academicJournals

Vol. 11(8), pp. 624-632, 25 February, 2016
DOI: 10.5897/AJAR2015.10480
Article Number: 373C6A257290
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Salinization and pollution of water table with wastewater and its impact on oasis crops

Benguergoura Laradj Samia[1]* and Remini Boualem[2]

[1]Department of Process Engineering, Faculty of Technology, University of Blida, Blida 9000, Algeria.
[2]Department of Water Science, Faculty of Technology, University of Blida, Blida 9000, Algeria.

Received 2 October, 2015; Accepted 27 January, 2016

The ancestral canal of Oued Righ at 150 km evacuates leachate water into the Chott Melghir, which has 50 oases. Excess water from discharges of sewage and drainage causes upwelling of groundwater that leads to an imbalance in the valley. The physico-chemical analysis of canal waters and water table has shown that the quality of these waters has very high salinity (class C5), with electrical conductivity of 26.30 ms/cm, and SAR> 28 (S4 class). Water hardness, the values of organic matter (O.M) and total solids (T.S) are very important. Thus, canal water has very poor quality, charged with mineral salts, and is a brackish water containing sodium chloride facies.

Key words: Canal, degradation, water, palm, water table, sol, Oued Righ.

INTRODUCTION

Oued Righ valley, located in the East of the septentrional Sahara, is a broad asymmetrical syncline pit. This region has sandy soil, mainly siliceous and forms of pure quartz; therefore, insoluble (Benhaddya, 2007). The water table is in the clay-evaporite sandy quaternary levels. The main system of agricultural production in this region is essentially phoéniculture. If the valley escapes the phenomenon of recovered water, it is due to the great collector, Wadi channel Righ, which is 136 km long and which transits the water around 5 m^3/s, and 120 to 160 million m^3/year (Khadraoui, 2005). However, over the years, the entire oasis shows a progressive fall in quantity and quality. This phenomenon has resulted in increased rates of discharge of sewerage and drainage water (Figure 1). A portion of the wastewater lacking pre-treatment joins the main collecting duct. The absence of natural outlets for receipt of waste, adequacy and effectiveness has caused an imbalance in the valley. There is flooding caused by the back water in the oasis, and the depletion of groundwater due to salinization problem. The oasis of the valley of Oued Righ can rightly be called sick oasis with too much water (Cote, 1998). Many palms are flooded in winter (Palm Tinedla, Djemaa, Ferdjaouenne and El Goug). There is secondary salinization after irrigation with highly mineralized water, and permanent hardness results in the suffocation of palms of Oued Righ (Sogreah 1970) (Figure 2). In this perspective, this work aims to analyze the water that

*Corresponding author. E-mail: samialaradj@yahoo.fr

Figure 1. Discharge point of wastewater.

Figure 2. Degradation of palm.

