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Suitability of surface water for irrigation in the Maffragh basin, North-East of Algeria

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Abstract

Water quality is an environmental priority for irrigation in rainfed agriculture. Recently, water quality has been affected by the uncontrolled disposal of wastewater, the use of chemical fertilizers in agriculture and, most significantly, by the excessive exploitation of water resources during the low season. The basin of the Maffragh in the Algerian north-east real is fed by two main rivers: Wadi El Kebir East and Bounnamoussa. From its source, the stream is continually contaminated with domestic and agricultural discharges through the tributaries causing a significant deterioration in water quality. In order to know the current state of water quality in the Maffragh basin and to determine its suitability for irrigation without any prior treatment, research has been conducted in the two streams at representative sampling points in catchment areas used for irrigating crops. To assess the quality of water and detectable compounds monitoring, laboratory methods are used. The various volumetric and colorimetric assays were carried out according to Jean Rodier. Organic parameters such as nitrites, ammonium and phosphates, were measured using a UV/VIS 6705 JENWAY spectrophotometer, at wavelengths of 543 nm, 630 nm and 880 nm respectively for nitrites, ammonium and phosphates. The BOD5 and COD parameter was measured using a DIN EN 1899-1-H51 spectrophotometer and DIN ISO15705: 2002 spectrophotometer. The performed analyses on conductivity shows oscillating values ranging between 425 and 495 $\mu S \cdot cm^{-1}$ for January 2018, while for the low water level of July 2018 the conductivity varies between 433 and 796 $\mu S \cdot cm^{-1}$; this parameter is determinant for water quality assessment and its use for irrigation. Beside the conductivity test, the Riverside–Wilcox diagram was applied, to combine conductivity and sodium absorption rate (*SAR*). The obtained results of the two seasons show satisfactory results in the applicability of the water to irrigate in the basin.

Key words: *irrigation, Maffragh basin, northeastern Algeria, rain-fed agriculture, surface water*

INTRODUCTION

The surface water quality in a region is related to anthropogenic practices, mainly the nature and extent of industry and intensity of agricultural activities. ASHRAF *et al.* [2010], categorised the sources of water pollution into "point sources" and "non-point sources".

Point sources discharge pollutants at specific locations (e.g., landfills and industrial wastes) through inlets into the surface water, while non-point sources (e.g., acid rain, agriculture, construction and domestic pollutants) cannot be put into a single source [NAJAH *et al.* 2009]. Therefore, the quality of water affects virtually all water related activities [BARNETT *et al.* 2018] such as agricultural, including irrigation and livestock, and human lives. In the case of surface watercourse based agriculture, the impact could be catastrophic and irreversible for both humans and lands.

Two main reasons were identified by researchers for this: population growth, accompanied by rapid urbanization causing many disturbances to the environmental system [MCKINNEY *et al.* 2002; PEÑA-HARO *et al.* 2010] and industrialization, leading to an unsustainable use of fertilizers and pesticides [PEÑA-HARO *et al.* 2010; TAGMA *et al.* 2009], especially with a lack of public awareness of the global warming and water scarcity. These reasons create an imbalance within the ecosystem and generate polluting

elements that can affect the physico-chemical and biological quality of the receiving aquatic environments [AL--OTHMAN 2019; MULLISS *et al.* 1997].

This study focuses on the quality of irrigation water in El Mafregh–El Taref region located in the North-East of Algeria. The region is characterized by high piezometric levels and adoption of different methods of irrigation, with gravitational irrigation the most common [KHERICI *et al.* 1996; LEKOUI *et al.* 2019].

STUDY MATERIALS AND METHODS

STUDY AREA

The Maffragh watershed is one of the Constantinois-Est coastal watersheds and coded as 03 (National Agency for Hydraulic Resources (Fr. Agence Nationale des Ressources en Eaux – ANRH). Its boundaries are: To the north – the Mediterranean Sea, to the south – the Medjerdah Basin, To the east – the Algerian–Tunisian border and to the west Seybouse (Fig. 1). It is drained by two major rivers: Wadi Bounamoussa to the west and Wadi El Kebir East to the east. These two rivers join the sea at a single outlet forming the delta Wadi Maffragh [ZOUINI *et al.* 1997]. The area of the basin exceeds 2000 km^2.

