through boreholes, wells and even wadis regardless of the nature of household and industrial waste. Hence, the need for the establishment of analysis reports as part of the quality control of water intended for irrigation.

Anthropogenic and particularly agricultural activities tend to develop preferably near watercourses, and even more so where the water body is easy to reach. The Bounamoussa Wadi constitutes a privileged area in humid region, characterized by a clay and sandy-clay filling of which the piezometric levels are very close to those of a soil generally very fertile.

The data collected during our study provided a portrait of the physicochemical quality of surface water:

• The surface waters do not exceed the standards recommended by WHO, especially at the station level (9). However, our sampling waters are moderately mineralized and accentuated with a neutral appearance require certain precautions such as leaching, which can reduce the yield of sensitive plants and cause slow salinization of the soil hence the need for this research.

• The surface waters are very poor in soluble salts and very weakly charged, so they present no immediate risk for its use in irrigation.

• The evolution of the contents of cations and anions which presents the same order of decreasing abundance for the two seasons as follows: for the Na^{+}> Ca^{+2}> Mg^{+2}> K^{+} for the cations and Cl^{-}> SO_4^{-2}> NO_3^{-}> NO_2^{-} for the anions with the absence of carbonates and bicarbonates.

• Low levels of calcium and magnesium, which means that our waters are very mild.

The study of the chemical quality of the surface waters made it possible to determine that the ionic balance of the surface waters of our study area were characterized by a dominance of the sodium then the calcium among the cations, and the chloride then the sulphate among the anions.

This study has also shown the importance and utility of multivariate analysis techniques to obtain information on water quality, to identify the dominant typology of water and thus prevent any kind of pollution.

The chemical facies of the surface waters of Bounamoussa wadi made it possible to understand the relationships that exist between the chemical parameters of these waters and their origins. The most predominant facies of these waters is sodium chloride facies.

The spatiotemporal variation of several physicochemical parameters gave us an idea of a relatively intense pollution which results in a significant polluting load and a deterioration of the water quality, particularly in the area of Ben M'Hidi located partly upstream of Bounamoussa wadi, subject to urban, agricultural and industrial discharges (Station S9 presents a risk of occasional accidental pollution).

The seasonal variation in the concentration of chemical elements is related to the effect of climatic conditions in the region (precipitation, evaporation), and the exploitation of resources by pumping, and to irrigation.

Salinity can lead to significant adverse effects due to the fixation of sodium chloride by soil colloids. In addition, salts cause changes in soil structure (permeability and aeration) that directly affect crop development. Irrigation with raw water that is too rich and rich in salt will result in an increase in soil salinity after enrichment with chloride, sodium and calcium. These waters are generally acceptable for agricultural use, but require prior checking.

The release of the Cheffia dam plays an important role in improving the quality of the surface waters of Bounamoussa wadi, with caution in irrigation areas. These discharges contained in water have adverse effects on the soil and agriculture and can create health risks for farmers who come into contact with these waters and for consumers of agricultural products.

This study has also shown the importance and utility of multivariate analysis techniques to obtain information on water quality, to identify the dominant typology of water and thus prevent any kind of pollution.

5. ACKNOWLEDGEMENTS

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