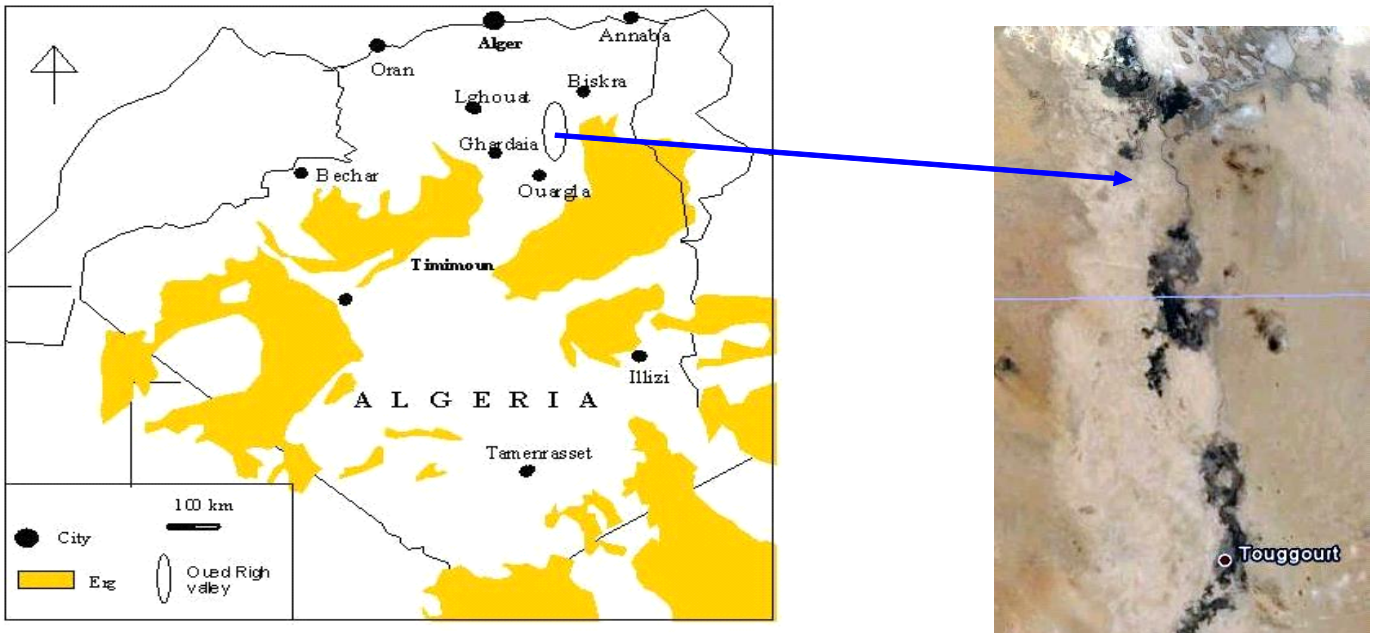


Figure 3. Location of the Oued Righ valley.

discharges at different points in the collecting duct which communicates with the water table, and the impact of these waters on the degradation of palm cultivation as well as the relationship between the channel and water table.

Presentation of the area studied

Oued Righ is located in South eastern Algeria (Figure 3). It spreads over 150 km long. It is located in two wilaya: Ouargla and El Oued. It is bordered in the north by the Plateau Still; east by the Great Erg Oriental; South by the extension of the Grand Erg Oriental and west by the Sandstone Plateau. This region is characterized by an elongated depression from south to north. Highest coast is 100 m in El Goug upstream and 30 m in Chott Merouane downstream. The slope is generally very low (1‰). This slope allows excess water to flow to the north. Region of Oued Righ has nearly 50 oases and covers around 25,000 ha of palm (Dubost, 1991). These oases are aligned on a North-south axis.

MATERIALS AND METHODS

In order to assess the impact of urban effluents on the canal, and subsequently its impact on date palm cultivation, three rounds of sampling were performed over three months of the year (February, 2009 and May October, 2010). They were nine stations discharging into the canal, at about 30 km; they cross the canal in the West (St: 1) and East (St: 9). The distance between the Kerdeche station and Rannou station is 19 km, and between Kerdeche and Temacine it is about 7 km. From Kerdeche station to Zaouia El Abidia station is about 30 km (Figure 4).

The research focuses on the waters of the groundwater by means of piezometers. For the samples collection, our choice was based on five stations, of about 46 km, from Kerdeche station to Sidi Slimane station. The samples were collected manually in plastic bottles, with identification of each point. The sampling stations chosen for the spatial and temporal variation of the water table and canal water composition is based on finding a possible contamination of these two levels and their impact on the growth of date palm tree, and also the impact of the upwelling water table on the date palm cultivation. In this study we tried to give some solutions to these problems.

The water samples' physico-chemical and pollution analyses were carried out in Water Treatment Laboratory of National Agency of Hydraulic Resource (NAHR). Measurement procedures are deducted from the standard analytical methods. The pH is determined using a pH meter (WTW), and the conductivity is determined using an electrical conductivity meter (DELTA OHM) which gives directly the sample conductivity in mmhos/cm or ds/m. The total and calcium hardness is determined by complexometric titration (EDTA). Finally, a variety of analytical methods were used for the various experimental tests: titrimetric, electrochemical and spectroscopic methods.

RESULTS AND DISCUSSION

Study of physico-chemical parameters and pollution in the canal

Temperature affects the degree of evapotranspiration and therefore it acts on the salinity of the water. In this study, the temperature is generally variable with an

