

STUDY OF THE APPLICATION OF FLOATING BEDS OF MACROPHITES (*Vetiveria zizanioides* and *Phragmites australis*) IN PILOT SCALE FOR THE REMOVAL OF HEAVY METALS AND OF ÁGUA FORTE STREAM IN THE ALENTEJO REGION (PORTUGAL)

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Introduction

In the region of the Sado Basin, the surrounding area of Roxo stream has completely barren sections, undermining the productivity of the agricultural activities practiced there. This may be due, in addition to others, to the affluence of Água Forte stream (Figure 1), which contains heavy metals from the acid mine drainage (AMD) of the Aljustrel mining activity (ALMINA) (Maia et al., 2012). AMD contains products resulting from the oxidation of pyrite (FeS₂): This oxidation occurs with the aid of bacterial activity, producing acidic waters with pH around 2, abundant colloidal Fe and high concentrations of transition metals (Kefeni et al., 2017).

At present, floating beds of macrophytes for wastewater treatment have been used as an environmentally sustainable alternative to improve their quality, thus promoting greater productivity in the surrounding agricultural areas (Pavlineri et al., 2017).

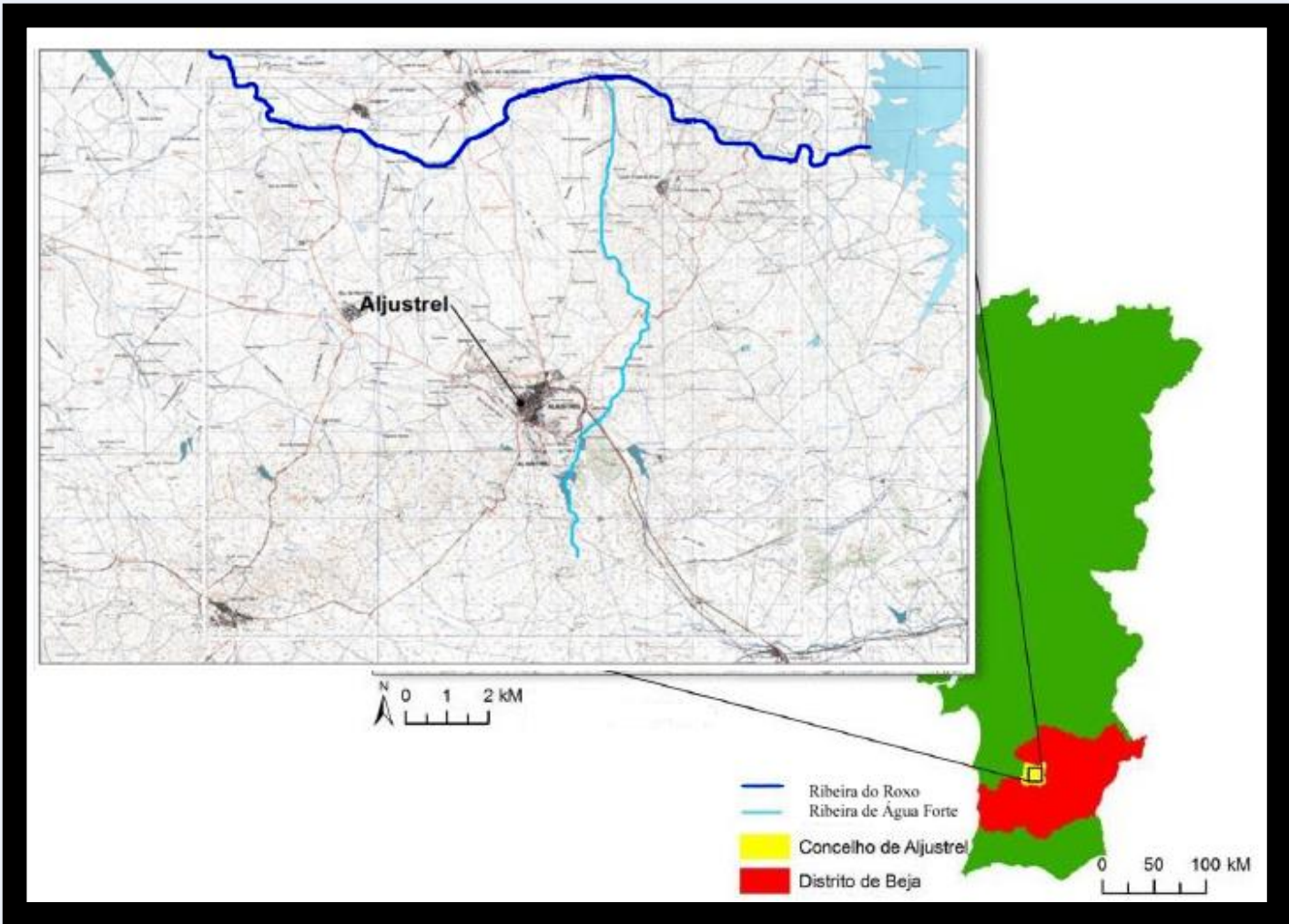


Figure 1- Location of Água Forte stream (adapted from Guimarães, 2012).

Objective

The goal of this study was to test the efficiency of removal of heavy metals from Água Forte water, using floating beds of macrophytes, namely *Vetiveria zizanioides* (native to India) and *Phragmites australis* (native to Portugal), in installation at the pilot scale, based at the Escola Superior Agrária of Beja (ESAB), where monitoring and evaluation of water quality and macrophyte performance were carried out. We also sought to select the best performing macrophyte. This work also intends to disseminate the use of this eco-rehabilitation technology in this type of surface water bodies.

