

# Contribution to the salinization risk assessment, under drought conditions, in the Alqueva irrigation area (South Portugal)

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## Introduction and Aim

In Mediterranean regions, climate changes have increased water limitation for crops, leading to an increase demand for irrigation water. During 2017, Portugal experienced a drought season that has extended throughout almost the entire territory of mainland Portugal, reaching the level of severe drought (IPMA, 2018). Under water scarcity conditions and high atmosphere evaporative demand, the risk of land salinization is one of the major threats to the sustainability of irrigated agriculture. This scenario makes very important the evaluation of the quality of irrigation water and the risks of salinity for crop production, in order to adopt appropriate management practices in irrigated areas.

Taking the above in consideration, in this study we focused on (i) assessing the Alqueva reservoir water quality for irrigation, and (ii) estimating soil salinity risks and potential yield losses due to salinization of the most representative crops grown in the area.

## Methods

The **study area** is the irrigation perimeter of the large Alqueva reservoir (Guadiana river basin; Southern Portugal), with a total area of 120000 ha, of which about 70000 ha were in operation in 2017.

The main crops in the area are: olive (*Olea europaea* L.), occupying more than half of the irrigated area; maize (*Zea mays* L.); grapevine (*Vitis vinifera* L.); forages and pastures, like Ryegrass (*Lolium multiflorum* Lam); sunflower (*Helianthus annuus* L.); almond (*Prunus dulcis* (Mill.) D. A. Webb); barley (*Hordeum vulgare* L.); wheat (*Triticum aestivum* L. and *Triticum durum* Desf.). Other crops present are mainly horticultural, like melon (*Cucumis melo* L.), tomato (*Solanum lycopersicum* L.), pepper (*Capsicum annuum* L.), garlic (*Allium sativum* L.), onion (*Allium cepa* L.), pumpkin (*Cucurbita pepo* L.) and strawberry (*Fragaria x ananassa* Duchesne).

The dominant climate in the region is Mediterranean, Csa, according to Köppen classification.

The **water chemical characterization** was performed throughout 2017, every two months. pH and electrical conductivity ( $EC_w$ ), and the major inorganic ions, decisive in evaluating the quality of water for irrigation, were analyzed in water samples collected at 4 platforms (Montante, Mourão, Álamos, Lucefécit) located in the reservoir (APHA, 1998).

**Irrigation water quality** was evaluated using both the Portuguese regulations (DL 236/98) and the FAO paper nº 29 guidelines (Ayers and Westcot, 1985), comparing parameters that are common to both standards.

**Soil salinity** ( $EC_e$ ) estimates were obtained according to Ayers and Westcot (1985), with  $EC_e = EC_w \cdot X$ , considering two salt concentration factors :

i)  $X = 1.5$ , a standard value for leaching fractions (LF) of 0.15, representing a medium-high irrigation efficiency and;

