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Zinc Accumulation in Plant Species from a Contaminated Portuguese Site

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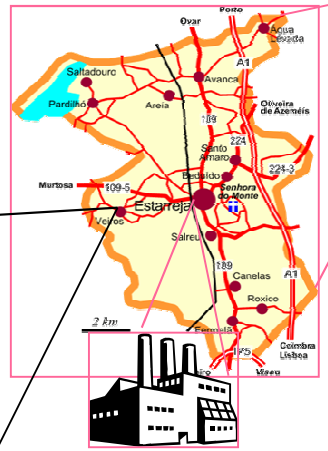
Aims

Site-specific constraints can render the known- to-date species used for phytoremediation inadequate

Enlargement of the data concerning plant species valuable for phytoremediation

Plant screening in contaminated sites can lead to the identification of further species of interest

Investigation of the potential for phytoremediation of plants indigenous to a historically HM contaminated site: Estarreja



Study Site Description

✓ **Discharge of solid residues directly to the soil in the surrounding area, with its consequent contamination;**

✓ **Conducting of the wastewaters of the factories into the nearby watercourses;**

➢ **HM reach hazardous levels;**

➢ **Zn appears as one of the main contaminants** (further attention should be given to As and Pb)

Despite this, vegetation remains prolific

Methods - Survey Location

Wastewater discharge point	Industrial complex border	Sludge deposit*	Esteiro de Estarreja
A	B	C	D

*10-ha dry sedimentation pond deposit resulting from the production of polyvinylchloride over a 25-year period

Methods

Selection of the spots

Plants and soil from its rooting zone were collected in cold (autumn/winter) and flowering (spring/summer) season

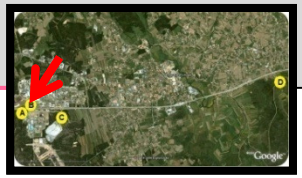
Soil

- ✓ N and P
- ✓ pH
- ✓ Water content
- ✓ Organic matter (OM);
- ✓ Total, available and extractable Zn

Plants

- ✓ Identification,
- ✓ Zn levels in roots and shoots
- ✓ AMF colonisation
- ✓ Bioconcentration factor (BCF) and Translocation factor (TF)

Results



Site A – Wastewater discharge point

Agrostis stolonifera
Found in the summer and in the winter

Calluna vulgaris
Found in the summer

Conyza bilbaoana
Found in the summer

Conyza bonariensis
Found in the summer

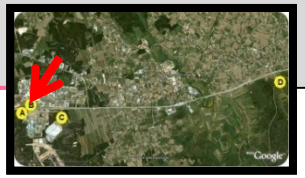
Conyza sumatrensis
Found in the summer and in the winter

Cyperus eragrostis
Found in the summer

Digitalis purpurea
Found in the sumer and in the winter

Epilobium tetragonum
Found in the sumer

Results



Site A – Wastewater discharge point

Hirschfeldia incana
Found in the sumer and in the winter

Holcus lanatus
Found in the summer

Hypochoeris radicata
-Found in the summer

Lycopus europaeus
-Found in the sumer and in the summer

Paspalum urvillei
-Found in the winter

Spergularia capillacea
-Found in the winter

Verbascum virgatum
Found in the summer

Results

Site B – Industrial complex border

Agrostis castellana
Found in the summer

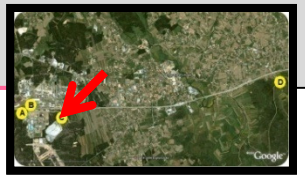
Atriplex prostrata
-Found in the winter

Cyperus eragrostis
-Found in the summer

Juncus effusus
-Found in the winter and
in the summer

Phalaris arundinacea
-Found in the summer

Results



Site C – Sludge deposit

Aster squamatus
-Found in the winter

Apium nodiflorum
-Found in the winter

Salix atrocinerea
-Found in the winter

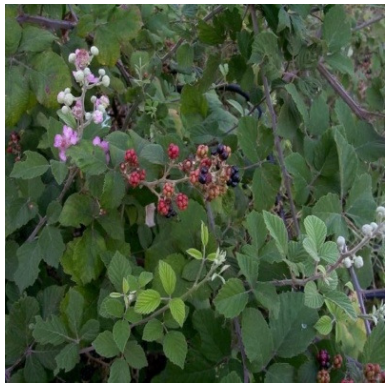
Results

Site D – Esteiro de Estarreja

Convolvulus sp.
-Found in the summer

Phragmites australis
-Found in the winter and in the summer

Pteridium aquilinum
-Found in the summer



Rubus ulmifolius
-Found in the winter and in the summer

Solanum nigrum
-Found in the winter and in the summer

Results/Discussion

Plant diversity

✓A total of 26 plant species was found growing in the area (some show seasonality, with clear higher abundance in spring/summer season);

✓Some of the collected plants have been reported growing in other contaminated areas (*H. radicata*, *V. virgatum*, *A. squamatus, H. lanatus*, *S. nigrum,* eg.);

