Use of different types of plants for the uptake of contaminants

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Stressed and polluted sites

Metal uptake by local plants

Mycorrhizal fungi

- ❖ Effect of mycorrhiza → **Revegetation using different plants**
- ❖ Isolation
- ❖ Field trials

Constructed wetlands

- ❖ Different plants and growth substrates → **Wastewater treatment**

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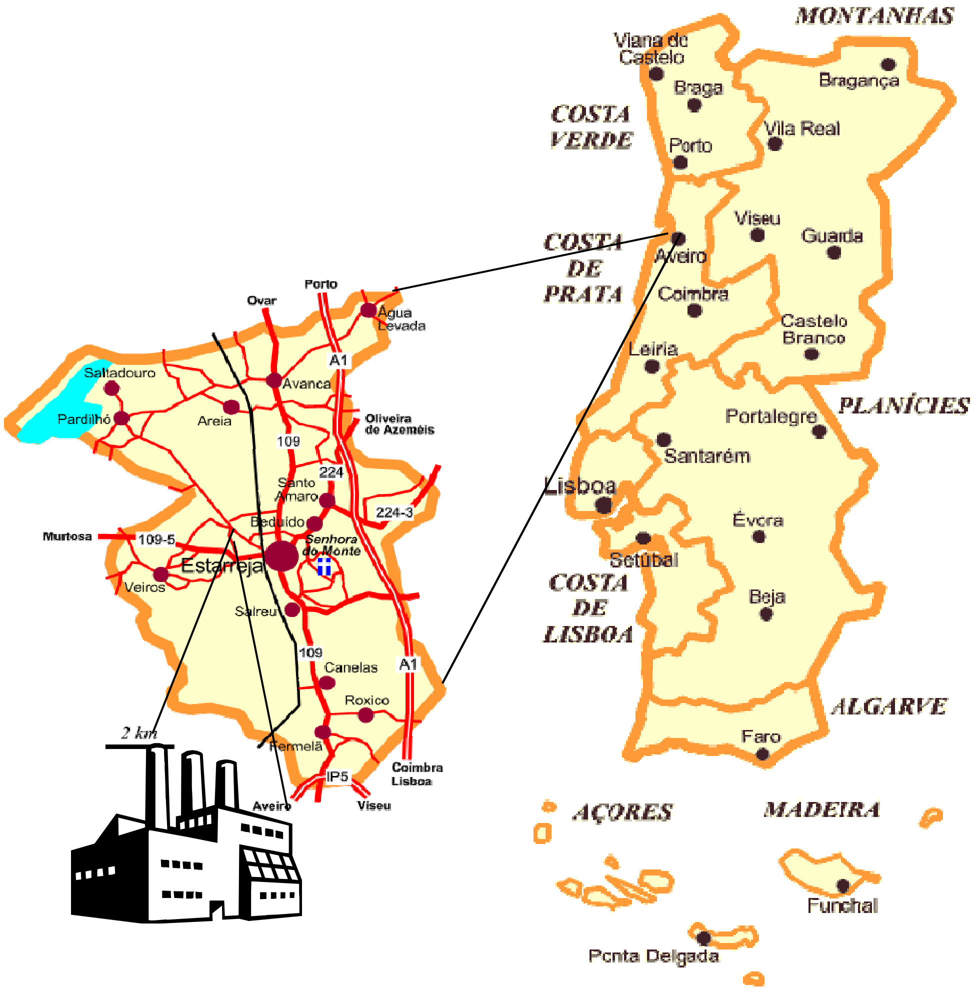
Metal uptake by plants in Estarreja

- Located in NE Portugal
- Traversed by a large stream ("Esteiro de Estarreja")- with several smaller connections
- Existence of a strong industrial complex, composed essentially by chemical facilities.



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“Esteiro de Estarreja”: Past Situation analysis

- Discharge of solid residues in the surrounding area, with consequent contamination of the aquiferous
- Conducting of the wastewaters of the factories into the stream nearby (“Esteiro de Estarreja”)
- Discharge of domestic sewer
- High permeability of the soils

Levels of heavy metals such as Pb, Zn, As and Hg, in the sediments of the stream to a depth of 50 cm, remain above the limits established by EC Directive 86/278/EC in the present

General view of the stream

Studied indigenous plants

Rubus ulmifolius

Convolvulus sp.

Phragmites australis

Solanum nigrum

a) Preliminary sampling (total plant only)

Metal / Plant	**Lead** (mg/Kg dry weight)	**Zinc** (mg/Kg dry weight)	**Arsenic** (mg/Kg dry weight)	**Mercury** (mg/Kg dry weight)
Solanum nigrum	2.6	**1130**	5.4	9.1
Rubus ulmifolius	6.0	**714**	31.2	0.5
Phragmites australis	2.7	**374**	2.9	12.7
Convolvulus sp.	2.8	**599**	2.3	1.6

Through the results of the preliminary sampling it was possible to conclude that:

The levels for **Arsenic** are moderate but not significative, with the highest value registered for ***Rubus ulmifolius***.

