



Real-scale study of use of *Vetiver Zizanioides* floating beds to improvement quality of surface water body in a Mediterranean climate

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Introduction

The Roxo stream, located on the right bank of the Sado river (Southern Portugal), near the city of Aljustrel, is a perennial water course and has been heavily influenced by mining, livestock farms and agricultural activity of the region. As a result, the quality of water for irrigation is bad, according Portuguese Law [1] and presents poor ecological state, when evaluated only for the physicochemical parameters [2]. Thus, solving this problem by using an effective and environmentally sustainable pollutant removal solution is considered relevant. The use of Floating Beds (FB) is one of rivers Eco-rehabilitation strategies [3]. FB are floating matrices, which are associated with ecological communities such as macrophytes and microorganisms [5]. They have the ability to degrade pollutants by taking advantage of the benefits that ecosystems have, so they can be used to improve the surface water bodies quality [4]. The main aim of this work is to test, at real scale, the floating bed technology (FB) using floating matrix with the macrophyte *Vetiver zizanioides*, with the purpose to improve water quality of Roxo stream, contributing to it ecological improvement and also, in order, if possible, to be used in irrigation proposes.

Material and methods

1. Field Installation

Three floating beds with the dimensions of 3.3 m²/unit were placed on Roxo stream (location: coordinates GPS: 37.944685-8.153876), on May 2020, (Fig.1). They were placed in a water section, that presented the depth of 0.9 ± 0.3 m, the wide of 10.0 ± 1.3 m and a flow rate of 0.12 ± 0.10 m³/s.

2. Experimental Procedure

The sampling collection was made in two points, namely after floating beds location (Outlet) and around 100 m before them (Inlet). They were carried out by May 2020 to December 2020 according to Standard Methods of Analysis [5].

Physical-chemical monitoring was performed bimonthly, *in situ*, for some parameters: using multiparametric portable probe (HI9829 HANNA).

The remaining parameters were monitored monthly *in lab*, and were determined according to Standard Methods for the Examination of Water and Wastewater [5]. For the parameter ECW was calculated the mean removal efficiency using the Eq.1. For the remaining parameters It was calculated the load rate in both sampling points and it was calculated the average of removal efficiency for each parameter using, also, the Eq.1.

$$\%R = \frac{Inlet - Outlet}{Inlet} \times 100 \quad (Eq.1)$$



Fig.1. Field Installation of floating beds.

Table1. Water physicochemical quality characterization of Roxo's stream

Parameters	Units	Roxo's Water Quality	Decree-Law No. 236/98 (Annex XVII)		Ecological State (Water Institute, 2009)
			VMR	VMA	
Soren S.		6.2 ± 1.6	6.5-8.4	4.5-9.0	6-9
T _w	°C	17 ± 2	-	-	-
Eh	mV	522 ± 19	-	-	-
B ³⁺	mg/L	0.2 ± 0.1	0.3	3.75	-
ECW	µS/cm 20°C	1813 ± 117	-	-	-
DO	mg/L	7 ± 1	-	-	≥5
COD	mg/L O ₂	23 ± 3	-	-	-
CBO ₅	mg/L O ₂	4 ± 0.0	-	-	≤6
PO ₄ ³⁻	mg/L	0.007 ± 0.001	-	-	-
TP	mg/L	0.2 ± 0.2	-	-	≤0.13
TN	mg/L	4 ± 1	-	-	-
NH ₄ ⁺	mg/L	2 ± 1	-	-	≤1
NO ₃ ⁻	mg/L	7 ± 1	50	-	≤25
SO ₄ ²⁻	mg/L	391 ± 31	575	-	-
F ⁻	mg/L	1.0 ± 0.0	1.0	15.0	-
Cl ⁻	mg/L	700 ± 21	70	-	-
TSS	mg/L	19 ± 1	60	-	-
TDS	mg/L	1238 ± 232	-	-	-
Zn	mg/L	3.0 ± 2.1	2.0	10.0	-
Fe	mg/L	0.5 ± 0.3	5.0	-	-
Cu	mg/L	0.6 ± 0.3	0.20	5.0	-
Mn	mg/L	2.2 ± 0.7	0.20	10	-
RAS	-	2 ± 1	8	-	-

Results and discussion

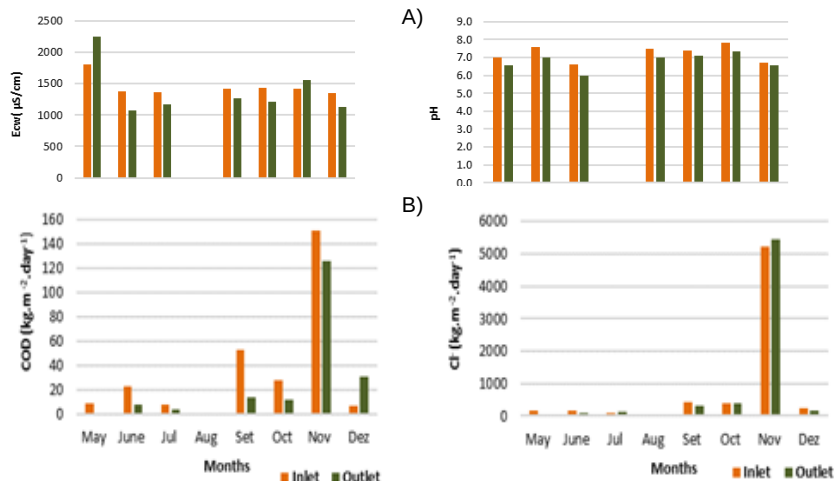


Fig. 2. A) Representation of the values of Electrical Conductivity (ECw) and pH at inlet and outlet of FB obtained along the monitorization period, B) Representation of load rates of chemical organic matter, COD, and chlorides (Cl-) at inlet and outlet of FB obtained along the monitorization period.