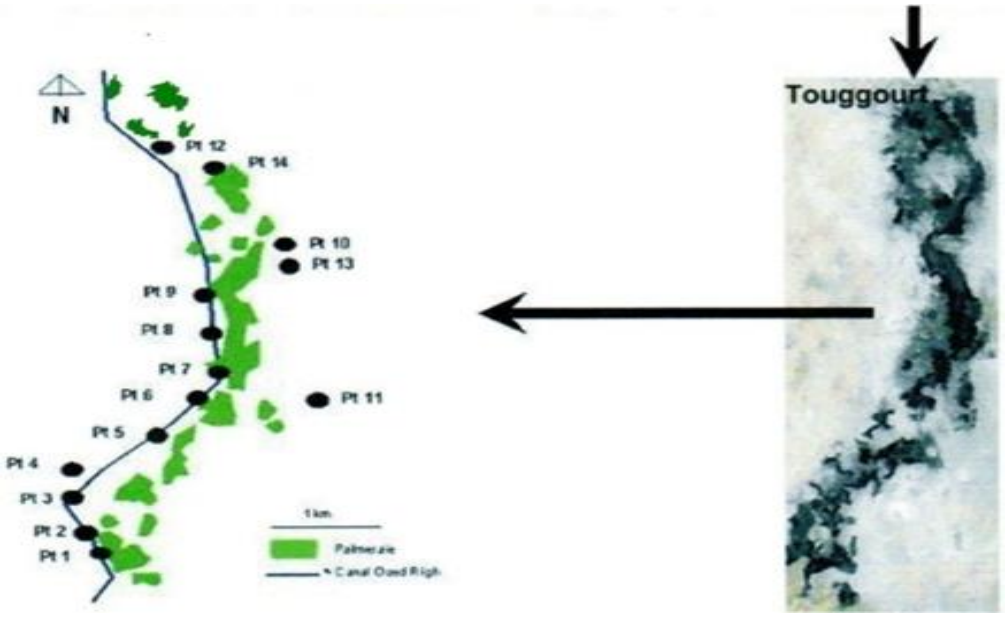


Figure 4. Different sampling points.

Table 1. Parameters of water quality of Oued Righ channel.

Parameter	Value
pH	7.3 - 8.3
E.C (ms/cm)	1500 - 26300
T.H (°f)(total hardness)	73 - 582
T.S (mg/l)	2249 - 16528
O.M (mg/l)	44.5 - 111

Table 2. Parameters of water quality groundwater.

Parameter	Value
pH	7 - 7.71
E.C (ms/cm)	6.04 - 17.90
T.H (°f)	219 - 408
T.S (mg/l)	5141 - 14920
O.M (mg/l)	7.93 - 52.86

average of 22.5°C. The results obtained for the canal waters and the waters of the groundwater Table during the period (2009-2010) are shown in Tables 1 and 2.

The pH and electrical conductivity (EC) are very high in the canal (Figure 5). However, these values were maximum at Station 12 in the water table. The canal water is very hard. The waters of Station 12 at the groundwater have a maximum hardness (Benguergoura and Remini, 2013). The results obtained for the total solids are very important for the majority of canal water (May 2010 and October 2010) due to the evaporation of water (Figure 6). Indeed content of salts can exceed 12 g/L of total solids in most solutions discharged into the canal. It should be noted that the upper limit allowed is 10 g/L for sustainable agriculture (Djennane, 1990). One can notice that the values of the total solids can reach 14920 mg/l at Station 12 or the water becomes unpleasant (Figure 7).

Sewage water with a level of organic materials (OM) > 15 mg/l is classified as highly polluted. In Figure 8, the canal's rate of organic materials is > 50 mg/l. In spatio-temporal evolution, the rate of organic matter ranges from 46 mg/l (Station 2) to 111 mg/l (Station 9) in October 2010. However, this wastewater contaminates the groundwater, which was confirmed at Station 12 (Figure 9). In this case, all the benefits of organic matter to the soil, such as better porosity, good permeability, good ventilation, better soil warming and good water retention (Jones and Jacobsen, 2001) will be absent (Mustin, 1987). Organic matter releases minerals which are essential to the nutrition and development of cultures (Bollag, 1998). However, salinity exists in the canal waters and groundwater is the main cause of low palms (Rietz and Haynes, 2003). Increasing salinity inhibits microbiological activity of organic matter. This leads to a decrease in crop yields.

Hydrochemistry of canal water and groundwater

Agricultural practices, including the establishment of irrigation systems, have an effect on water quality. The