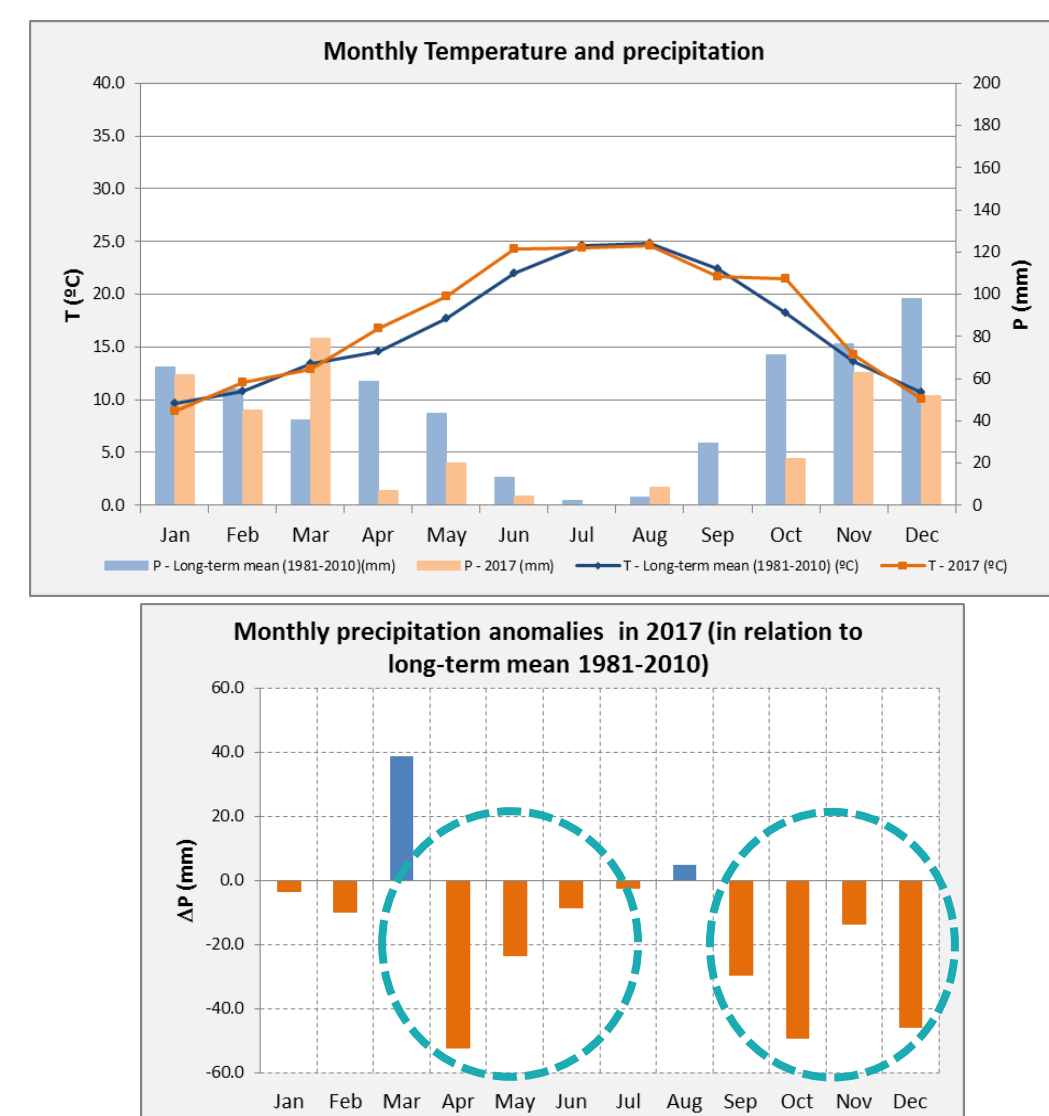
ii)  $X = 3.2$ , for LF = 0.05, corresponding to high irrigation efficiency with low percolation losses.

**Potential yield** reduction in the most representative crops was assessed using the relative crop yield ( $Y_r$ ) function:  $Y_r = 100 - b \cdot (EC_e - a)$  (Maas and Hoffman, 1977).

