

SURVEY OF THE HEAVY METAL ACCUMULATION ABILITIES OF PLANT SPECIES INDIGENOUS TO A METAL POLLUTED REGION IN PORTUGAL

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THE AREA OF ESTARREJA AS A PROLIFIC SITE FOR THE SURVEY OF PLANTS WITH PHYTOREMEDIATION POTENTIAL

Soil contamination by heavy metals (HM) poses major environmental problems worldwide with serious damages on ecosystems and public health. Phytoremediation may offer a low cost method for the remediation of these HM contaminated soils. The search for plants adapted to metal-stressful field conditions may be an adequate approach to find species with the capacity to be applicable in further phytoremediation strategies. The region of Estarreja (Figure 1) is known for its strong industrial complex, composed essentially by chemical facilities. For many years, several of these industries have discharged its solid residues in improved parks in the surrounding area, and conducted its wastewaters into the streams nearby.

The levels of heavy metal contamination, specially Zn, in the soils, water and sediments of the area are above the limits established by EC Directive 86/278/EC. The contamination distribution is very heterogeneous. Nevertheless, in the areas surrounding these industrial zones the vegetation remains proliferous. The purpose of this study was to identify plant species indigenous to the site and to determine their ability to uptake these heavy metals.

The harvesting of plant samples occurred in the summer and winter seasons and was distributed by four locations – A, B, C, and D (Figure 2) – near known contamination sources of discharge, where the species present at a larger extent were chosen at each time. Zn levels were assessed for these samples and maximum levels for the plant's roots (R) and aboveground (AG) tissues are shown; several species showed accumulations higher than the levels established as phytotoxic (> 500 mg Zn kg⁻¹) – values highlighted in color in Figure 2.



Fig.1: Location of the studied region

Site B – At the border of the industrial complex



Agrostis castellana
- Found in the summer
- R: 388 mg Zn kg⁻¹
- AG: 243 mg Zn kg⁻¹



Cyperus eragrostis
- Found in the summer
- R: 145 mg Zn kg⁻¹
- AG: 46 mg Zn kg⁻¹



Phalaris arundinacea
- Found in the summer
- R: 107 mg Zn kg⁻¹
- AG: 293 mg Zn kg⁻¹



Atriplex prostrata
- Found in the summer
- R: 941 mg Zn kg⁻¹
- AG: 1687 mg Zn kg⁻¹



Juncus effusus
- Found in the winter and in the summer
- R: 914 mg Zn kg⁻¹
- AG: 418 mg Zn kg⁻¹

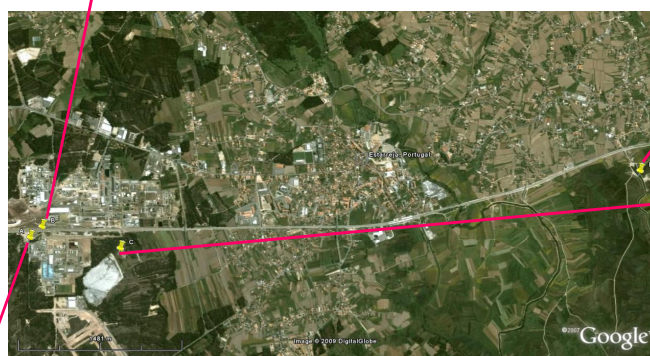


Fig.2: Location of the sampling regions and plants collected at each site

Site D - Esteiro de Estarreja

For several years the non-treated wastewaters of the industrial complex have been directed to this stream.



Convolvulus sp.
- Found in the summer
- R: 324 Zn kg⁻¹
- AG: 34 mg Zn kg⁻¹



Solanum nigrum
- Found in the winter and in the summer
- R: 1130 mg Zn kg⁻¹
- AG: 263 mg Zn kg⁻¹



Pteridium aquilinum
- Found in the winter
- R: 206 mg Zn kg⁻¹
- AG: 75 mg Zn kg⁻¹



Rubus ulmifolius
- Found in the winter and in the summer
- R: 537 mg Zn kg⁻¹
- AG: 108 mg Zn kg⁻¹



Phragmites australis
- Found in the winter and in the summer
- R: 130 mg Zn kg⁻¹
- AG: 78 mg Zn kg⁻¹

Site C – Sludge deposit

For many years the sludge residues of polymer production at the industrial complex have been discharged at this site, resulting in a contaminated area of ca.10 ha with pH=12.