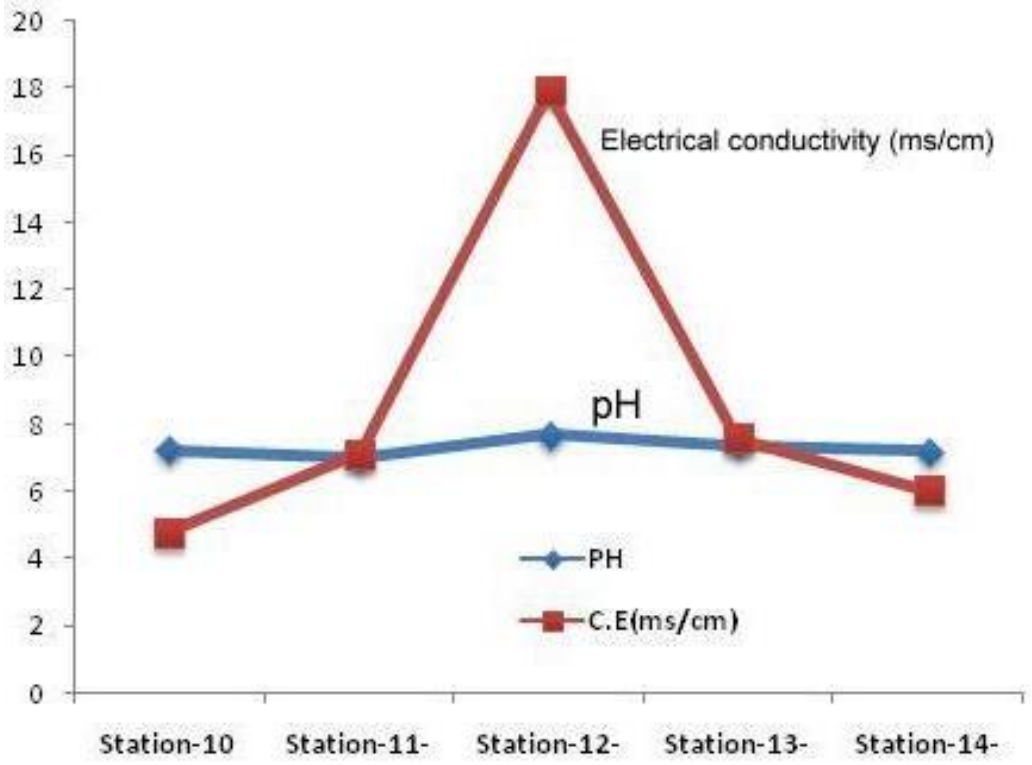


Figure 5. Evolution of pH and EC of groundwater.

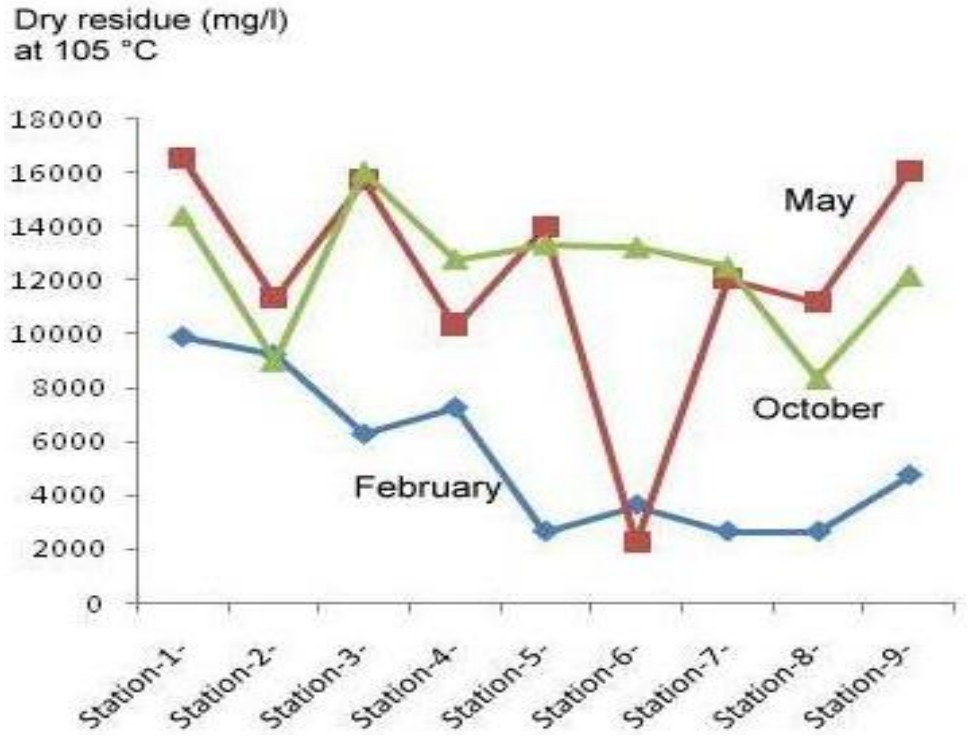


Figure 6. Spatio-temporal evolution of the dry residue of water channel.

