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Hydro-chemical characterization of an aquatic ecosystem water of El Kala national park (Case of Oubeira Lake, Northeast Algeria)

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Abstract

The endorheic Oubeira lake is located in El Kala national park which is ranked seventh of eight national protected parks in the north of Algeria, a shallow lake considered as a wetland of international importance particularly as waterfowl habitat. It receives waste water from small towns which is used for agricultural activities during dry seasons. The objective of this work is devoted to the physico-chemical data analysis of water drawn on the lake's perimeter. These analyses are concerned the parameters of quality measured *in-situ* using field's multi-parameter (temperature, pH, electrical conductivity, oxydo-reduction potential and dissolved oxygen), and at the laboratory (chlorides was done by titrimetry method, bicarbonate were carried out by sulfuric acid and sulphate by $BaCl_2$ gravimetric method, Cations such as calcium and magnesium were made by complexometry, while sodium and potassium by atomic absorption spectrometry) according to a network of monitoring 15 water points. The results of the hydrochemical study indicate that the lake's water presents an average mineralization (electrical conductivity < 1000 µs/cm) and a pH slightly alkaline. According to Piper diagram, the two dominant chemical facies are chloride magnesium and magnesium bicarbonate respectively with rates of 80% and 20%. For irrigation, the water of the study area presents no risk on cultures; it is of good quality following Richard's diagram.

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Introduction

El-Kala national park is located at the extreme North-East of Algeria in the region of El-Taref **(**Ouelmouhoub, 2005; Grimes, 2005) (Fig. 1). This integral reserve extends over an area of 76 438 ha, or 26% from the region's total surface (Bouazouni, 2004).The park represents a reservoir of biodiversity in the mediterranean, the faunistic and floristic richness (Stevenson *et al.,* 1988; Samraoui andde Belair, 1997).

Mediterranean lakes and particularly those of North Africa know a qualitative and quantitative degradation, resulting from natural constraints (precipitation, flows) and Anthropogenic (surveys, wastes). This degradation had consequences on the economic development of certain areas (Alayat, 1991). The Oubeira lake, which was maintained since the quaternary, was drained completely at the end of the summer 1990, following the important pumping intended for the supply of drinking water and for a sequence of dry years. Consequently, the hydrous potential even if it is sufficient, it is not inexhaustible (Alayat, 2013).

The quality of water plays an important role in the biological, physical and chemical processes that occur in the aquatic environment (Roux, 1987).The present study aims to contribute the characterization of Oubeira's lake water quality, based on physico-chemical analysis through the determination of some parameters.

Materials and methods

Study area

The Oubéira lake, with a surface of 2200 ha, is the subject of this study, located in El Kala national park which is situated in the extreme North east of Algeria 36°51'N - 8°23'E, bordering Tunisia **(**DGF, 2003) (Fig. 1)**.**It has an essentially rainfed power supply, the most important tributaries are the vales of Demenet Er Rehan, Degrah and Bouhchicha.