Besides its topographic and geological variety, the Maffragh watershed is distinguished by high rainfall, its mild and humid climate, and its richness of water resources.

Taking into account the various activities identified in the study area (domestic sewage, agro-industrial, etc.), seven (7) sampling points were selected throughout the two main watercourses of the Maffragh watershed, presented in Figure 2. These points are reflective of the general characteristics of surface water at the level of the study area [KHERICI *et al.* 1996].

For representative purposes, two samples are collected at each point; during high and low water level [DERRADJI *et al.* 2004]. The collected water samples were packaged in opaque bottles and kept cold whilst waiting for admission to the laboratory analyses [RODIER 2005; THIOULOUSE *et al.* 1997].

ANALYSIS PROTOCOL

The water samples are taken in clean containers, rinsed several times with the water to be analysed and filled completely. Then sealed tightly without leaving any air bubbles in the bottle. After sampling, the bottles are labelled and placed in a cooler, protected from light at a temperature of 4°C, to prevent the germ portion of the water from changing.

The chemical analyses is carried out by three types of dosing: Spectrophotometry method (nitrate – NO_3^-, nitrite – NO_2^-, phosphate – PO_4^{3-}, ammonium – NH_4^+, COD, BOD_5 and sulphates SO_4^{2-}), volumetric method (chlorides – Cl^-, magnesium – Mg^{2+}, calcium – Ca^{2+}) and the Flame Photometer method (bicarbonates HCO_3^-, potassium – K^+ and sodium – Na^+).