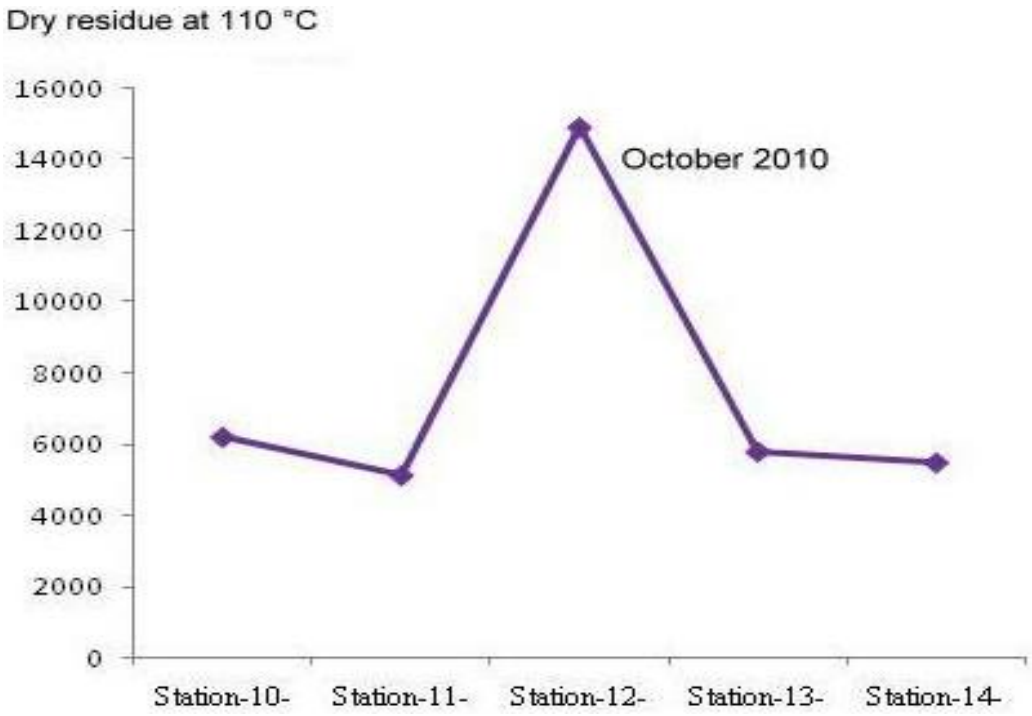


Figure 7. Evolution of total solids in water groundwater.

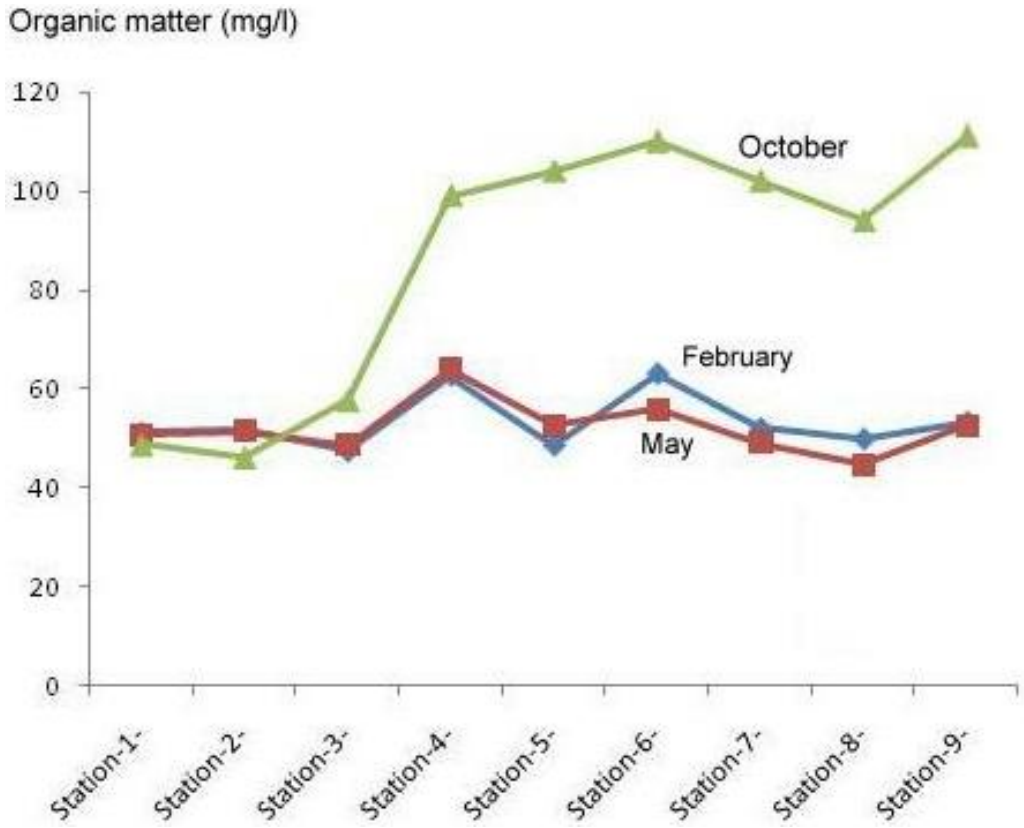


Figure 8. Spatio-temporal evolution of organic matter of water channel.