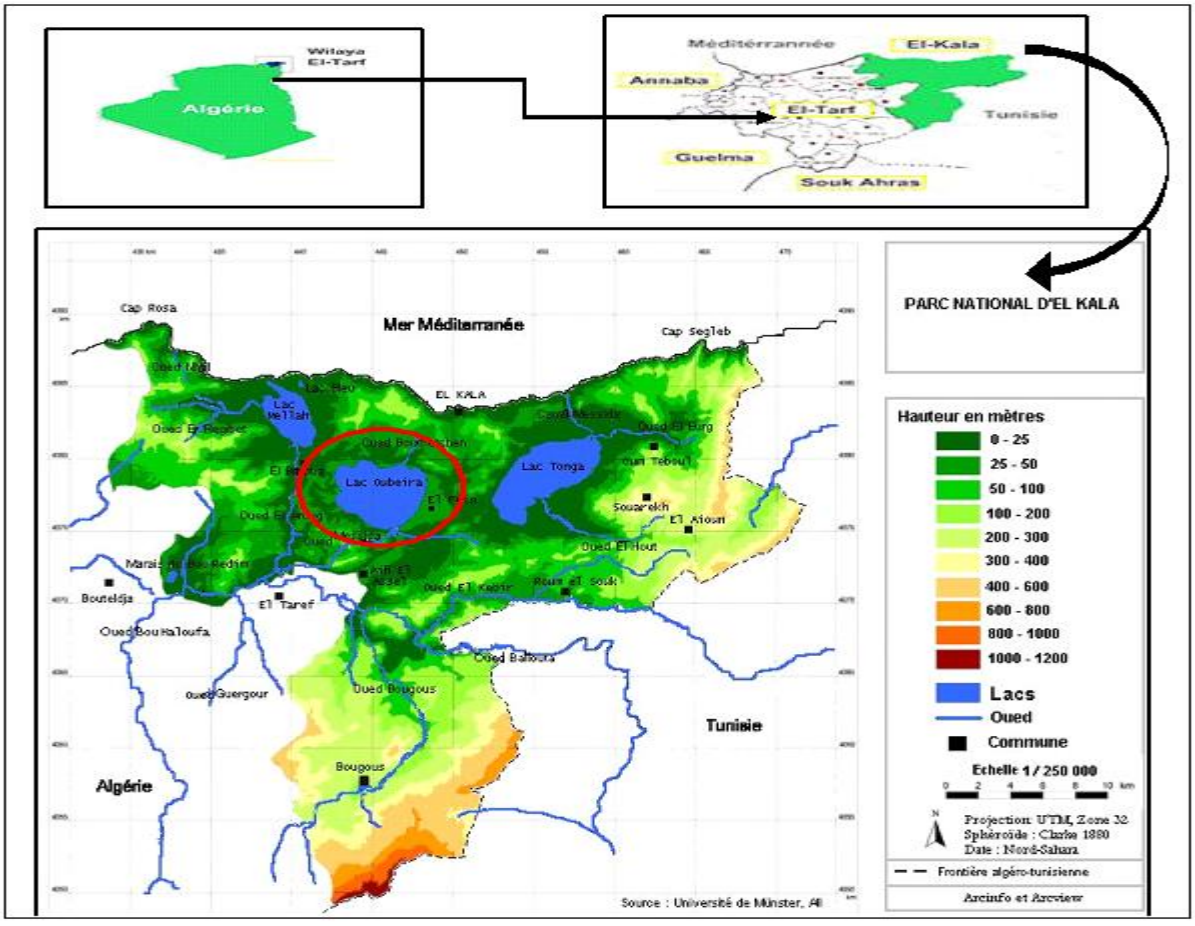

Fig. 1. Geographical situation of El Kala national park (Source: Hamouda, 2013) Study Area.

The lake is located in the center of a watershed of 9800 ha, to a depth of 4 m; it is limited by the Djebel Bou Merchène in Northeast, and bordered by Mellah Lake in the Northwest and by the Northern ridges in the North (Messerer, 1999).

The Oubeïra lake, with El Kala region are located in the sub-humid Mediterranean climate characterized by a dry season from May to September, during which a rain deficit is registered, and a wet season which extends from October to April, with permanent winds to Northwest dominance.