Lead does not seem to be significantly accumulated in any of the plants.

Mercury levels are very fickle, with the highest value registered for *Phragmites australis.*

The metal that it is being accumulated to a higher extent is **Zinc.** The plant that presents higher accumulation of this metal is ***Solanum nigrum***, with ***Rubus ulmifolius*** also presenting significant accumulation.

b) Larger sampling (soil and plant)

Taking in account the results of the first sampling, a larger extent along the stream was covered in a new plant and soil sampling of *P. australis* and *Rubus ulmifolius* in order to **establish a relation of the total and bioavailable metal levels in the soils with the concentrations in the plants** (and possible colonisation by arbuscular mycorrhizal fungi)

Sample	Mycorrhizal Fungi colonisation	Zn in soil (mg/Kg dry weight)	Zn in plant (mg/Kg dry weight)		
			root	shoot	leaf
R. ulmifolius	Not found	526 - 993	151 - 537	53 - 108	46 - 90
P. australis	Not found	138 - 452	41 - 129	43 - 59	38 - 55

Solanum nigrum experiments

After the analysis of the potential of *S. Nigrum* through the observation of the results of the first sampling, a set of experiments was planned using this plant.

1) Toxicity tests using a sand matrix with different metal concentrations and nutrition conditions (and comparison with a toxicity test model plant)

2) Growth experiments with *S. nigrum* plants submitted to several Zn concentrations and inoculated with 4 isolates of arbuscular mycorrhizal fungi and mixed inocula (on-going study)

1) Toxicity tests

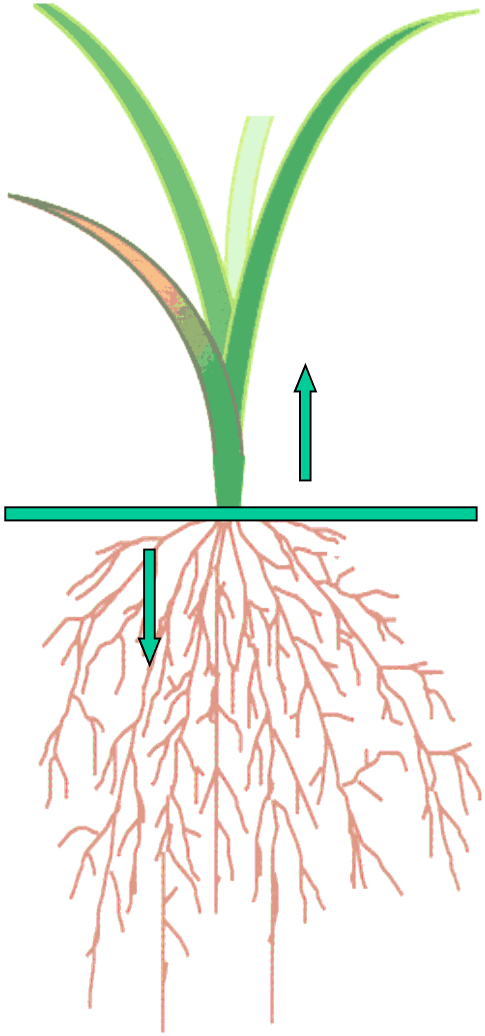
Metal	Plant	Nutrition	EC_{10}	EC_{50}
Zn	*Trifolium incarnatum*	none	3.9	5.3
		Hoagland solution	2.9	4.8
	Solanum nigrum	none	3.8	6.5
		Hoagland solution	4.9	8.0
Pb	*Trifolium incarnatum*	none	3.5	5.0
		Hoagland solution	2.8	4.6
	Solanum nigrum	none	6.8	11.9
		Hoagland solution	3.8	6.5
As	*Trifolium incarnatum*	none	4.4	5.2
		Hoagland solution	0.4	1.3
	Solanum nigrum	none	8.4	11.3
		Hoagland solution	1.6	6.9

Values in table expressed in mg metal / kg sand.
EC50 and EC10 are the effective matrix concentrations causing 50% and 10% inhibition of seed germination, respectively.

