THE UPTAKE OF ZINC IN PLANT SPECIES INDIGENOUS TO A PORTUGUESE POLLUTED SITE

Ana P. G. C. Marques[(1)], António O.S.S. Rangel and Paula M. L. Castro

Escola Superior de Biotecnologia, Universidade Católica Portuguesa

Rua Dr. António Bernardino de Almeida, 4200-072 Porto, Portugal

(1)amarques@mail.esb.ucp.pt

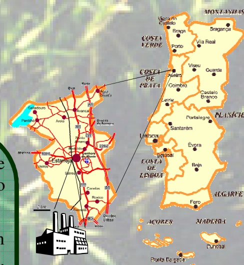


Fig.1: Location of the studied region

THE USE OF PIONNERS FOR THE PHYTOREMEDIATION OF TOXIC METAL CONTAMINATED SOILS

Pollution of the environment and the non controlled migration of metal contaminants have increased dramatically since the birth of the industrial revolution, causing serious damage on ecosystems and affecting public health. These and other reasons bring up the need for new solutions of remediation. Phytoremediation is an emergent technology that uses plants to remove, degrade or immobilize the contaminants, offering a low cost method for soil remediation.

The use of fast growing pioneer species capable of colonizing poor, contaminated soils is potentially very useful for phytoremediation strategies. Field studies are necessary to obtain information on how these indigenous plants behave under the conditions installed. The region of Estarreja appears as a strong candidate for this kind of research as for many years, several chemical facilities of the region have discharged its solid residues in an improvised park in the surrounding area, and conducted its wastewaters into a stream nearby. In spite of the levels of zinc (amongst other metals as Pb, Hg and As) remaining above the limits established by the european legislation in the sediments of this stream and of the high permeability of the soils in the area, the vegetation remains proliferous on the banks of the stream. Through an observation of the indigenous flora, two high biomass plants appear as the main colonizers: *Phragmites australis* (common reed) and *Rubus ulmifolius* (dewberries).

The aim of this study was to determine the distribuition of zinc in different sections - roots, shoots and leaves - of the selected plants and relate that to the zinc content of the soil. The mycorrhizal status of the sampled plants has also been analysed. Arbuscular mycorrhizal fungi (AMF) are a group of soil microorganisms that form symbiotic associations with the plants roots in order to improve growth and reproduction and it has been shown that they are valuable in the adaptation of plants to heavy metals contaminated sites.

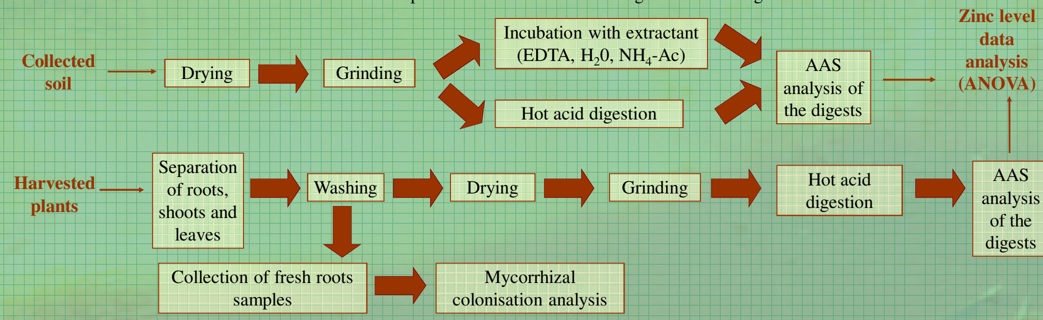
Fig.2: General view of the stream

Fig..3: Sample of *Rubus ulmifolius* collected in the area of the stream

Fig.4: General view of *Phragmites australis* present in the area of the stream

MATERIALS AND METHODS

The harvesting occurred in the spring/summer season and was distributed by seven points, separated by 10 m from each other, along the course of the stream. *R. ulmifolius* was collected from one bank and *P. australis* from the other. Adjacent soil was also collected. Samples from non metal contaminated sites were taken as controls. The samples were then treated according to the following method .



RESULTS

- No AMF were observed in any of the sampled roots; confirmation of the inexistence of AMF should me made by a sampling across the climate changes through the year.

- The soil levels of zinc in the soil were variable, ranging from 138 to 993 mg Zn/kg dry weight

- For *P.australis* the concentrations of zinc ranged from 38 to 78 ppm in the leaves, 33 to 59 ppm in the shoots and 41 to 129 ppm in the roots

-For *R. ulmifolius* Zn in the tissues ranged from 51 to 90 ppm for leaves, from 37 to 108 ppm for shoots and from 151 to 537 ppm for roots.

-For *P. australis*, positive correlations were found between Zn concentrations in the soil with all the different extractants and the zinc levels in the roots and shoots tissues.

-For *R. ulmifolius*, positive correlations were found between Zn concentrations in the soil with different extractants (with the exception of water extractable zinc) and the zinc levels in the roots and leaves tissues, with stronger correlations being shown for the roots.

