Technosols produced with sediments from Mediterranean aquaculture for the cultivation of halophyte *Limonium algarvense*

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Abstract (300-word limit)

The Technosols are constituted by anthropogenic parent materials that can be natural or technogenic (IUSS Working Group, 2014). The aquaculture is the farming of marine organisms under controlled conditions (Grigorakis and Rigos, 2011). In the last years, the Mediterranean aquaculture has been established mainly in abandoned or inactive coastal salt production areas Rosa et al., 2012). In that activity is necessary to remove the sediments from de ponds to improve the quality of water (Thunjai et al., 2004). However, these sediments may contain high salt burden as well as hazardous elements so their deposition on productive soil can lead to a degradation of soil properties and consequently local biodiversity (fauna and flora) reduction (Yuvanatemiya and Boyd, 2006).

Halophytes are salt tolerant plants able to grow under high salinity concentrations (Flowers and Colmer, 2008). The cultivation of that plants in Technosols made with sediments from aquaculture pond can be an alternative. The sepecie *Limonium algarvense* Erben is a halophyte whose infusions and decoctions of flowers has an antioxidant activity so high as the green tea and can be considered a potential functional beverage due to its proprieties (Rodrigues et al., 2016). The aim of this work is to test the utilization of Technosols produced with sediments from Mediterranean aquaculture ponds and organic wastes as amendments in the *L. algarvense* cultivation and to assess the different rates of amendments application using brackish and deionized water irrigation.

Methodology and Theoretical Orientation:

A sediment (75 kg) from aquaculture ponds and brackish water (54 L) were collected in Reserva Natural do Sapal de Castro Marim e Vila Real de Santo António (Algarve, Portugal). The sediment were analyzed for pH, electrical conductivity (EC), organic carbon (C organic), and NPK concentrations. The chemical characteristics of brackish water were also analyzed: pH, EC, Cl^-, NO_3^-, N-NO_3^-, N-NH_4^+, HCO_3^-, CO_3^{2-}, Na^+, Mg^{2+} and Ca^{2+}. To produce the Technosols were used the sediments from aquaculture and a mixture of low value organic wastes as amendments. It were applied two different concentrations of amendments: 180 g/kg of sediment (Tec180) and 360 g/kg of sediment (Tec360). The *L. algarvense's* seeds were also collected in Castro Marim and germinated in jiffy pots. One month later, the seedlings were transferred to pots with commercial substrate (du Vitor, Portugal) where they grow during 4 months irrigated with deionized water before they be transferred to the pots of microcosm assay. The microcosm assay was set up in triplicate with four treatments: sediments (positive control, C^+), commercial substrate (negative control, C^-), Tec180 and Tec360. The *L. algarvense* plants were cultivated and irrigated with brackish water, except C^+ which was irrigated with deionized water. The Technosols were analysed at the beginning (T0) and at the end of the experiment (T1) for pH, EC, C organic and NPK concentrations. The number of leaves, the leaves length, the leaves width and the number of scapes of the *L. algarvense* plants were measured.

Findings:

The sediment from aquaculture ponds had a pH 3.12, high EC (4.92 mS/cm) and N-NH_4^+ concentration (41.1 x 10^{-3} g/kg). In opposition showed low levels of N-NO_3^- (8.6 x 10^{-3}), C organic (9.47 g/kg), extractable P (62.26 x 10^{-3} g/kg) and K (0.16 g/kg) content. The brackish water showed a neutral pH (7.2), high EC (17.22 mS/cm) and Cl^- (8118.1 mg/L), $HCO3^-$ (139.8 mg/L) , Na^+ (3474.8 mg/L) , Mg^{2+} (564.8 mg/L) and Ca^{2+} (229.4 mg/L) concentration and low N-NO_3^- (<0.5 mg/L) content. In comparison with sediments, the Technosols showed a significant decrease in EC, N-$NH4^+$ and N-NO_3^-, and a significant increase of pH, extractable K, extractable P and organic C. The latter revealed a significant increase mainly in Tec 360 due to amount of organic wastes used as amendments. After the irrigation with brackish water (T1), the Technosols presented a significant increase of EC