2) Experiment with Arbuscular mycorrhizal fungi

Arbuscular mycorrhizal fungi

- Group of soil microorganisms
- Form symbiotic associations with plants roots
- Improve plant growth and reproduction
- Capture mineral nutrients from soil
- Receive carbohydrates from associated plants
- May influence heavy metal uptake



Growth experiments with *Solanum nigrum:*

- plants submitted to several Zn concentrations (100, 500, 1000 ppm) in a sand matrix

- plants growing in contaminated soil from the banks of "Esteiro de Estarreja"

- inoculated with 4 isolates of arbuscular mycorrhizal fungi and mixed inocula (on-going study)

Aims of the study

- ✓ Determination of the Zn level present in the artificially prepared and naturally polluted soils
- ✓ Determination of the Zn accumulation in different parts of the plant (root, shoot and leaves) for the different metal exposure conditions
- ✓ Determination of the effect of arbuscular mycorrhizal fungi on metal uptake and plant growth under different Zn levels

Relation of the metal levels in the soils with the concentrations in the plants and its colonization by different arbuscular mycorrhizal fungi

Constructed wetlands

Case Study:

- Wastewater from a leather company
- High organic loading

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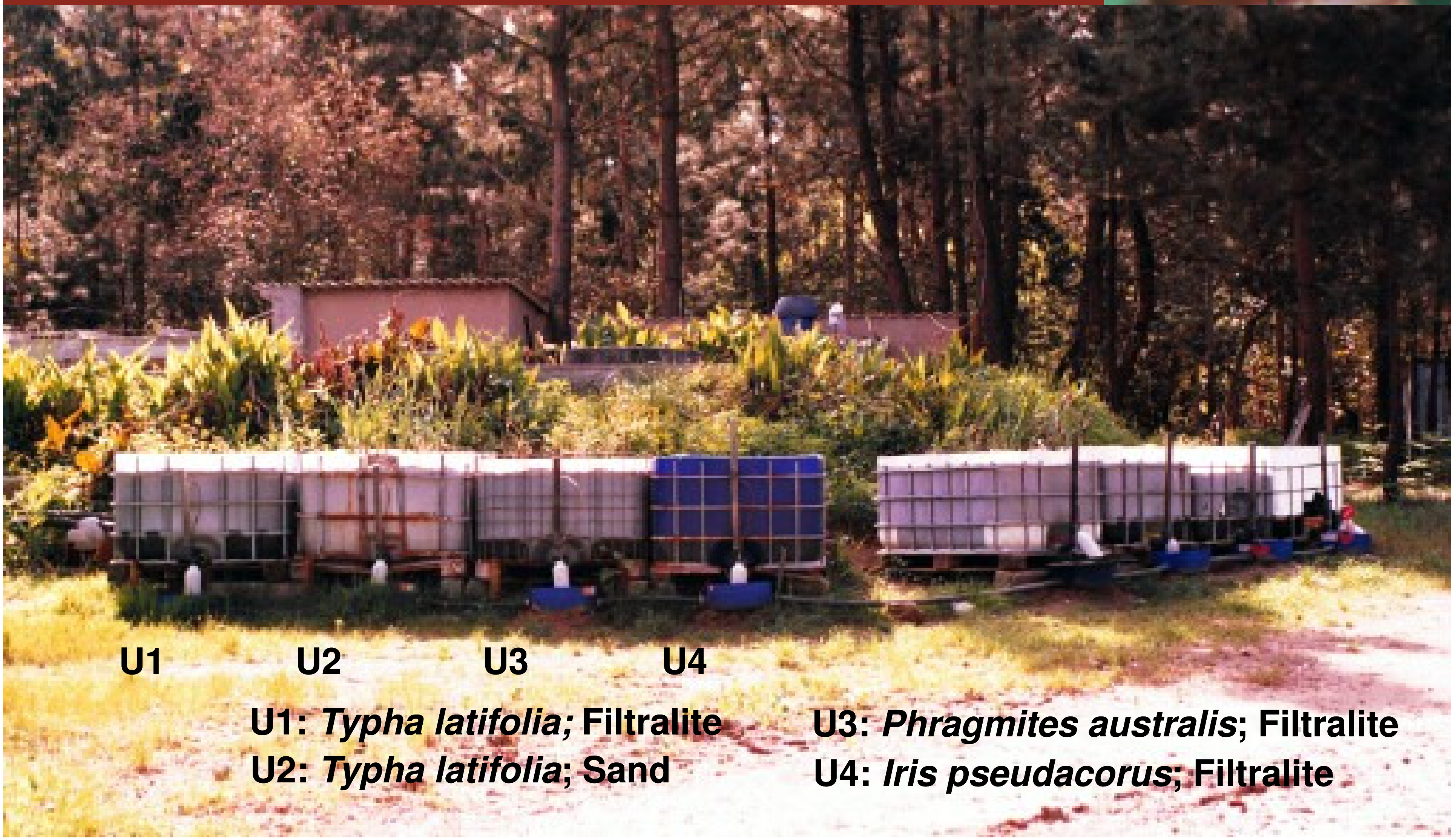
Pilot-Scale Units