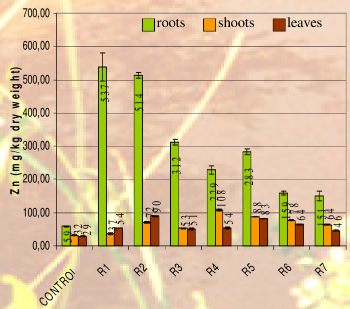


Fig. 5: Zinc concentration in the tissues of *Rubus ulmifolius* for each collection site

Table 1: Zinc concentration in the different collection sites of *Rubus ulmifolius*

Collection site	Zn (mg Zn/kg soil)			
	total	H_2O extract	EDTA extract	NH_4-Ac extract
R1	957 ± 74 [a]	0.8 ± 0.2 [ab]	87 ± 2 [a]	4 ± 0.2 [a]
R2	992 ± 30 [a]	1.1 ± 0.3 [c]	102 ± 22 [b]	12 ± 1 [b]
R3	715 ± 47 [b]	1.1 ± 0.2 [bc]	71 ± 2 [c]	12 ± 1 [b]
R4	588 ± 23 [c]	0.9 ± 0.2 [abc]	42.3 ± 0.3 [c]	3.5 ± 0.3 [a]
R5	853 ± 13 [d]	0.7 ± 0.3 [a]	42 ± 2 [cd]	10.7 ± 0.3 [c]
R6	526 ± 12 [e]	1.17 ± 0.06 [c]	29.0 ± 0.2 [d]	3. 9 ± 0.2 [a]
R7	713 ± 55 [b]	1.0 ± 0.3 [bc]	35 ± 2 [d]	2.8 ± 0.2 [d]
Rcontrol	196 ± 4 [f]	0.80 ± 0.07 [ab]	7.77 ± 0.05[e]	0.90 ± 0.07[e]

Results are expressed as means ± SD (n=3). Means in the same column with different letters are significantly different from each other (p<0.05) according to the Tukey test.

Table 3: Spearman's correlation coefficients between zinc concentration in the plant parts and in the soil

		Zn soil factors			
		total	H_2O extractable	EDTA extractable	NH_4-Ac extractable
Roots	*P. australis*	0.541 **	0.427 *	0.472 **	0.818 **
	R. ulmifolius	0.850 **	ns	0.947 *	0.779 **
Shoots	*P. australis*	0.720 **	0.795 **	0.737 *	0,489 *
	R. ulmifolius	ns	ns	ns	ns
Leaves	*P. australis*	ns	ns	ns	ns
	R. ulmifolius	0.557 **	ns	0.510 *	0.685 **

** correlation is significant at the 0.01 level; * correlation is significant at the 0.05 level; ns, no significant correlation

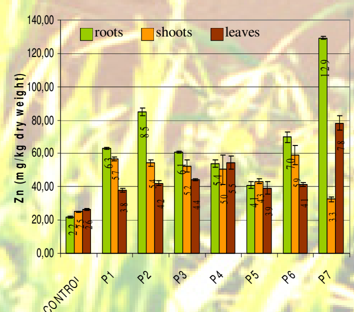


Fig. 6: Zinc concentration in the tissues of *Phragmites australis* for each collection site

Table 2: Zinc concentration in the different collection sites of *Phragmites australis*

Collection site	Zn (mg Zn/kg soil)			
	total	H_2O extract	EDTA extract	NH_4-Ac extract
P1	452 ± 24 [a]	8.0 ± 0.4 [a]	113 ± 3 [a]	20 ± 2 [a]
P2	328 ± 46 [bd]	7.8 ± 0.5 [a]	91 ± 1 [b]	14.9 ± 0.4 [b]
P3	257 ± 6 [d]	3.2 ± 0.7 [b]	57 ± 0.8 [c]	12 ± 1 [c]
P4	360 ± 34 [df]	4.7 ± 0.4 [c]	102 ± 9 [d]	12.0 ± 0.4 [c]
P5	138 ± 4 [e]	1.0 ± 0.2 [d]	36 ± 0.5 [e]	11 ± 1 [c]
P6	387 ± 44 [f]	9.2 ± 0.03 [e]	101 ± 7 [d]	27 ± 2 [d]
P7	296 ± 9 [b]	1.7 ± 0.06 [f]	67 ± 3 [f]	21 ± 1 [a]
Pcontrol	97 ± 2 [g]	1.6 ± 0.1 [f]	15 ± 2 [g]	7.5 ± 0.4 [e]

Results are expressed as means ± SD (n=3). Means in the same column with different letters are significantly different from each other (p<0.05) according to the Tukey test.

CONCLUSIONS

The present field study shows that *Rubus ulmifolius* and *Phragmites australis* colonize a heavy metal, specially zinc, contaminated site and uptake and accumulate the metal, with no visual toxicity signs.

In both species, the highest levels of zinc were always found in the roots tissues, which can be interpreted as a low metal translocation to the aboveground tissues. For this, the use of *R. ulmifolius* and *P. australis* for phytoextraction purposes does not appear as an effective method of metal removing, but these native metal tolerant plant species can be used to reduce the effects of the contamination, avoiding Zn passing into the food chain. The positive correlations between zinc levels in plant tissues and zinc concentrations in the soil indicate that Zn concentrations in plant tissues increase with the increasing concentrations of total and available metal in the soil.

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