Apium nodiflorum
- Found in the winter
- R: 229 mg Zn kg⁻¹
- AG: 257 mg Zn kg⁻¹



Aster squamatus
- Found in the winter
- R: 262 mg Zn kg⁻¹
- AG: 88 mg Zn kg⁻¹



Salix atrocinerea
- Found in the winter
- R: 160 mg Zn kg⁻¹
- AG: 275 mg Zn kg⁻¹

Site A – Wastewater discharge point

Former point of discharge of non-treated wastewaters resulting from the production in the industrial complex.



Agrostis stolonifera
- Found in the summer
- R: 206 mg Zn kg⁻¹
- AG: 176 mg Zn kg⁻¹



Conyza bonariensis
- Found in the summer
- R: 217 mg Zn kg⁻¹
- AG: 247 mg Zn kg⁻¹



Cyperus eragrostis
- Found in the summer
- R: 193 mg Zn kg⁻¹
- AG: 193 mg Zn kg⁻¹



Conyza bilbaosana
- Found in the summer
- R: 73 mg Zn kg⁻¹
- AG: 355 mg Zn kg⁻¹



Epilobium tetragonum
- Found in the summer
- R: 231 mg Zn kg⁻¹
- AG: 334 mg Zn kg⁻¹



Spargularia capillacea
- Found in the winter
- R: 2922 mg Zn kg⁻¹
- AG: 383 mg Zn kg⁻¹



Verbascum virgatum
- Found in the summer
- R: 95 mg Zn kg⁻¹
- AG: 784 mg Zn kg⁻¹



Hypochaeris radicata
- Found in the summer
- R: 119 mg Zn kg⁻¹
- AG: 640 mg Zn kg⁻¹



Conyza sumatrensis
- Found in the summer and in the winter
- R: 394 mg Zn kg⁻¹
- AG: 517 mg Zn kg⁻¹



Hirschfeldia incana
- Found in the summer and in the winter
- R: 298 mg Zn kg⁻¹
- AG: 442 mg Zn kg⁻¹



Holcus lanatus
- Found in the summer
- R: 1479 mg Zn kg⁻¹
- AG: 481 mg Zn kg⁻¹



Calluna vulgaris
- Found in the summer
- R: 127 mg Zn kg⁻¹
- AG: 63 mg Zn kg⁻¹



Lycopodium europaeus
- Found in the summer
- R: 289 mg Zn kg⁻¹
- AG: 418 mg Zn kg⁻¹



Digitalis purpurea
- Found in the summer and in the winter
- R: 233 mg Zn kg⁻¹
- AG: 226 mg Zn kg⁻¹



Paspalum urvillei
- Found in the winter
- R: 897 mg Zn kg⁻¹
- AG: 425 mg Zn kg⁻¹

RELATION OF METAL ACCUMULATION IN THE INDIGENOUS PLANT SPECIES WITH THE PRESENCE OF AMF

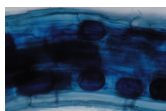


Fig.3. Example of root colonisation by AMF

Plant development in toxic environments can be influenced by soil microorganisms that associate with plant roots to form the rhizosphere community, namely arbuscular mycorrhizal fungi (AMF) - a group of soil organisms that form symbiotic associations with the majority of land plants – which hamper plant survival, growth and reproduction in disturbed ecosystems. However, few of the collected species have shown presence of AMF (example of root colonisation status in Figure 3), as seen in Table 1.

Table 1. Maximum percent colonisation of species showing AMF presence

Plant Species	Percent colonisation (%)	Collection site
<i>Pteridium aquilinum</i>	39	D
<i>Conyza bilbaosana</i>	30	A
<i>Digitalis purpurea</i>	40	A
<i>Conyza sumatrensis</i>	42	A
<i>Paspalum urvillei</i>	47	A
<i>Aster squamatus</i>	69	B

RELATION OF METAL ACCUMULATION IN THE INDIGENOUS PLANT SPECIES WITH METAL LEVELS IN THE SOILS

Ongoing work includes the assessment of the levels of Zn in the soil samples collected from the rhizosphere of the plants, and further soil properties in order to:

- relate the metal accumulation and dispersion abilities of the selected plant species to the total metal content of the soil;
- investigate possible relations between plant accumulation and the soil water, available and exchangeable Zn fractions;
- assess the interactions of the metal uptake by the plants and soil pH, humidity, organic matter content and nutrient levels.

EVALUATION OF THE POTENTIAL APPLICATION IN SOIL PHYTOREMEDIATION OF THE INDIGENOUS SPECIES