U1: *Typha latifolia;* Filtralite

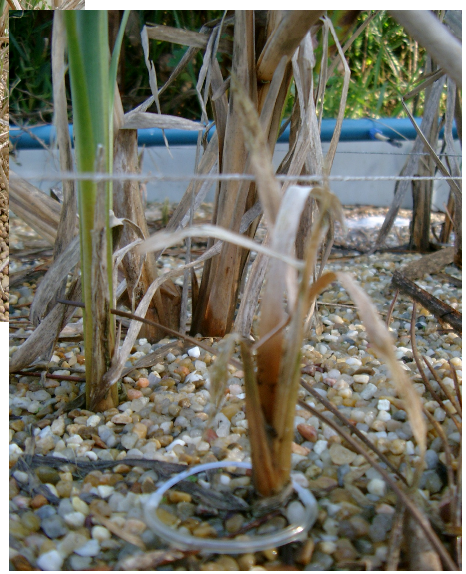
U2: *Typha latifolia*; Sand

U3: *Phragmites australis*; Filtralite

U4: *Iris pseudacorus*; Filtralite

Plant species

Typha latifolia
(cattail)



***Typha latifolia* (cattail)**

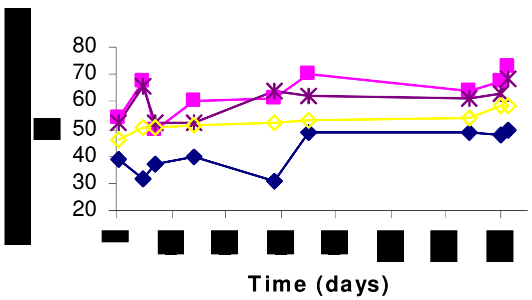
Iris pseudacorus

Phragmites australis
(common reed)

Removal efficency for different organic loading rates in each pilot unit

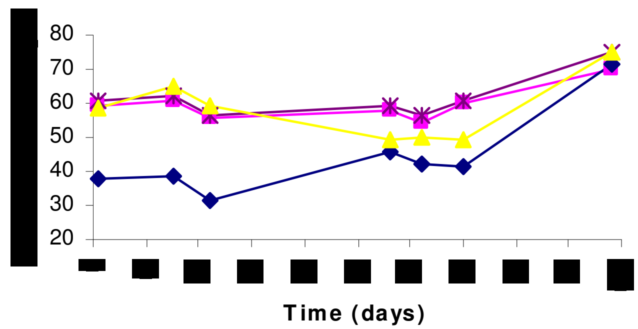
Hidraulic loading rate= 43mm/d

Organic loading rate= 497KgCODha^{-1}d^{-1}



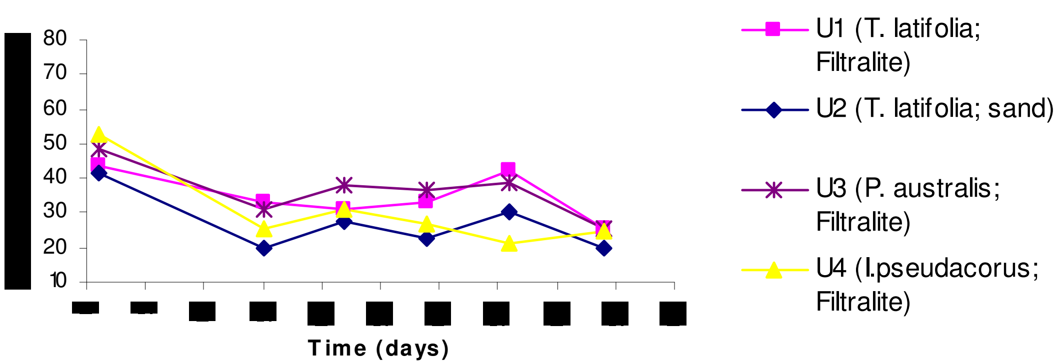
Hidraulic loading rate= 86.4 mm/d

Organic loading rate= 1278 KgCODha^{-1}d^{-1}



Hidraulic loading rate= 259 mm/d

Organic loading rate= 2843 KgCODha^{-1}d^{-1}



Considerations

- The mortality of the plants during the establishment of the pilot units was considerable
- The sand substract with *Typha latifolia* was found to be the one for which the removal efficency (in terms of organic loading) was lower
- Between the the pilot units with Filtralite substrate, the ones with *Typha latifolia* and *Phragmites australis* were the most effective in terms of removal efficiency (organic loading)
- More studies are going to be undertaken concerning the pilot units

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