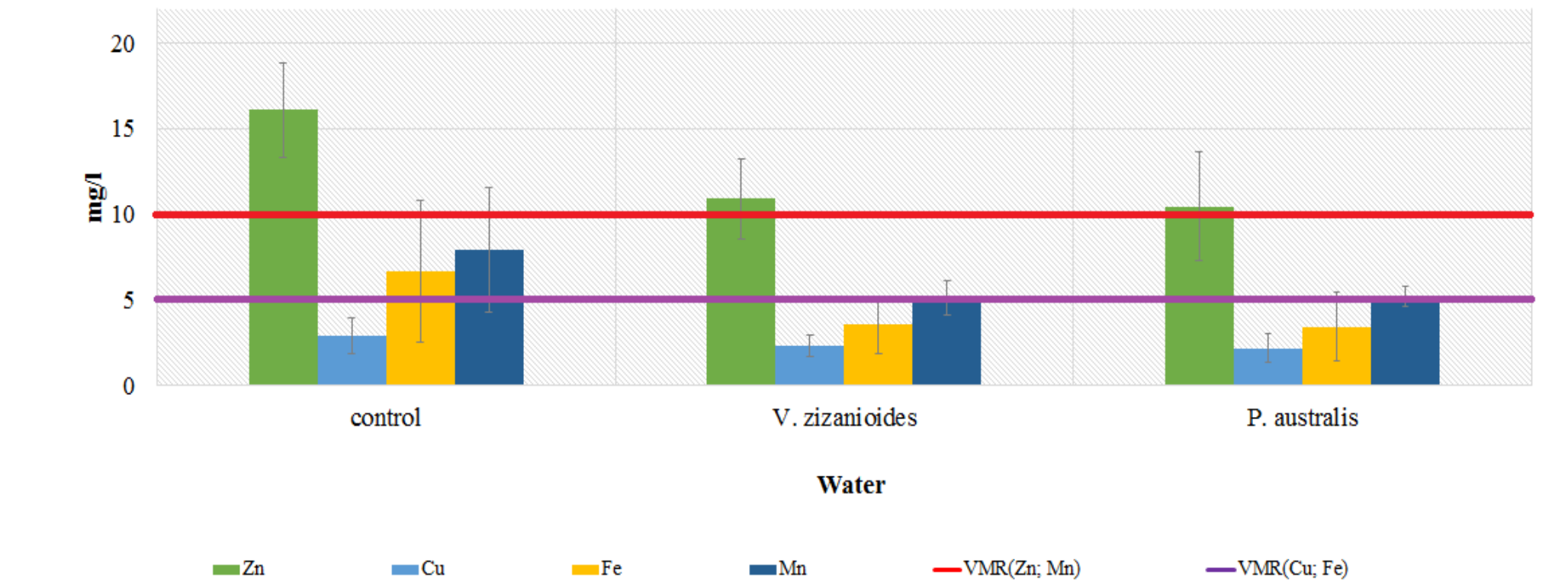
Methodology

The pilot facility consists of: (a) Floating bed with *Vetiveria zizanioides* - containing the floating raft with *V. zizanioides* and water from Água Forte stream; (b) Floating bed with *Phragmites australis* - containing the floating raft with *P. australis* and water from Água Forte stream. The control is considered water which is replaced monthly. The collection of the volume of water sample required for the pilot installation was carried out in Água Forte stream.

