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IRRIGATION WATER QUALITY IN ALENTEJO (PORTUGAL) STUDY OF THE IRRIGATION PERIMETER OF THE RESERVOIR OF ROXO

SUMMARY

Alentejo is a region of Portugal located in the south of the country and the main economic activity is agriculture. In Alentejo the precipitation is very irregular. The problem of droughts often occurs.

The Alqueva reservoir is the biggest reservoir in Europe and provides water for more than 120,000 hectares for agriculture. Before the use of the reservoir, the main agricultural products were cereals. Now farmers grow vegetables and they make an intensive culture of olive trees and almond trees.

The Roxo reservoir is one of those will receive water from Alqueva in 2016. The increase of water in quantitative and qualitative terms can provide very significant increases in the growth of the soil production that we must monetize in the best way.

The aim of this study was evaluate the quality of water resulting from the monitoring carried out during 2014/2015 in the hydraulic system and in the drainage network of the irrigation perimeter of Roxo's reservoir to be made a more sustainable management of irrigated area. The main conclusions were as follows: i) the water of the irrigation channel and drainage network show a mild to moderate degree of salinity risk; ii) doesn't show characteristics to modify the soil infiltration conditions; iii) indicates degree of restriction slight to moderate due to the amounts of Na^+ and Cl^-; iv) the drainage network presents toxicity due the chlorides and boron; v) the ammonia nitrogen and nitrate values were low. The application of nitrogenous fertilizers seems to influence the results.

Keywords: *Irrigation water quality, Sustainable management, Droughts, Alentejo, Portugal.*

INTRODUCTION

In 2016 the construction of the Alqueva Multipurpose Project (AMP) will provide an increase in quantitative terms of the water available in Roxo reservoir (Alentejo - Portugal).

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The irrigation water and soil are determinant resources for the growth of the irrigated areas production. The available water can provide very significant increases in the growth of the soil production that we must monetize in the best way. However, we must keep in mind the decline and the collapse of many irrigation perimeters along the history resulting in the loss of the cultures production and in an increasing regional desertification so difficult to stop and to invert (Oliveira, 2012; Annetta and Colonna, 2004). In the origin of this situation are several ways of soil degradation and specially those related to the irrigation water quality deterioration (Oliveira, 2012).

In a hydro-agricultural project the problem diagnosis must be realized including the soil and water usage, farming, production means and others. Relatively to the soil and water usage the problems are related to the low efficiency of the irrigation at the parcel level, irrigation methods unadapted to the cultures and soil characteristics (Russo, 2013). The bad quality of the irrigation water can provoke serious problems in the soil quality of the irrigation perimeter (Sequeira *et al*., 1995 in Gonçalves *et al*, 2007), becoming particularly important when is used in slow kinetic soils which is the case of the thin texture soils existing in Alentejo (Gonçalves *et al*, 2007).

The aim of this study was: i) to evaluate the quality of water resulting from the monitoring carried out during 2014/2015 in Roxo hydro-agricultural holding (irrigation channel and drainage network); ii) to constitute a database for further comparison with the water quality resulting from the mixture after the connection to the Alqueva Multipurpose Project (AMP) in order to provide the implantation and maintenance of irrigation cultures of high lucrativeness and that may contribute indirectly to the inversion of the desertification in Alentejo.

MATERIALS AND METHODS

The Roxo Irrigation Perimeter, (Figure 1), including the Roxo's Reservoir and Dam, is in Baixo Alentejo (Portugal) and serves presently 7,730 ha. With the connection to the Alqueva System will reach the 15,000 ha in 2016 (Parreira and Marques, 2012).

The monitoring campaign of the water quality of the Roxo perimeter was carried out monthly, between July 2014 and September 2015. Samples were taken in 11 important spots of the irrigation channel and of the drainage network (Figure 1 and Table 1). The irrigation channel includes 7 sampling points. The drainage network includes the 4 remaining sampling points. The parameters analyzed were namely, pH, Electrical Conductivity (EC), Bicarbonates, Dissolved Oxygen (DO), Demand Chemical Oxygen (DQO), Chloride (Cl^-), Sodium (Na^+), Calcium (Ca^{2+}), Boron (B^{3+}), Nitrates (NO_3^-), Ammonia nitrogen (NH_4^+), Kjeldahl nitrogen, Total Phosphorus (P_{total}), Phosphates (PO_4^{3+}), Potassium (K^+), Magnesium (Mg^{2+}) and Sulphates (SO_4^{2-}). Experimental determination was made according to the standard methods for the water analysis (APHA, 1998).