## Results

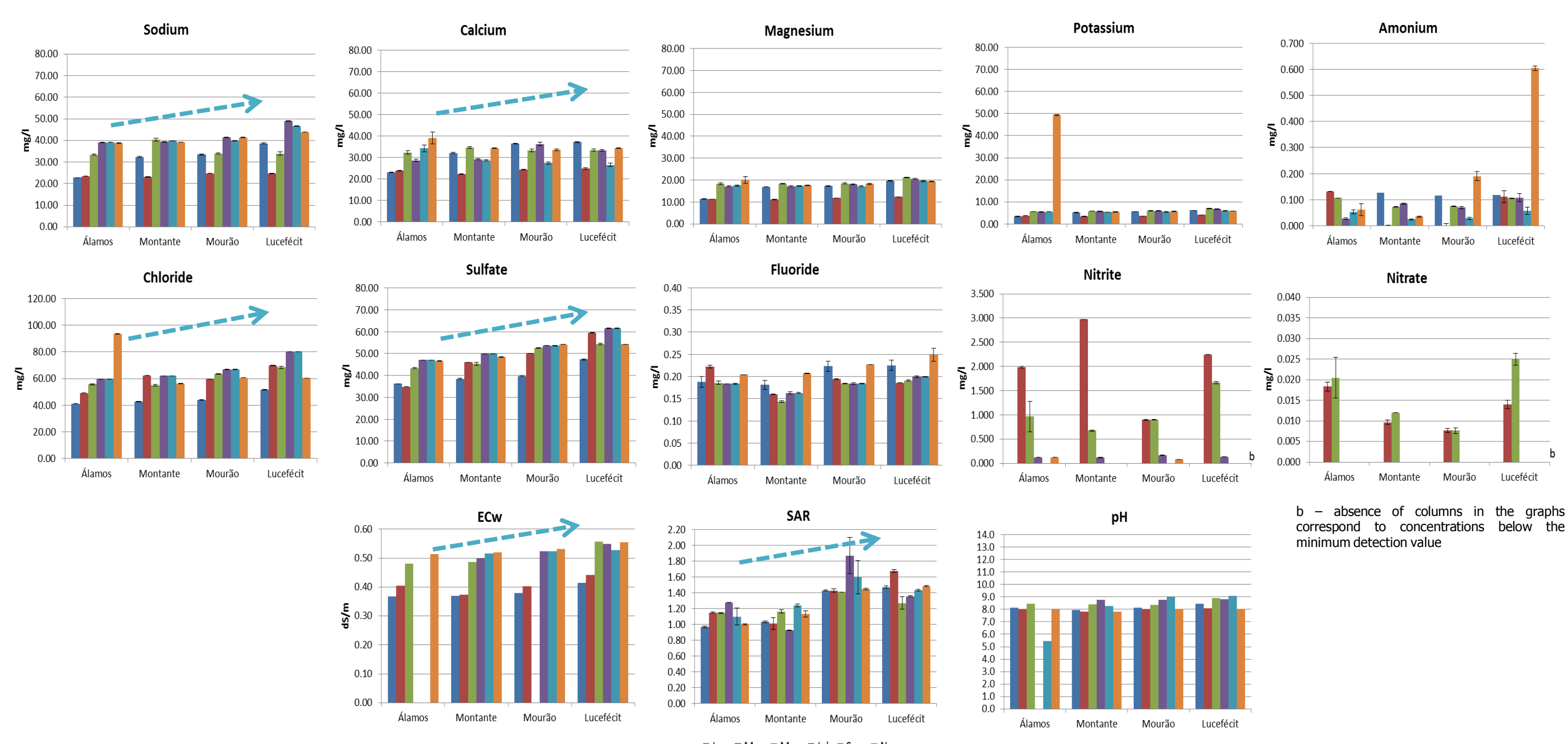
### DROUGHT CONDITIONS

- The year 2017 was classified as extremely hot and dry, being among the 4 driest years since 1931. The period from April to December, with persistently negative precipitation anomalies, was the driest of the last 87 years (IPMA, 2018).
- 2017 annual total precipitation was about 35% below the normal value in the region (long-term mean of 558 mm for the 1981-2010 period).
- There were two periods with four consecutive months precipitation values below normal.
- The first dry period (April to July) overlaps the growing season of Spring-Summer crops, further increasing their water requirements.



### CHEMICAL PARAMETERS

- In general, highest concentrations occur in samples collected in the Mourão and Lucefécit (most upstream platforms).
- Over the year, there was a slight upward trend in Sodium, Chloride, Calcium, Sulfate,  $EC_w$  and SAR.
- As expected, SAR values follow a tendency similar with the Sodium concentration values.
- pH remains stable around 8.0, with the maximum value (9.1) recorded in September in Lucefécit.



### IRRIGATION WATER QUALITY

- The only two parameters in non-compliance at some dates and sites are Chloride ( $>70$  mg/l) and, primarily, pH (outside the range 6.5 - 8.4).
- For the estimation of soil infiltration rate declines and surface crust formation problems FAO guidelines recommended the complement analysis of  $EC_w$  and SAR. This evaluation shows a slight to moderate degree of restriction of use in all water samples collected.