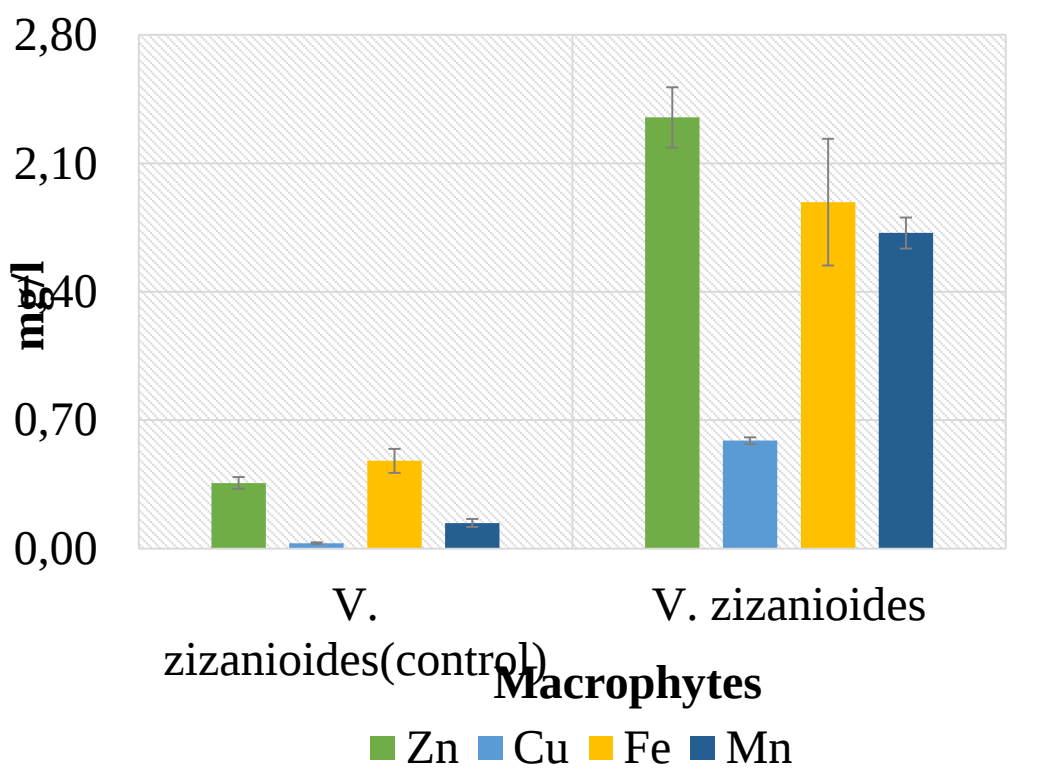
Monitoring in the pilot plant was carried out monthly on a 4-month basis (January to April 2019) and consists of: (i) determination of the physico-chemical parameters of the water; (ii) determination of plant growth using a tape measure; (iii) determination of the heavy metals (Cu; Fe; Zn; Mn) present in water and in the root and follicular part, by Atomic Absorption (AA). These determinations were performed according to standardized water quality methods (APHA, 2012).