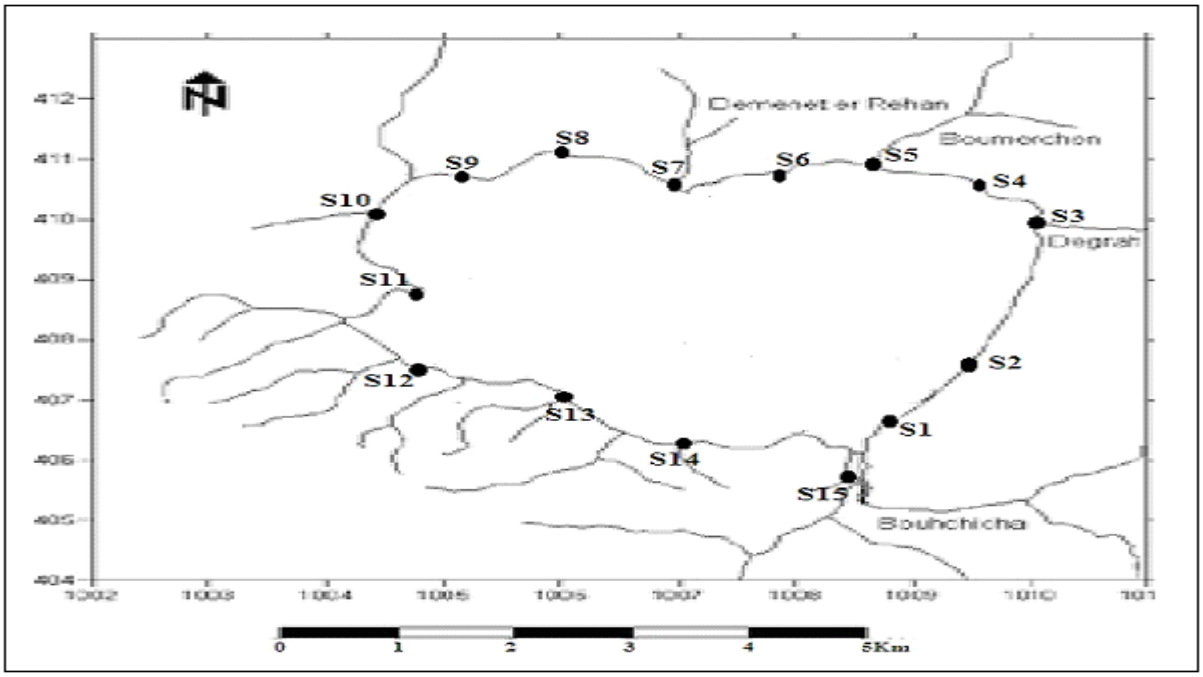

Fig. 2. Location map of the study area and sampling sites.

Choice of stations and sampling

The choice of stations was made in a rational way in order to have a good estimate and follow the spatial evolution of the physico-chemical quality of water of 15 stations on all the perimeter of the Oubeira lake .Water samples were collected in the period of May 2016 (Fig. 2).

Analytical techniques

In-situ measurements

Five physico-chemical parameters (temperature, the hydrogen potential, the oxydo-reduction potential, the electrical conductivity and the dissolved oxygen) were measured *in-situ* using field's multi-parameter.

Analysis of chemical elements

Chemical analyzes were carried out on the main elements responsible for the mineralization of water, called major elements: (Cl^-, HCO_3^-, $SO4^{--}$, Mg^{++}, Ca^{++}, Na^+, K^+) which were analyzed after filtration at the laboratory of Badji Mokhtar University, Annaba, Algeria, according to the standard techniques of Rodier *et al.* (2009).

Dosage of Chloride (Cl^-) was done by titrimetry (Mohr method). The bicarbonates (HCO_3^-) were carried out by sulfuric acid, and sulfates (SO_4^{-2}) by $BaCl_2$ gravimetric method. Cations such as calcium and magnesium (Ca^{+2}, Mg^{+2}) were made by complexometry, while sodium and potassium (Na^+, K^+) by atomic absorption spectrometry.

The chemical facies of waters is determined by software DIAGRAM of Avignon University (France).

Results and discussion

The physico-chemical characteristics of water

Temperature (T°C)

Temperature is one of the physical parameters most sensitive to natural changes (Rodier, 1984).