Parameter	Site	Degree of restriction on use according to FAO29						Compliance with DL 236/98					
		Jan	Mar	May	Jul	Sep	Nov	Jan	Mar	May	Jul	Sep	Nov
$EC_w$	Plat Alamos	N	N	N			N	C	C	C			C
	Plat Montante	N	N	N	N	N	N	C	C	C	C	C	C
	Plat Mourão	N	N		N	N	N	C	C		C	C	C
	Plat Lucefécit	N	N	N	N	N	N	C	C	C	C	C	C
SAR	Plat Alamos	N	N	N	N	N	N	C	C	C	C	C	C
	Plat Montante	N	N	N	N	N	N	C	C	C	C	C	C
	Plat Mourão	N	N	N	N	N	N	C	C	C	C	C	C
	Plat Lucefécit	N	N	N	N	N	N	C	C	C	C	C	C
Soil infiltration rate	Plat Alamos	SM	SM	SM	SM	SM	SM						
	Plat Montante	SM	SM	SM	SM	SM	SM						
	Plat Mourão	SM	SM	SM	SM	SM	SM						
	Plat Lucefécit	SM	SM	SM	SM	SM	SM						
$Cl^-$	Plat Alamos	N	N	N	N	N	N	C	C	C	C	C	NC
	Plat Montante	N	N	N	N	N	N	C	C	C	C	C	C
	Plat Mourão	N	N	N	N	N	N	C	C	C	C	C	C
	Plat Lucefécit	N	N	N	N	N	N	C	NC	C	NC	NC	C
$NO_3^-$	Plat Alamos	N	N	N	N	N	N	C	C	C	C	C	C
	Plat Montante	N	N	N	N	N	N	C	C	C	C	C	C
	Plat Mourão	N	N	N	N	N	N	C	C	C	C	C	C
	Plat Lucefécit	N	N	N	N	N	N	C	C	C	C	C	C
pH	Plat Alamos	C	C	NC		C	C	C	C	NC		C	C
	Plat Montante	C	C	NC	NC	C	C	C	C	NC	NC	C	C
	Plat Mourão	C	C	C	NC	NC	C	C	C	C	NC	NC	C
	Plat Lucefécit	NC	C	NC	NC	NC	C	NC	C	NC	NC	NC	C

N – none degree of restriction; C – in compliance; SM – slight to moderate degree of restriction; NC – non-compliance

### POTENTIAL YIELD

- For LF = 0.15, and given the information available in the literature regarding threshold salinity (Maas and Grattan, 1999), the estimates show that there is no yield reduction in any of the studied crops.
- For LF = 0.05, adjusted to the most common irrigation systems found in the Alqueva irrigation perimeter, namely drip and center-pivot systems, the main crops in the perimeter (olive, maize or vine) are not salt affected or else register yield reductions below 5%.
- The highest potential yield loss (resulting from water samples collected between May and November) occur in strawberry, one of the most sensitive crops relatively to salinity tolerance scale. Nonetheless, strawberries are a greenhouse hydroponic cultivation occupying a residual area in the region.
- Sensitive or moderately sensitive, open-field, horticultural crops, such as melon, onion or pumpkin, show yield reductions estimations from 6 to 10%.

Crop						Potential yield reduction (%)
	Sunflower, Barley, Wheat, Olive, Tomato, Broccoli, Garlic					None
	Maize, Grape, Almond, Pepper					1 - 5
	Melon, Onion, Pumpkin					6 - 10
	Strawberry					11 - 15

## Conclusion

- $EC_w$  and SAR values were in compliance at all sites and dates.
- In the Spring-Summer season, water presented pH values outside the recommended range.
- Water quality assessment regarding soil infiltration rate decline and surface crust formation problems showed a slight to moderate degree of restriction of use. This result should be taken into account when surface or sprinkler irrigation systems are used, particularly in fine textured and poorly structured soils.
- The main crops in the perimeter (olive, maize and grapevine) showed none or below 5% yield reductions estimations. In open-field horticultural crops like melon, onion and pumpkin, salt susceptible, potential yield reductions estimates were in the range of 6 to 10%, so appropriate agronomic management practices, such as the addition of leaching fractions to irrigation, should be taken into account.

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