Results

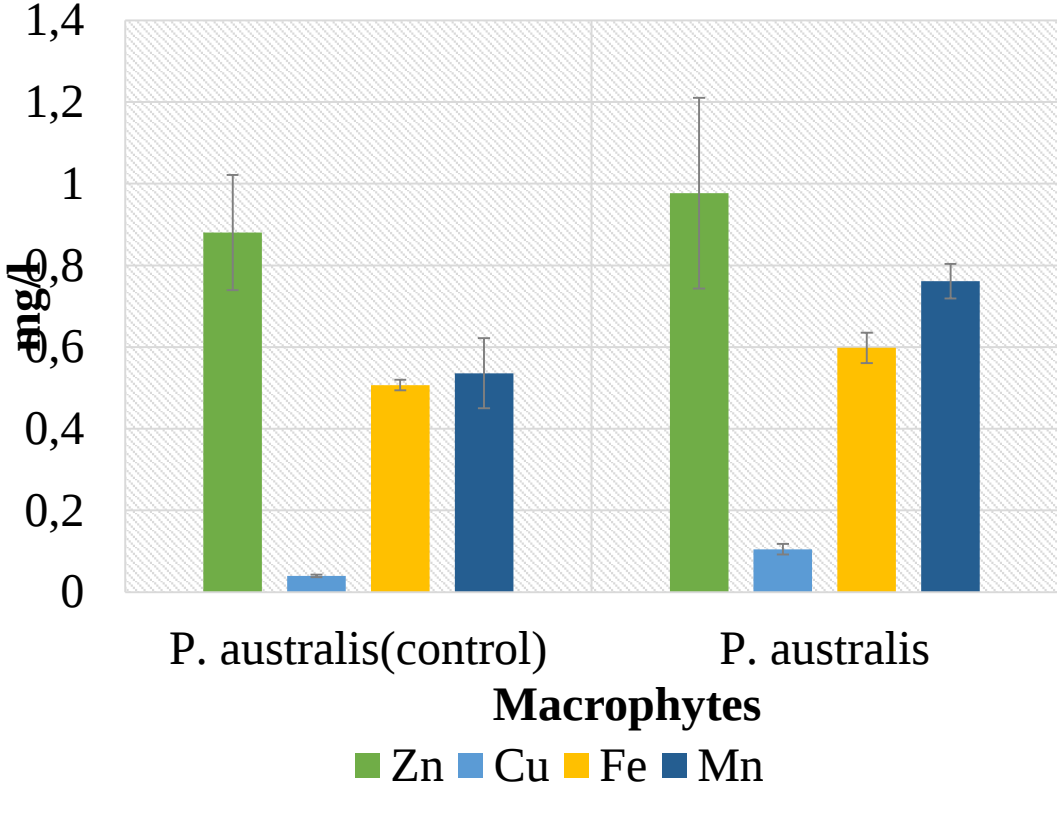
The results suggest a good performance of the pilot plant, with removal rates of heavy metals in water in the floating beds of *V. zizanioides* and *P. australis*, of Fe = 48.6%; Mn = 34.7%; Zn = 25.2%; Cu = 24.4% and Fe = 47.1%; Mn = 35.3%; Zn = 26.6%; Cu = 19.0%, respectively (Graph 1). The order of removal efficiency of the heavy metals in the water of the two floating beds is Fe> Mn> Zn> Cu.