The electrical conductivity archived an average of removal efficiency of 6.7%. The values obtained from ECw were always high and above the MVR referred in Annex XVI of Decree-Law No. 236/98, indicating that this water body presents mild to moderate risk of salinity (Ce=700-3000 µS/cm) [13]. The parameter pH remains neutral. According [6] the macrophytes don't promote significant pH changes in medium. (Fig.2 A):

Chemical organic demand, COD, (Fig.2.B)) shows that they are always high (ranged between 8.8-150 kg.m².day⁻¹), with November month standing out remarkably due to the precipitation conditions recorded. The FB allowed small load removals rates and the average of removal efficiency obtained was, only, 3%.

The continuous use of waters with high salt content (e.g. Cl⁻ion), can lead to soil salinization, making it impossible for agricultural use. The inflow loads are very high (ranged between 98-5227 kg.m².day⁻¹), (Fig. 2.B)), but the treatment by FB allowed an average removal efficiency of 10.8%.

References [1] Decree Law nº. 236/98. Ministry of the Environment, 1 August 1998; [2] Instituto da Água. (2009). *Crítérios para a classificação do estado das massas de água superficiais*. Ministério do Ambiente. Ordenamento do Território e do Desenvolvimento Regional; [3] Durão, A. C. R. (2013). Estratégias para a melhoria da qualidade da água na Bacia Hidrográfica do Rio Ardila_Tese elaborada na Universidade de Évora, para a obtenção do grau de doutor em Ciências da Engenharia do Território e Ambiente, Évora. Accessed on 19 of March of 2019; [4] Billore, S.K., Prashant, Sharma, J. K. (2009). Treatment performance of artificial floating reed beds in an experimental mesocosm to improve the water quality of river Kshipra. *Water Science and Technology*, 60 (11), 2851-2859. doi:10.2166/wst.2009.731; [5] APHA (2012). *Standard Methods for Examination of Water and Wastewater*. American Public Health Association (APHA): Washington, DC, USA. [5] Kadlec, R. H., & Wallace, S. D. (2009). *Treatment Wetlands*. Second Edition (2nd ed.).

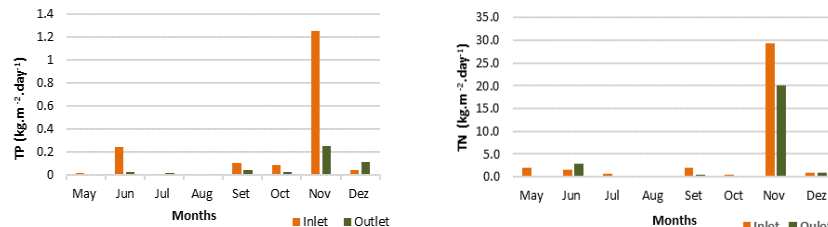


Fig. 3. Representation of load rates of total phosphorus (TP) and total nitrogen (TN) at inlet and outlet of FB obtained along the monitorization period.

For phosphorous, (Fig.3) the inflows range of load rate were 0.003 -1.30 kg.m².day⁻¹ and outflows were 0.01-0.26 kg.m².day⁻¹. The FB system showed capacity to remove this parameter, reaching the average of removal efficiency of 13%. For total nitrogen, (TN), the inflows are lows too and FB has showed a capacity to reached an average of removal efficiency of 20.7%.

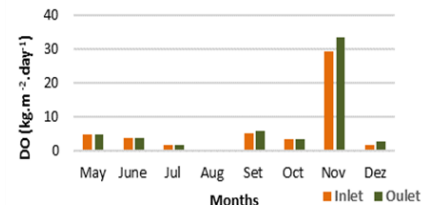


Fig. 4. Representation of dissolved oxygen, DO, loads at inlet and outlet of FB obtained along the monitorization period.

In Fig.4, It can be observed that the OD loads were low with the exception in the month of November in which an unexpected increase occurred. This was due to the great rainfall that occurred in this month. In any case, it seems that exists a trend of a gradual increase in the values of OD at the exit of FB compared to the input.

Conclusions

- The influent pollutants to the river are very closely related to the hydrological behaviour.
- The main results obtained had shown that the average removal efficiencies obtained were (i) ECw=6.4%, (ii)TN=20.7%; (iii)TP=13%, (iv) COD=3,1% and (v) Cl=10,3%.
- DO level increased slightly and the pH remained neutral.
- Although the study carried out was short-lived, the results suggest that the use of FB may constitute a long-term, ecological and economical system for the treatment of the Roxo stream water.
- Further work is needed to consolidate the results and to determining hydraulic parameters relevant to the possible dissemination of this technology.