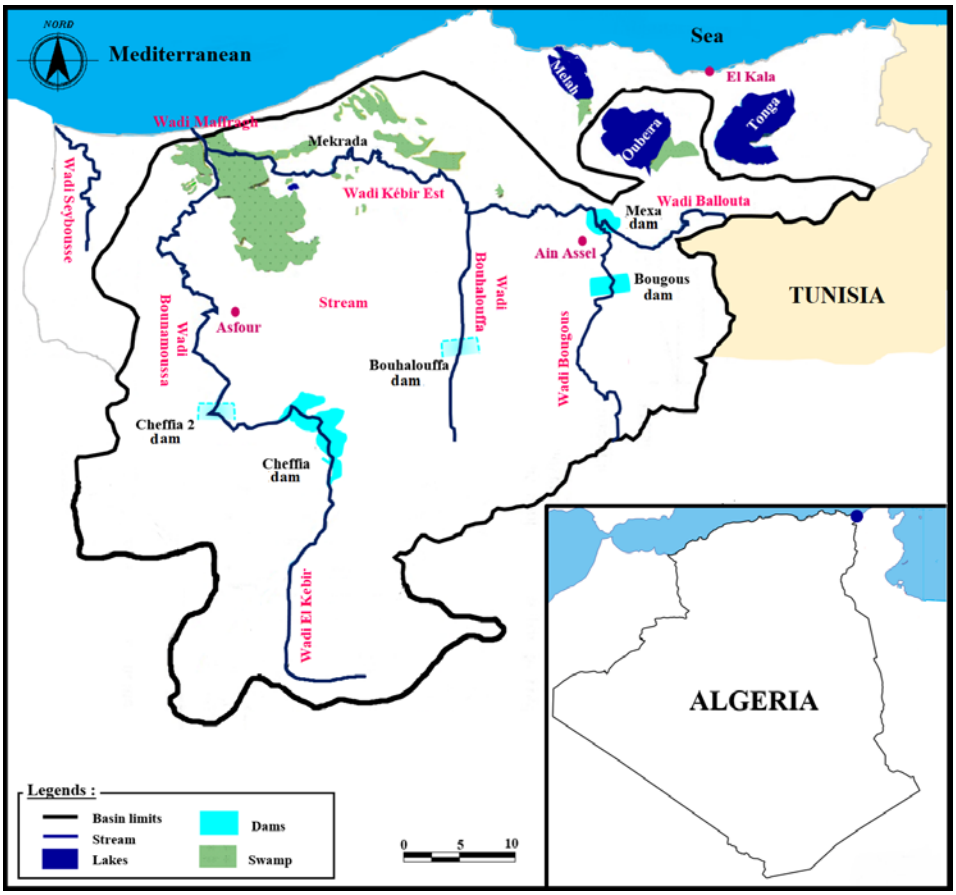

Fig. 1. Geographic situation of Maffragh watershed; source: own elaboration

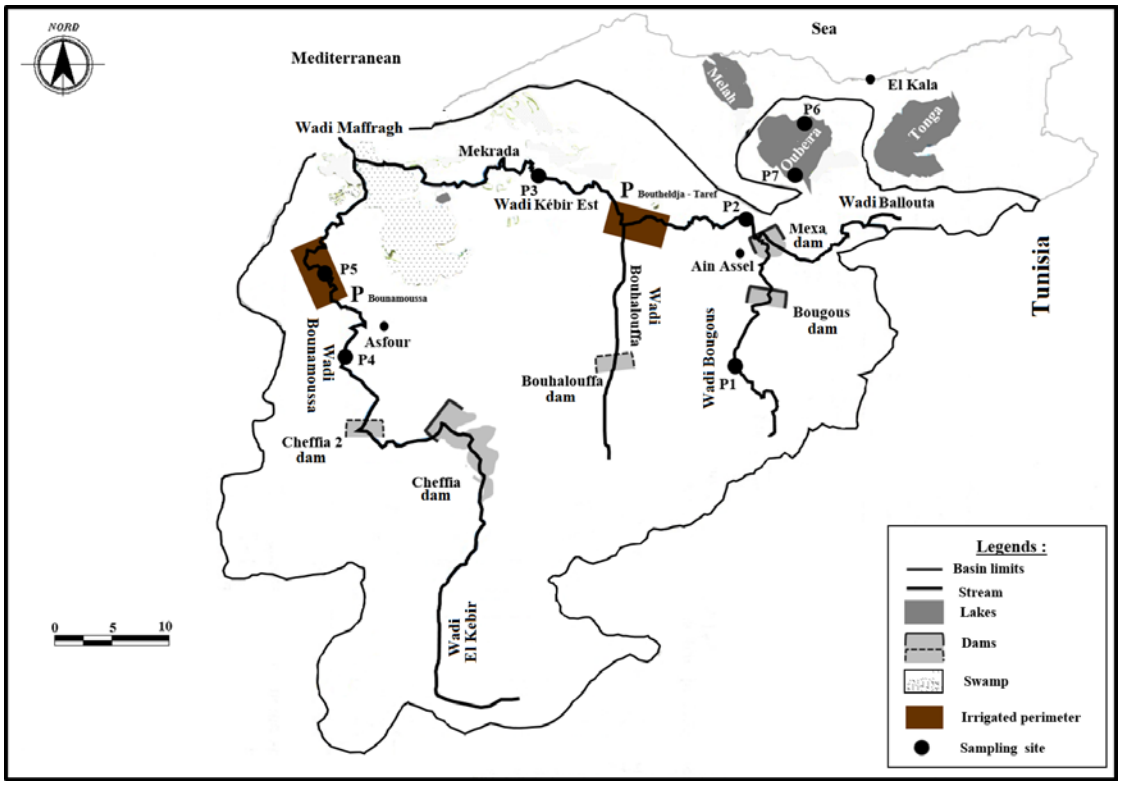

Fig. 2. Sampling points location; P1 = Wadi Bougous at Bougous Bridge, P2 = Wadi El Kebir downstream from Mexa Dam, P3 = Wadi El Kebir at Sabaa Bridge, P4 = Wadi Bounnamoussa above Asfour, P5 = Wadi Bounnamoussa, Bouzitoun Bridge downstream of Asfour, P6 = North Oubeir, P7 = Oubeira South – plant valve; source: own elaboration

As for the parameter conductivity, temperature and pH, turbidity, dissolved oxygen these elements were measured in situ using a multi-parameter apparatus.