That was expectable a significant increase of EC since it is a soil salinity indicator (Rhoades and Chanduvi, 1999). The Technosols showed also a significant increase of extractable K and significant decrease of N-NO_3^- and extractable P. The Tec180 demonstrate as well a decrease of N-$NH4^+$ but the Tec360 did not show variation. The Technosols did not present significant variation for pH and C organic values. The plants cultivated in C^+ succumbed and the plants cultivated in Technosols presented a similar number of leaves with similar size as well. However, the plant cultivated in Tec180 did not present scapes but 2 of 3 plants in Tec 360 developed scapes

Conclusion and Significance:

The plants are not able to grow in the sediments from aquaculture ponds irrigated with brackish water and the amendment concentration Tec180 was not enough to the plants development. However, plants cultivated in Tec360 irrigated with brackish water were able to grow, to produce flowers and seeds. It can be concluded that sediments from Mediterranean aquaculture ponds can be valorized, after organic amendments application, in the halophyte plants cultivation, like *L. algarvense*, even under the irrigation with brackish water.

Image:

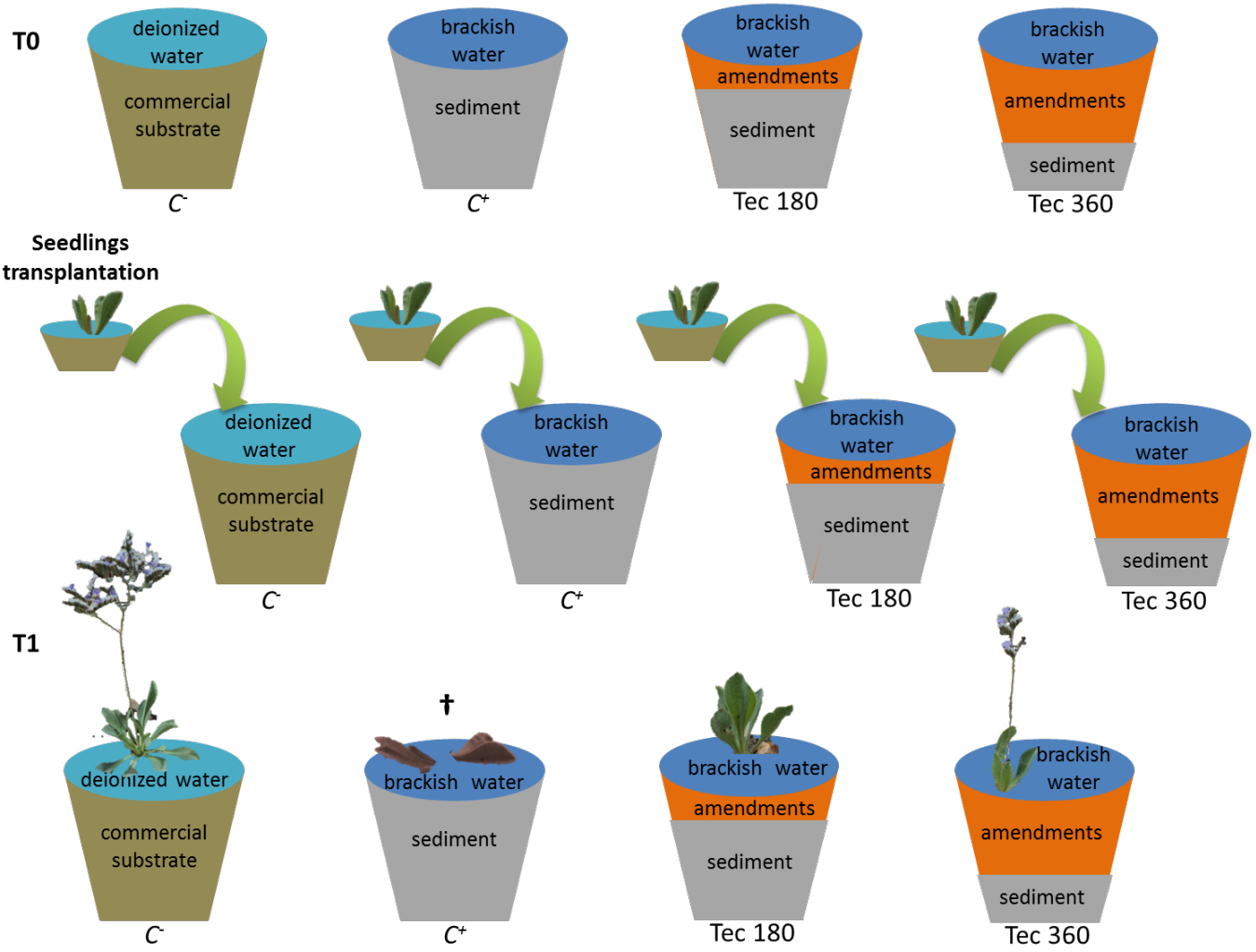


Figure 1. Schematic representation of microcosm assay with four treatments: C^+ - sediment from aquaculture ponds, C^- - commercial substrate, Tec 180 - amendment concentration 180 g/kg, Tec 360 - amendment concentration 360 g/kg. The time T0 and T1 represent the beginning and the end of assay, respectively, when de soils, sediments and/or plants were analyzed.

Recent Publications (minimum 5)

1. Flowers TJ, Colmer TD (2008) Salinity tolerance in halophytes. New Phytologist 179: 945–963.
2. Grigorakis, K., Rigos, G (2011) Aquaculture effects on environmental and public welfare–The case of Mediterranean mariculture. Chemosphere, 85(6), 899-919.