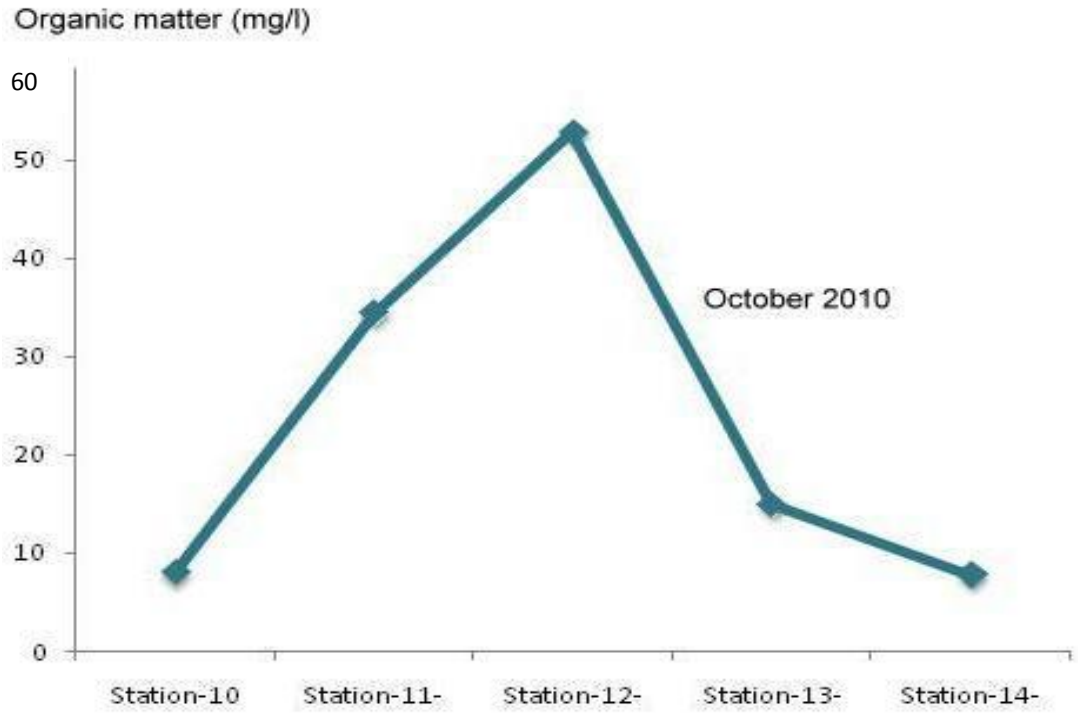


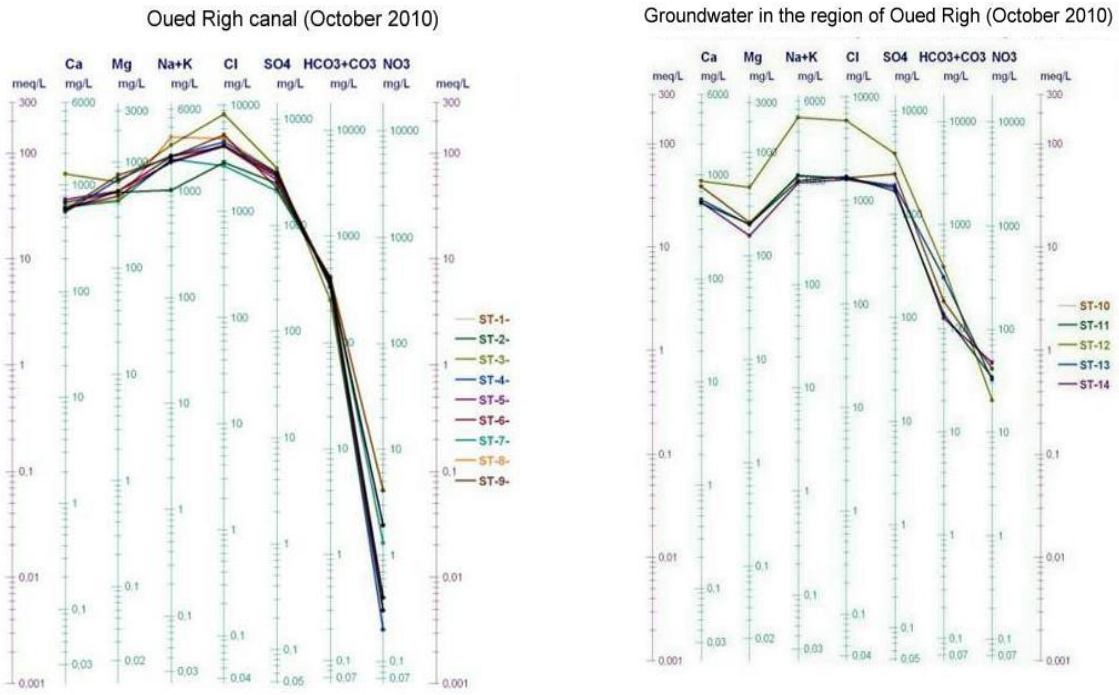
Figure 9. Evolution of organic matter in water groundwater.