RESULTS AND DISCUSSION

APPLICABILTY IN IRRIGATION PURPOSES

The chemical composition of water has the utmost importance in water usage decision; whether for drinking or other uses (industrial or irrigation purposes, etc.). To categorise the irrigation water, Richards diagram [RICHARDS 1954] is preferable. In this diagram, quality classes are defined based on Wilcox's sodium absorption rate *SAR* as a function of electrical conductivity measurement. This study aims to assess the suitability of Maffragh waters for irrigation [DERRADJI *et al*. 2007]. The basic concept of the *SAR* approach is projecting *SAR* values and measured conductivities on the classification diagram of irrigation water with three main categories:

– *SAR* < 10: Water used with little risk of alkalization,
– 10 < *SAR* < 18: Water used with an appreciable alkalizing hazard,
– *SAR* > 26: Water presenting a very high risk of alkalization.

Classification of irrigation water taking into account this parameter should be as follows:

– conductivity <700 $\mu S \cdot cm^{-1}$, there is no restriction for irrigation;
– conductivity ranging between 700 and 3000 $\mu S \cdot cm^{-1}$, the restriction for irrigation is light to medium;
– conductivity higher than 3000 $\mu S \cdot cm^{-1}$, the restriction for irrigation is high.

The suitability of water for irrigation is related to its effect on soils and crops, the effect is done generally by the portion and nature of salt dissolved in water intended for agricultural use. The salts cause changes in the structure of the soil, its permeability and its aeration, affecting directly the growth of plants. Moreover, the growth of the crops is very low or absent in soils saturated with sodium [PEÑA-HARO *et al*. 2010].

RESULTS INTERPRETATION

The riverside diagram shows a concentration of all the sampling points (P1–P7) in class 2.1 (good quality), for high and low water levels (Figs. 3, 4). This is explained by the average salinity leading to low alkalization of the soil.

The Wilcox diagram [WILCOX 1948] confirms the riverside diagram results where sampling points range in class C2S1, also identified as “good quality” (*i.e.*, in all sampling points).

In fact, the Wilcox diagram correlates the electrical conductivity and sodium content that is excellent for both periods (January–July 2018). According to the water classification diagrams for irrigation, the surface waters of the Maffragh Basin are of a good quality for irrigation. Meaning they can be used without special controls for irrigation.

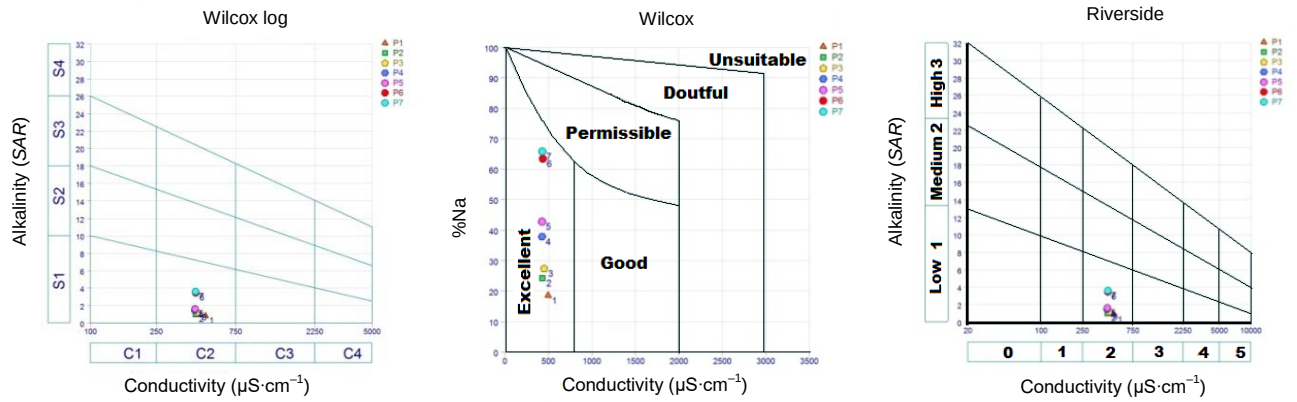

Fig. 3. Maffragh water classifications according to Wilcox and riverside diagrams high water level January 2018; source: own study