3. IUSS Working Group (2014) World reference base for soil resources 2014 international soil classification system for naming soils and creating legends for soil maps. FAO, Rome.
4. Rhoades, JD, Chanduvi, F (1999). Soil salinity assessment: Methods and interpretation of electrical conductivity measurements (Vol. 57). Food & Agriculture Org.
5. Rodrigues MJ, Neves V, Martins A, Rauter AP, Neng NR, Nogueira JMF, Varela J, Barreira L, Custódio L (2016) In vitro antioxidant and anti-inflammatory properties of Limonium algarvense flowers' infusions and decoctions: A comparison with green tea (Camellia sinensis). Food Chem. 200:322–9.

6. Rosa, R, Marques, A, Nunes, ML (2012) Impact of climate change in Mediterranean aquaculture. Reviews in Aquaculture, 4(3), 163-177.
7. Thunjai, T, Boyd, CE, Boonyaratpalin, M (2004) Bottom soil quality in tilapia ponds of different age in Thailand. Aquac. Res. 35, 698–705.
8. Yuvanatemiya, V, Boyd, CE (2006) Physical and chemical changes in aquaculture pond bottom soil resulting from sediment removal. Aquacultural engineering, 35(2), 199-205.



Biography (150-word limit-mandatory)

Ana Cortinhas holds a Master degree in Biodiversity: Conservation and Evolution, specialization in Biodiversity and Plant Conservation, at the University of Valencia, Spain. She is interested in uses and cultivation of halophytes, salt tolerance and functional food. She did the master thesis on halophytes species - "Taxonomic study of *Limonium vulgare* and related species in salt-marshes of Portugal Continental". Later, she participated in other research projects focused on halophytes such as "Cultivation of halophyte *Limonium algarvense* using saline water and amended underused sediments" at LEAF- Linking Landscape, Environment, Agriculture and Food, University of Lisbon, Portugal. Currently, she holds a FCT grant (SFRH/BD/130256/2017) to develop her PhD project "XtremeVeggies – Edible Halophyte Cultivation using Saline Water and Amended Underused Soils and Sediments" at LEAF, University of Lisbon, Portugal

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