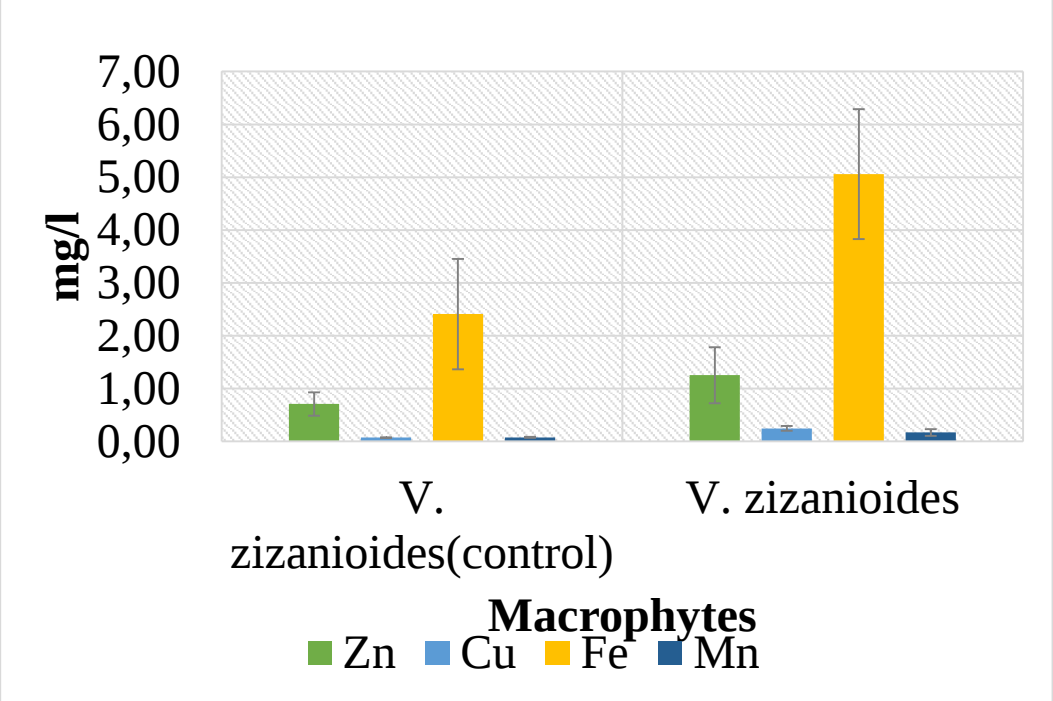
Graph 1-Relation between the concentration of heavy metals in the water in the control and in the two reservoirs in a period of 4 months.



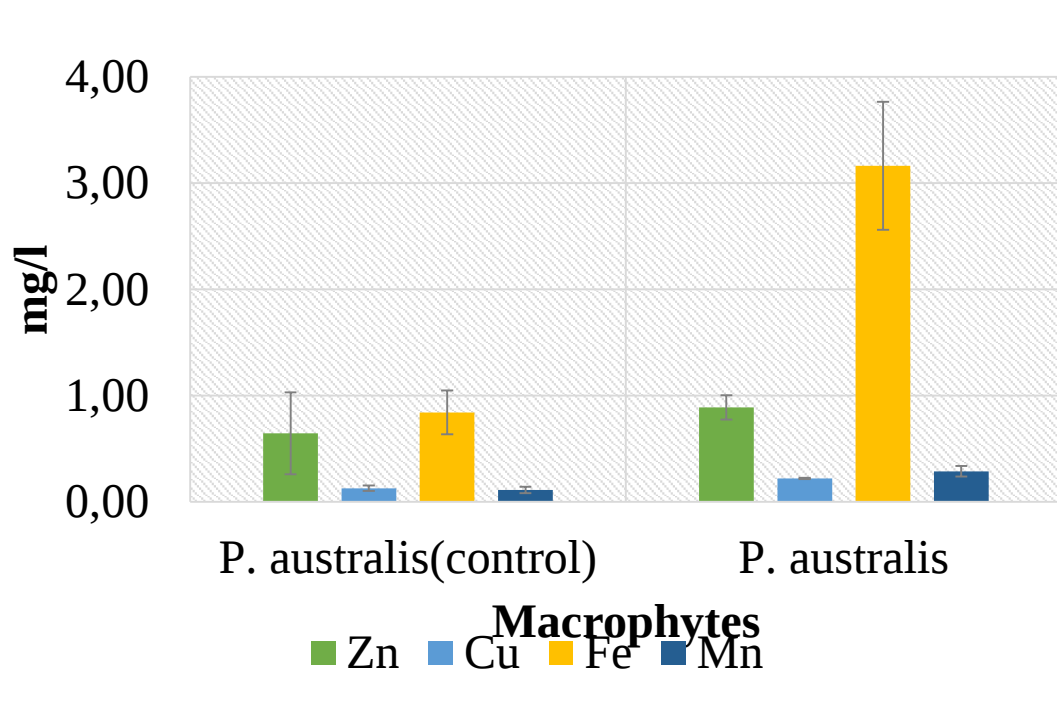
Graph 2-Evolution of the accumulation of heavy metals in the follicular part of *Vetiveria zizanioides*.