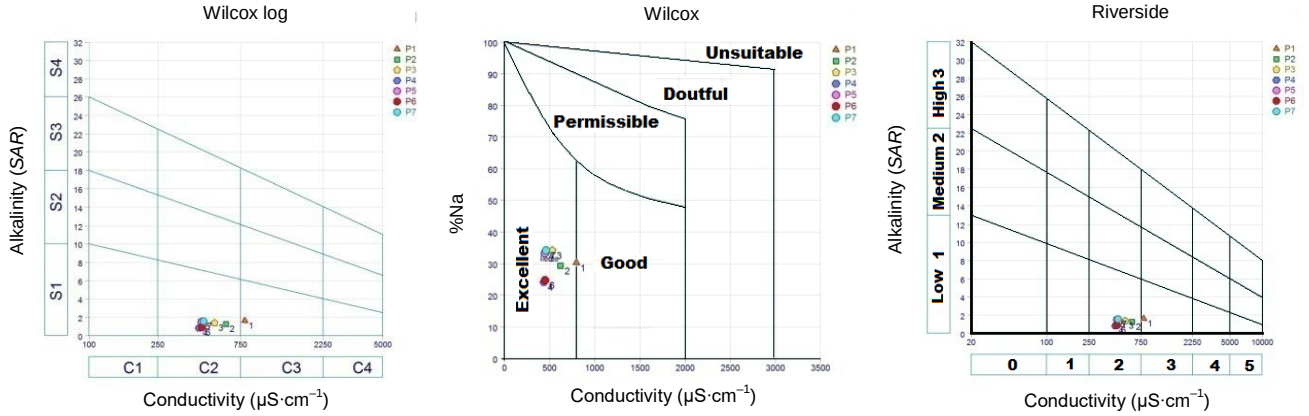

Fig. 4. Maffragh water classifications according to Wilcox and riverside diagram low water level July 2018; source: own study

PRESENTATION OF THE AGRO-DEVELOPMENT PROJECT OF THE BOUTELDJA-EL-TARF PLAIN

In the long term, the agricultural development programme will focus on the valorisation of several irrigated perimeters that require additional water resources through hydraulic schemes involving the construction of five (5) dams, two (2) of them already completed with three (3) still in the design stages.

The perimeter of Boutheldja-El Taref on Wadi El Kebir downstream. The proposed perimeter is over 90 km^2 area, the terraces of the Boutheldja and El Taref plains are renowned for the development of all market garden crops. Also, added the food crop, which is widespread and occupies small surfaces favouring land fragmentation. This future perimeter will allow for the development of several crops such as industrial tomato, melon, watermelon and as well as others. Becoming an agro-industrial pole of eastern Algeria.

Bounamoussa perimeter. The American company, Dravo Corporation, put into operation during the 1977–1978 irrigation season, mainly made the Bounamoussa Perimeter. The perimeter occupies an area of 165 km^2, currently in water deficit due to lack of priority (DWS: drinking water supply to City of Annaba) at the dam of Cheffia. It will be fed under the new project hydro-agricultural development. Other small perimeters with family activities practicing seasonal crops such as the perimeter of Lake Oubeira famous for its organic peanuts is still in a virgin environment.

CONCLUSIONS

The Maffragh basin, where the natural characteristics are advantageous (climate, precipitation, soils, topography, etc.) for both: traditional and modern agricultural development in a context of sustainable development by reconciling mobilization of water resources without altering the natural environment.

This present study discussed the suitability of these waters for irrigation purposes in an environment threatened by the local socio-economic development; the findings of water analysis encourage its use without prior treatment for irrigation purposes.

The year 2018/2019 saw a heavy rain. The implementation of this regional agricultural development strategy programme in the downstream Maffragh Basin requires a management strategy where all factors (water, agriculture, environment, communities, forests, farmers, etc.) must adhere to this participatory action of eco-development and flood control.

That however does not prevent recourse to the reuse of purified wastewater considering the development of treatment plant and the legislation in the material.

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