Figure 1. Representation of the Roxo Irrigation Perimeter.

The calculation of the relation of sodium adsorption ($RAS_{adjust.}$) was made to obtain a correct amount of the ion calcium that remains in the water after the link with the bicarbonates (Ayers and Westcot, 1994). The results were treated in the computer program *Statistica 8* grouped by parameters, place and period (wet and dry). The results were analyzed according to the Guide of FAO (Ayers and Westcot, 1994), compared with the maximum values recommended in the Portuguese legislation, VMR (Decree-Law nº 236/98 of the 1st August) (Water quality for irrigation) and specialized literature.

Table1. Sampling points: Localization, designation and GPS coordinates

Point	Localization	Designation	East	North	Quotation
1	Irrigation Channel	B_Roxo	4517,319	-192957	110,7138
2	Irrigation Channel	ROuteiro	12556,92	-190068	140,6319
3	Irrigation Channel	E_Amendoal	-5993,59	-189011	99,76268
4	Drainage Network	S_RRoxo	-15893	-189330	48,97927
5	Irrigation Channel	E_Milho			
6	Irrigation Channel	E_Olival	-13672,5	-189232	56,85863
7	Drainage Network	B_Xacafre	-6346,04	-190688	79,28525
8	Irrigation Channel	C_Geral	-4922,26	-188301	101,599
9	Irrigation Channel	RLouriçais	10210,16	-200178	151,791
10	Drainage Network	E_RRoxo	-718,215	-191362	78,7748
11	Drainage Network	E_Agua Forte	-2371,76	-191491	76,83632

RESULTS AND DISCUSSION

The sampling points were grouped according to their localization but the results were analyzed and discussed separately. The figure 2 shows the results related to the irrigation channel.

The sampling points, Outeiro creek (ROuteiro) and Louriçais creek (RLouriçais) flow to the Roxo's reservoir and they have different characteristics.

The first one is located upstream the reservoir and receives discharges from a Wastewater Treatment Plant. The second one is also located upstream the reservoir and receives the run-off from nearby livestock farming. These characteristics justify the differences found in the measured values. The junction of those creeks in B_Roxo allows the obtainment of a water quality more or less regular along the irrigation channel. The pH values from that point presents alkaline characteristics, with values in the range of VMR and without significant variations in the two periods of reference. As for DO, the values obtained from B_Roxo don´t present significant variations (p<0.005), being however high in the dry period in the E_Amendoal tree and E_Milho points which can be justified for the huge water quantity that is going to the cultivation parcels and consequently is suffering a bigger oxygenation. The values of DQO, from the B_Roxo, are more or less regular but relatively high, approaching the recommended by VMR for a superficial water of bad quality. In Louriçais creek and Outeiro creek we can see high values probably due to the sampling spots characteristics previously described.
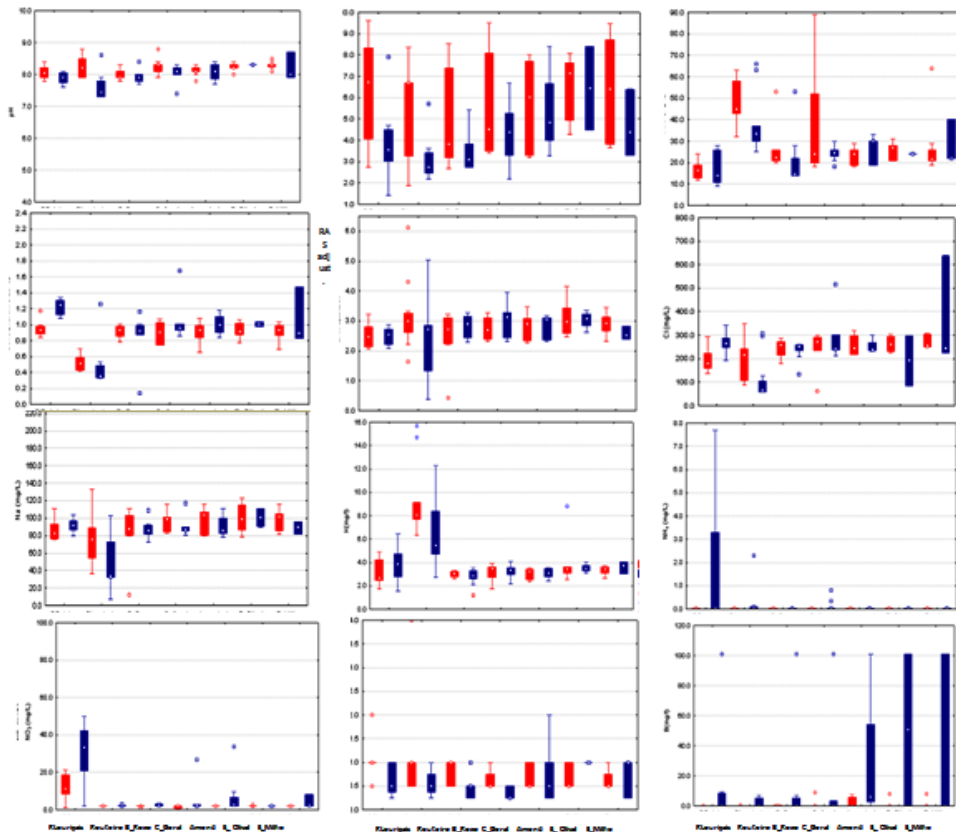