mineral salts in irrigation water have an impact on the soil and plants (Ratner, 1935). They can cause changes in soil structure and disrupt the development of vegetation (Person, 1978). The distribution of palm and associated crops in the ground root system gives an overview of the degradation of phoeinicicole heritage due to the contamination of groundwater by salinity and wastewater channel. To assess the water quality of the Oued Righ channel and groundwater, we used Schoeller Berkaloff diagram to represent the chemical facies of several water samples. Each sample is represented by a broken line. The concentration of each chemical element is represented by a vertical line on a logarithmic scale. When the lines are growing, a chemical change of facies is demonstrated (Roland, 2012). The mineralization Cl^- and Na^+ is dominant almost at 9 stations along the canal, followed by mineralization ions SO_4^{2-} and Ca^{2+}, or even a high concentration of Mg^{2+} ions. Sodium chloride facies were more (Figure 10a and b), with absence of bicarbonate facies. However, there is a clear dominance of sodium ion, followed by chloride and sulfate ions, at Station 12 groundwater which is grown all around the canal area. This confirms that the dominant hydrochemical facies is a chloride-sodium. So mineralization water of the web is linked to Cl^- and Na^+. The line of Station 10 which has a higher concentration of sodium ions than sulfate ions gives sulfated-sodium facies. The bicarbonate facies groundwater is absent.

Water-soil relationship and its impact on the culture of the date palm

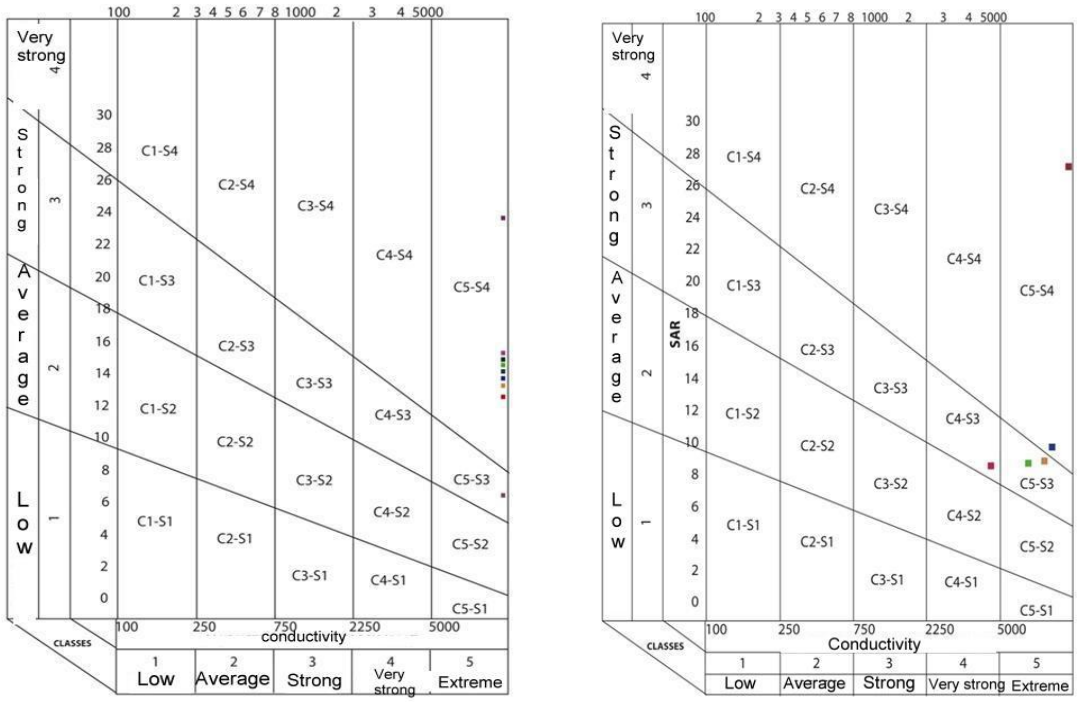
Oued Righ region is characterized by low rainfall and high evaporation. Some researchers estimate that it takes 1 m^3 of water to make 1 kg of dates (Simonneau, 1961). However, the most frequently used of 25.000 m^3/ha gives a water consumption of about 4 m^3 per kg of dates, for all the palm groves of Oued Righ. This amount needed for the development of 1 kg of dates amounts to 6 or 4 m^3. It is obvious that in different cases, a significant proportion of the water is intended for the fight against saline. Its underground water is too loaded with chlorides and sulfates or the existence of the risk of soil salinization (Mashali, 1996). A study requires a good estimate of some parameters of salinity in relation to agricultural use in the canal waters and waters of aquifer. This risk is determined using the value of Sodium absorbent sodium absorption ratio (SAR). For the same conductivity, the risk is even greater than the coefficient is higher. Richards' classification is very useful to characterize reliable irrigation water.

The results obtained by the Richards' diagram of the different stations water channel (Figure 11a and b) show that they are class C5S3. In this case, the water is highly mineralized. They are used only in exceptional circumstances. The C5S4 class affects virtually the majority of canal water. The waters are strongly



a) Canal **b) Ground water**

Figure 10. Schoeller Berkaloff diagram of the canal and water groundwater (October, 2010).



a) Canal ***b) Ground water***

Figure 11. Richards diagram of canal water and groundwater.

mineralized. This is not recommended for irrigation (Magistrad and Reitemeir, 1943). For the water table, C4S3 and C5S3 classes for Stations 10, 11 and 14 are used only in exceptional circumstances (Unesco, 1957). C5S4 class at Stations 12 and 13 is not advised for irrigation. Water quality and water channel of the web have very poor quality. So, there is a possible contamination of the two.