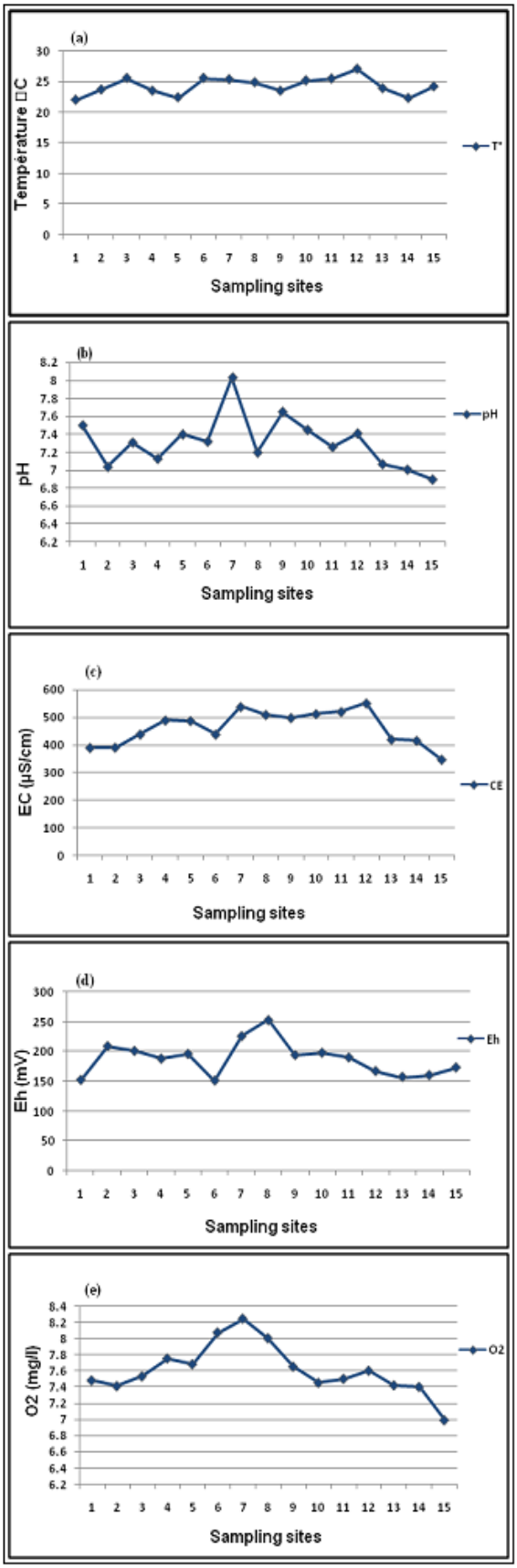

Fig. 3. Spatial Variation of : temperature (a), pH (b), electrical conductivity (c), the redox potential (D) and dissolved oxygen (e), of Oubeira lake water.

The temperature curve shows a similar evolution in all sampled stations, ranging from 22 °C to 27.1°C with an average of 24.34 °C (Fig. 3a). This temperature affects the density, viscosity, solubility of gases in water, dissociation of dissolved salts, chemical and biochemical reactions, development and growth of living organisms in water (WHO, 2004).

Hydrogen potential (pH)

The pH of surface water depends mainly on existing chemical compounds, photosynthesis and respiration of organisms. However, the presence of free carbon dioxide or humus lowers the pH (Chapman and Kimstach, 1996; RCWP, 2007). During our measurement period, the variation of PH shows a balance on all selected sites (Fig. 3b). The measured values oscillate between 6,90 and 8.03 pH units, indicating a slight alkalinity favorable to fish life (Belgriri, 1993).

Electrical conductivity (EC)

The electrical conductivity provides information on the degree of water mineralization (Derwich *et al.,* 2010).The electrical conductivity values are very close at all stations and have an average mineralization (conductivity <1000 µS/cm) (Vierling, 2008). The conductivity is also a function of water temperature, it is more important when the temperature increases (Dussart, 1966); it is the case of (S12) with a value of 551 µS/cm (Fig 3c).