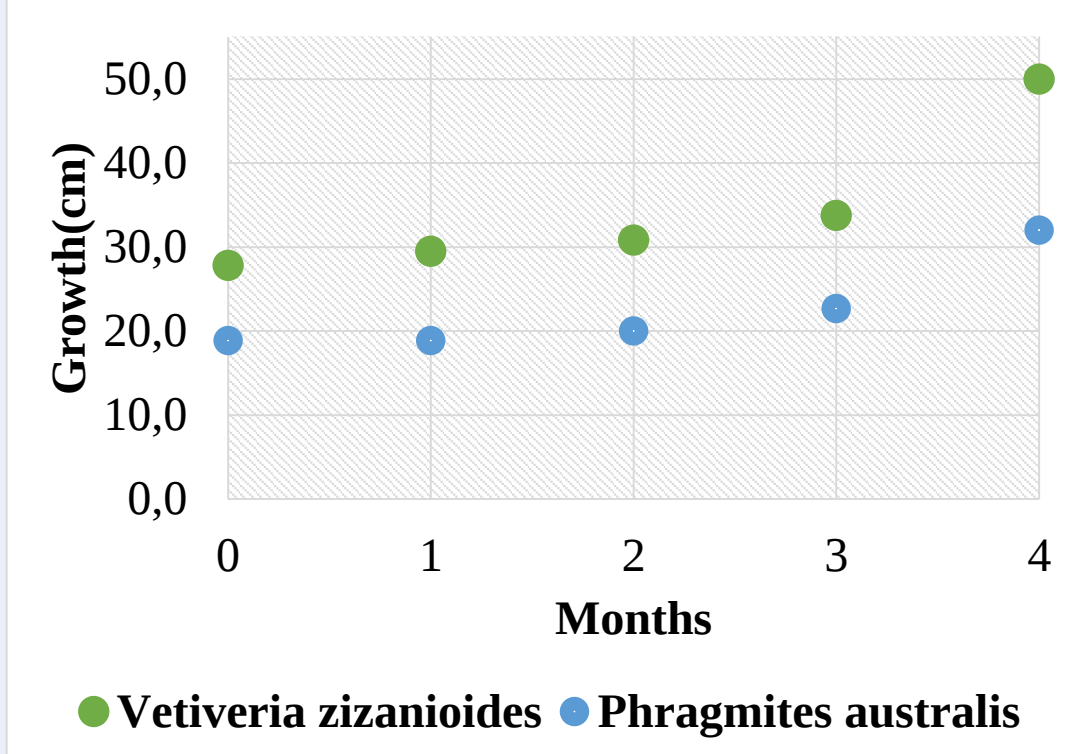
Graph 3-Evolution of the accumulation of heavy metals in the follicular part of *Phragmites australis*.