Conclusion

Oued Righ is characterized by the presence of sandy soil mainly siliceous and insoluble pure quartz. The water table contains clay-evaporite sandy soil. The water table is in this relatively flat region, with regular fluctuations. The static level of shallow groundwater, fed by sewage and drainage, steadily increases, upon arrival on the soil surface. The concentrations of the chemical elements of the water channel have shown the dominance of saliferous gypsiferous ions and acquired carbonate in salinity. The canal is excessively salty, very hard, slightly basic, and hyper-chlorinated global chemical sodium facies. Irrigation water has very poor quality and mostly belongs to C5S4 class. As for the environmental aspect of the sources of pollution of the channel, values in Sec residue and organic matter are higher than the national and international standard.

Pollution is felt at Kardéche station upstream channel where the flow velocity is low. It may be noted that pollution also increases at Zaouia El Abidia station or the width and depth of the channel decreases. So the speed of the flow of water also decreases.

The monitoring of the evolution of the quality of the water table surrounding the channel shows that the contamination of the water is very pronounced at Station 12 (Sidi Slimane station). Degraded water channels are routed in areas that favor the percolation of groundwater contamination. The combined action of a climate is characterized by intense evapotranspiration and the presence of a shallow water table makes most soils undergo secondary salinization. There is degradation of palm trees surrounding the canal. The solution to this problem is to find a means of pretreating the water before discharging in the canal. A treatment plant should be installed with an aerated lagoon where adjacent wastewater undergoes treatment before being returned to the main collecting canal.

1. There should be increased frequency of irrigation, increased water supply to plants by considering the needs of leaching and/or association of different water sources.
2. The exploitation of deep groundwater should be controlled, to prevent the underground water upwelling, and the flooding of agricultural land.
3. Finally, public awareness should be raised to save water.

Conflict of interest

The authors have not declared any conflict of interest.

REFERENCES

Benguergoura LS, Remini B (2013). The releases of wastewater in the Oued Righ valley: The palm groves in decline. Taylor & Francis, London. 52(10-12):2187-2192.
Benhaddya M (2007). Contribution to the inventory of trace elements in soils and groundwater in the region of the Oued Righ. Memory of magister. University of Oum El Bouaghi, 131p.
Bollag AL (1998). Interaction between soil minerals, organic compounds and microorganisms. Scientific Edition, Regist 404, Symposium No. 41.
Cote M (1998). Patients' oasis of too much water. J. Drought 9:123-130.
Djennane A (1990). Finding status of areas south of Algerian oasis. National Board of dates, Algeria, Mediterranean option, Serie A, No. 11, the Oasis Agricultural Systems.
Dubost D (1991). Ecology, Land and Agricultural Development Algerian oasis. PhD in geography and planning in the Arab world. Université François Rabellais Tours (France), Volume 2.
Jones C, Jacobsen J (2001). Plant nutrition and soil fertility. Montana University, Available at: www.colostate.edu/depts/coopExt/TRA/plants/nutrient/PDF.
Khadraoui A (2005). Soil and agricultural water in oases of Algeria, characterization, constraints and development proposals. EMPAC Editions, Algeria, 324p.
Magistrad OC, Reitemeir RF (1943). Soil solution concentrations at the wilting point and their correlation with plant growth. Soil Sci. 55:351-360.
Mashali AM (1996). Soil management practices for gypsiferous soils. International Symposium on Soils with Gypsum–Léida, Espagne, pp. 34-52.
Mustin M (1987). The management of compost organic matter. The agricultural use of composts and more generally organic materials. Dulux French Editions. Paris, 954p.
Person J (1978). Irrigation and drainage in Tunisia problem of soil salinity and water. Bull. BRGM, 2nd Ser. 3(2):143-151.
Ratner EI (1935). The influence of exchangeable sodium in the soil on its properties as a medium for plant growth. Soil Sci. 40:459-471.
Rietz DN, Haynes RJ (2003). Effects of irrigation-induced salinity and sodicity on soil microbial activity. Soil Biol. Biochem. 35:845-854.
Roland S (2012). Diagrammes version, 5-9, graphTxt, 1-6: http://www.Iha.Uvin-avignon.fr/LHA-Logitiels-htm
Simonneau P (1961). Observation on irrigation of date palm. The days of the date, Algiers 3 to 4 May 1961.
Sogreah (1970). Participation in the development of the Oued Righ. Agropedological study. Manuscript, 201p.
UNESCO (1957). Use of saline waters. Proceedings of Research on arid, NS .56 III, 5 F.