Oxydo-reduction potential (Eh)

According to the figure 3 (Fig. 3d), Oubeira Lake water have an Redox potentiel (Eh) between 150 mV (S6) and 253 mV (S8), which are slightly aerated water. The highest mean values of Eh reveal that the environment is well ventilated and the ecological conditions are favorable to oxidation. Low values indicate that the medium is low in oxygen and may contain reducing agents capable of combining with oxygen which may eventually enter it (Harch-Rass *et al.,* 2012).

The dissolved oxygen (DO)

The dissolved oxygen content in water is closely related to the thermal regime of the lake (Villeneuve *et al.,* 2006).

The average dissolved oxygen content of water in Oubeira Lake is between 6 and 8 mg/l (Fig. 3e). This can be explained by the dilution of the water; moreover, the photosynthetic activity of spring enriched this water with dissolved oxygen (Belaud, 1996). These results do not show any significant variations and the lake's water are then well oxygenated (I.B.G.E, 2005).

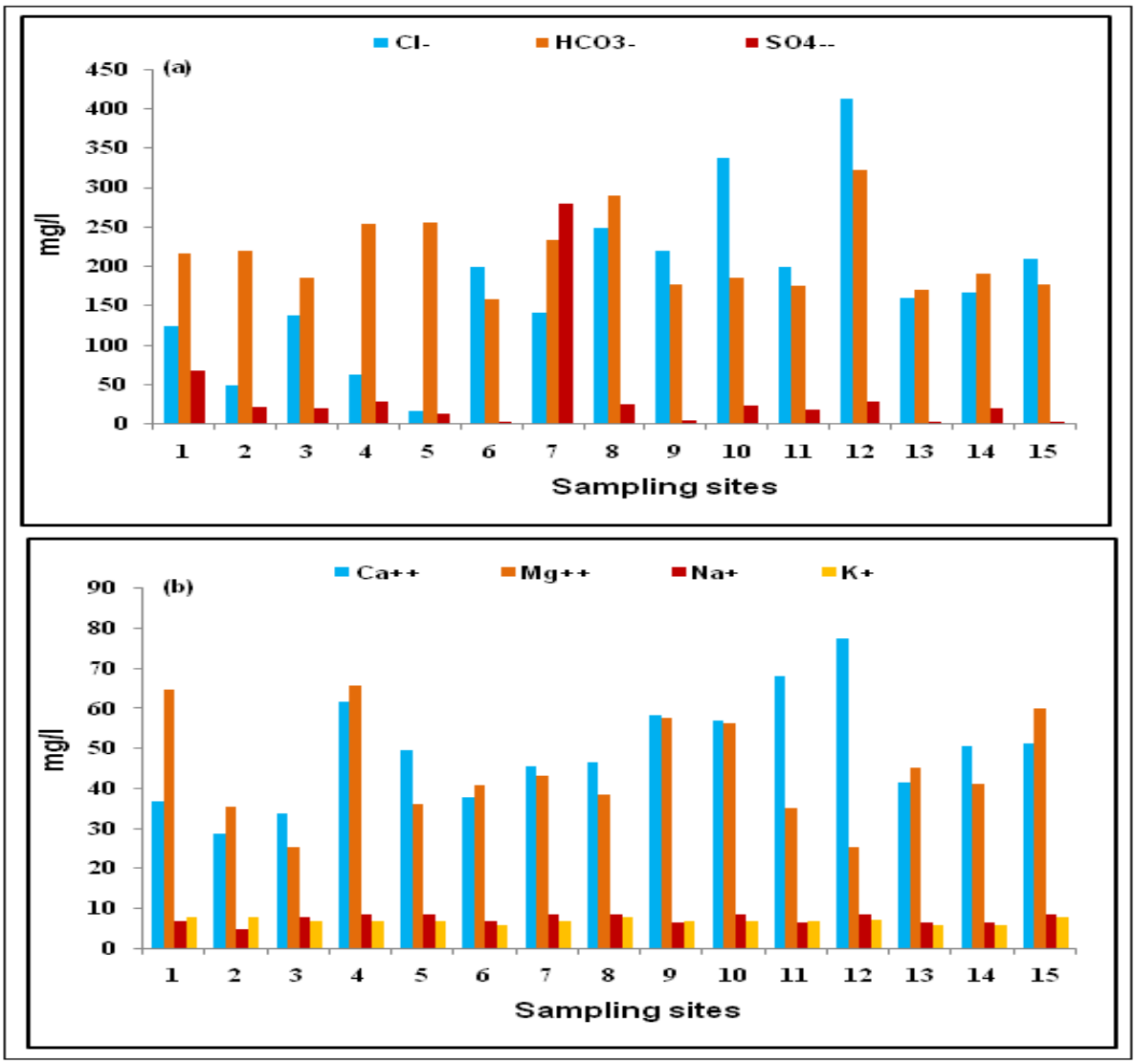

Fig. 4. Concentrations of the major chemical elements of Oubeira Lake water.

The major chemical elements

The results obtained show a great variation in the concentrations of the major elements such as the cations (Ca^{++}, Mg^{++}, Na^{+}, K^{+}) and the anions (Cl^{-}, SO_4^{-2}, HCO_3^{-}) (Fig. 4). The chloride content (Cl^{-}) generally increases with the degree of water mineralization. The measured levels are below the surface water standard (200 mg/l) at all sampling stations except for sites (S10) and (S12) (Fig. 4a) where these levels reached a maximum of 337,25 mg/l and 411,8 mg/l respectively. These chloride ions may be related to pollution from urban discharges into the lake.