Figure 2. Box-and-Wisker graph diagram of the results obtained from the sampling points of the irrigation channel, ordered from upstream to downstream and categorized by wet period (blue) and dry (red), for the parameters: pH, DO, DQO, EC, RAS adjust, NO_3^-, NH_4^+, Cl^-, Na^+, K^+, P_{total} and B^{3+}.

Concerning to the salinity risk, (evaluated in terms of EC), and considering 0.7mS/cm limits (below it there is no restriction of use) and 3.0mS/cm (above it the level of restriction is severe) (Ayers and Westcot, 1994), we can verify that in the first two sampling points, the conductivities are not altered with the reference periods. After the junction of Outeiro creek (ROuteiro) and Louriçais creek with the Roxo´s reservoir, the resulting water body shows that it has in all points of the irrigation channel, a mild to moderate degree of salinity risk because the values obtained are between 0.7mS/cm and 3.0mS/cm (Ayers and Westcot 1994). The values are very close to VMR=1mS/cm.

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To evaluate the degradation problems of soils permeability by the action of water quality, we analysed the *RAS adjust* with the EC. As a matter of fact, for a determinate RAS the infiltration rate increases when the water salinity increases (RECOQUAR, 2006).

Consequently, the water of the irrigation channel doesn´t have characteristics to modify soil infiltration conditions (Richards, 1954). To do the analysis of the toxicity of some specific ions that can affect the cultures susceptibility, the results are presented relating to the parameters Na^+ and Cl^- that cause the highest number of problems and for being the most common in the irrigation waters (Ayers and Westcot, 1994). Consequently, both ions don´t change significantly for reference period after the point 1, but the very high parametric values indicate a mild to moderate restriction degree in water usage (Ayers and Westcot, 1994). The chloride ion exceeds always the VMR of 70mg/L. The ammonia nitrogen and nitrate values along the irrigation channel were always low and the concentrations of NO_3^- always lower than VMR=25mg/L. The K^+ values and the phosphorus present slightly higher values to those considered typical for irrigation waters (Almeida, 2010). The phosphates were also monitored but their value was always lower than the detection limit of the analytical method. The Boron presents higher values and a high variability in the wet period in the sampling point E_Olival tree. The results for the drainage network are presented in figure 3.

The water pH presents alkaline characteristics except the entrance of *E_RAgua Forte* whose characteristics are acid (pH<7). This situation is due to the effect of the water coming from the Aljustrel´s mine in the wet period. However, as the Roxo's creek water is alkaline, it's junction with the previous *E-RAgua Forte* lowers the pH according to VMR (6.5<pH<8.4). Although the pH is just an indicator, any value out of the VMR may cause a nutritional unbalance or have a toxic effect (RECOQUAR, 2006). Regarding to the DO, the values obtained don´t show significant changes (p<0.005), for period, for each sampling point except in B_Xacafre, with higher values in the dry period probably due to

the water withdrawal for the irrigation causing a bigger oxygenation in the water body.

The DQO is similar to the irrigation channel in all sampling points with slightly higher values in the dry period.