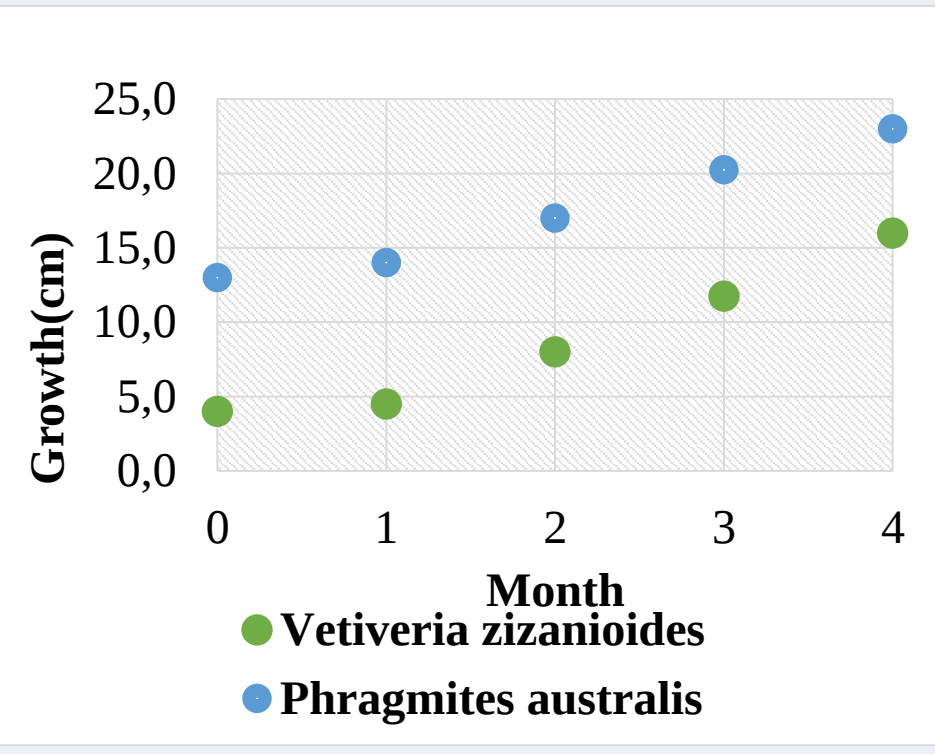
Graph 4-Evolution of the accumulation of heavy metals in the root part of *Vetiveria zizanioides*.



Graph 5-Evolution of the accumulation of heavy metals in the root portion of *Phragmites australis*.



Graph 6-Evolution of follicular growth of *Vetiveria zizanioides* and *Phragmites australis* in a period of 4 months.



Graph 7-Evolution of root growth of *Vetiveria zizanioides* and *Phragmites australis* in a period of 4 months.

The growth of *V. zizanioides* and *P. australis* in the follicular part was 2 ± 0.6 and 1.3 ± 0.43 cm / month (Graph 6) and in the root portion 2.6 ± 0.94 and 2.4 ± 0.85 cm / month (Graph 7), respectively.

The order of accumulation of heavy metals in *V. zizanioides* and *P. australis*, in the follicular part, was Zn> Fe> Mn>Cu and Zn> Mn> Fe>Cu (Graph 2 and Graph 3), respectively, and the root portion was Fe> Zn> Cu>Mn and Fe> Mn> Cu>Zn (Graph 4 and Graph 5), respectively.

Final considerations

In the monitored period of 4 months, the results suggest that the macrophytes were able to remove heavy metals contained in the water of Água Forte stream, accumulating them in the follicular and radicular part of the plant. On the other hand, the growth of the macrophytes evidences the ability to survive in waters containing AMD without the occurrence of severe damage in the external and anatomical morphology, although its growth undergoes some inhibition. It can be stated that in the long term, they can be effective in the decontamination of heavy metals in surface waters, in order to comply with the maximum recommended values (MRV) stipulated in Decree-Law no. 236/98 for irrigation.

Bibliographic references

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