The bicarbonates contents are very variable. They range from 158,6 mg/l (minimum observed value) at the site (S6) and 322,08 mg/l at the site (S12) (maximum observed value) (Fig. 4a). Concentrations of bicarbonates (HCO_3^{-}) in natural waters are directly related to pH of water, temperature, dissolved CO2 concentration and the lithological nature of soil.

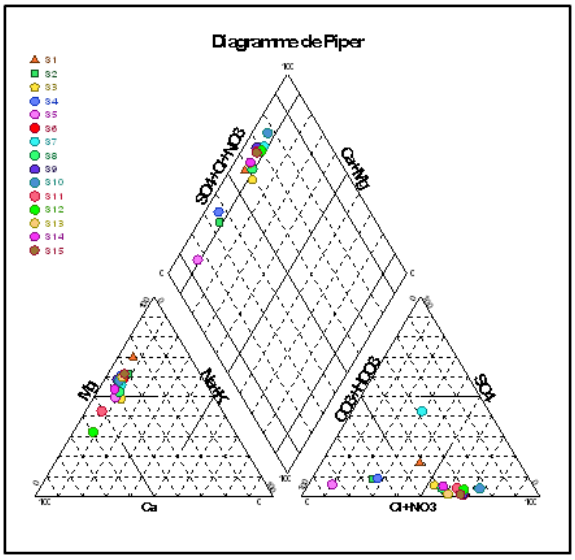

Fig. 5. Chemical facies of the Oubeira lake water according to Piper's diagram.

Sulfate (SO_4^-) contents in Oubeira Lake water at the different sites are very low except for the site (S7) which reaches a high value (279.84 mg/l) and exceeds the standards recommended by the WHO(250 mg/l) (Fig. 4a).

It is the result of wastewater discharge that comes from the Meridima village (commune of El Kala) that the Oued Demenet Er Rehan welcomes directly without any prior treatment.

The mean concentration of sodium and potassium of water are very low and do not exceed standards (Fig. 4b). This water also has relatively an average contents of calcium (28.8 to 77.6 mg/l) and magnesium (25.44 to 64.8 mg/l) relative to the overall mineralization.

Hydrochemical facies

Diagram of Piper

This type of diagram allows you to represent several water samples simultaneously. It is composed of two triangles, representing the cationic facies and the anionic facies, and a rhombus synthesizing the global facies.

According to figure 5, the triangle of the anions shows that chlorides represent the most abundant element. With regard to the cation triangle, the magnesium ions mark all the samples.