In relation to the salinity risk, analyzed in terms of electrical conductivity, there is in all the sampling points a mild to moderate degree of salinity risk because the values obtained are between 0.7mS/cm and 3.0mS/cm (Ayers and Westcot 1994). Most values are higher than VMR=1mS/cm. Regarding the sodium and salinity risks in the soil, the water quality of the drainage network kept the same risk degree as the water quality of the irrigation channel, that is, high salinity risk and low sodium risk (Richards, 1954).
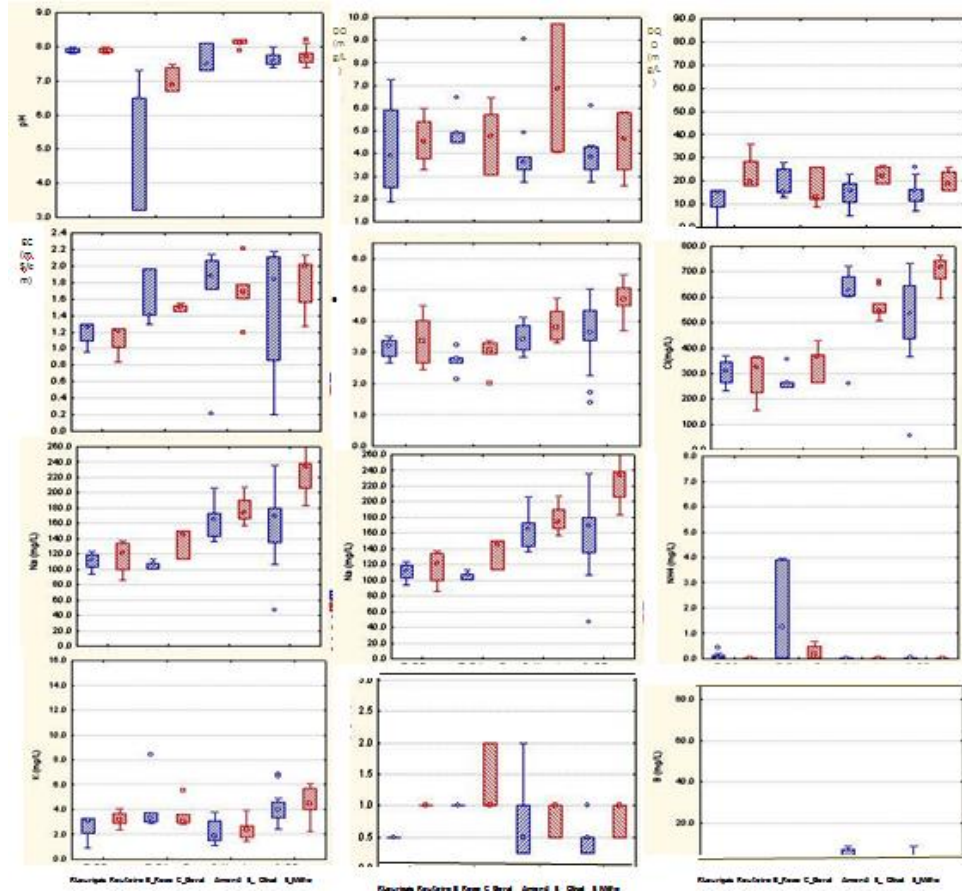

Figure 3. Box-and-Wisker graph diagram of the results obtained from the sampling points of the drainage network, ordered from upstream to downstream and categorized by wet period (blue) and dry (red), for the parameters: pH, DO, DQO, EC, RAS $_{adjust}$, NO_3^-, NH_4^+, Cl^-, Na^+, K^+, P_{total} and B^{3+}.

CONCLUSIONS

The water of the irrigation channel of Roxo´s reservoir, after the junction of the side branches; Louriçais creek and Outeiro creek; has in all analyzed points a mild to moderate degree of salinity risk which is kept in the drainage network.

The water of the irrigation channel and of the drainage network don´t present characteristics to modify the conditions of infiltration in the soil. Regarding the sodium and salinity risks in the soil, the water quality of the drainage network kept the same risk degree as the water quality of the irrigation channel, that is, high salinity risk and low sodium risk.

The highly parametric values of Na^+ and Cl^- ions in the irrigation channel indicate a mild to moderate restriction degree in the water usage which is kept in the drainage network with higher values to downstream of the irrigation perimeter. The ammonia nitrogen and nitrate values along the irrigation channel were always low, but in the drainage network, the application of nitrogenous fertilizers, in the parcels of the Almond tree, seems to influence the point B_Xacrafre in the wet period.

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