The representation of the major ion contents on the Piper diagram (Piper, 1944), shows the dominance of two chemical facies (Fig. 5):

Magnesium bicarbonate facies: represents 20% of the lake's water at the sites (S2, S4 and S5). This type of facies is observed mainly in the East of the Oubeira Lake, this facies generally represents the weakly mineralized water.

Chloride magnesium facies: represents the majority of samples with 80% of the sites (S1, S3, S6, S7, S8, S9, S10, S11, S12, S13, S14 and S15). It is the facies the most dominant in the study area. It is observed in the North, South and Northwest of Oubeira lake view abundant presence of the Numidia clays and lake water is moderately mineralized.

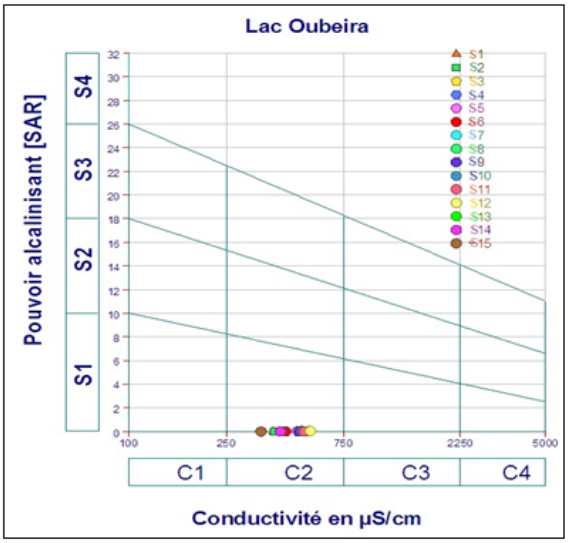

Fig. 6. Classification of water irrigation in Oubeira lake according to Richards's diagram.

Ability of waterto the irrigation

Diagram of Richards

Agriculture is the most dominant activity in Oubeira Lake watershed, especially the groundnut culture and vegetable cultures that occupy the Eastern part. The salinization and alkalinization of waters are the main risks to irrigation water. In order to evaluate these two risks, the results of the physicochemical analyzes were projected on Richards's diagram; the deferral of the results on this diagram allows us to classify the different types of water irrigation and to indicate the various uses according to the tolerance of cultures.

On this graphic representation, the risk of salinity is estimated by the conductivity expressed in µS/cm. Whereas the risk of soil alkalization is quantified by S.A.R (Sodium Adsorption Ratio) (Nishanthiny *et al.,* 2010; Salman and Elnazer, 2015). SAR is given by the formula below; it is used in combination with the electrical conductivity of water (Wilcox, 1948; Richards, 1954).

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

Where all elements are expressed in meq/l.

The Water can be classified on the basis of SAR in excellent water (SAR <10), good (10-18), doubtful (18-26) and unsuitable (>26) for irrigation (El Nazer *et al.,* 2017). According to Richards's diagram the Oubeira Lake water belonging to class C2S1 (Fig. 6). This class represents the low mineralization water encountered around the lake. Class C2S1 characterizes water suitable for irrigation and can be used without special control for plants with medium tolerance to salts and on soils with good permeability.

Conclusion

The respect for the environment is a major concern in our societies today. In the present work, we carried out the study on the water of Oubeira lake in the El Kala National Park (PNEK), which are used by a large population of the region in some agricultural (peanuts and vegetables). The results of this study show that the water is well oxygenated moderately mineralized. The pH of the lake's water is slightly alkaline and very close to neutrality, which constitutes a value of the criterion of protection for aquatic life. Some major chemical elements of this water exceed the standards recommended by the WHO, Probably due to a degradation of the lake's quality. According to the Richards diagram, the water in Oubeira Lake belonging to the C2S1 class, which characterizes water eligible for irrigation, that is to say water can be used without special control to irrigate medium tolerant plants or on a soil with good permeability.

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