✓Zn content in the plant tissues was frequently found to be above those considered as normal levels - ***10 to 100*** **mg.Kg^{-1}** (Frisberg et al, 1986) and many even show phytotoxic levels – ***500 to 1500*** **mg.Kg^{-1}** (Chaney, 1989):

Winter	ranging from **34 mg Kg^{-1}** in *Convolvulus* sp. shoots to **2440 mg Kg^{-1}** in *Spergularia capillacea* roots
Summer	ranging from **35 mg Kg^{-1}** in *Cyperus eragrostis* shoots to **1503 mg Kg^{-1}** for *Atriplex prostrata* shoots

Results/Discussion

Site A – Wastewater discharge point

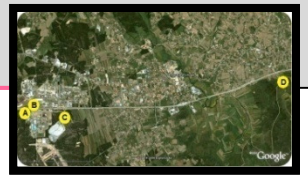


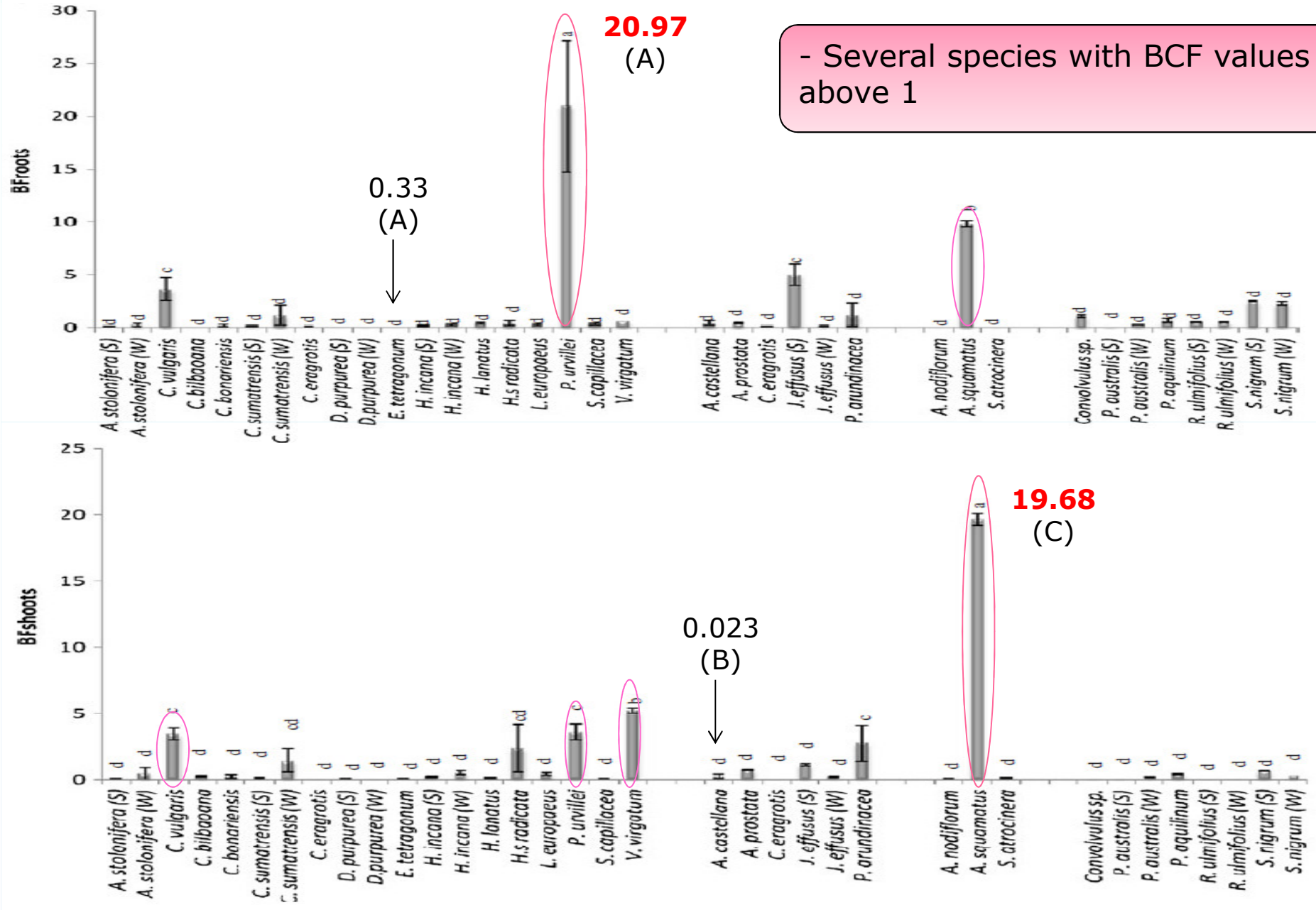
Table 1: Zn levels in shoots and roots (mg·kg^{-1})

Plants collected (family)	Family	Life cycle	Life form	Spring/summer		Autumn/winter	
				Shoots	Roots	Shoots	Roots
A							
Holcus lanatus L.	Poaceae	PE	HE	383±117 ^{efg}	1,300±205 ^{*b}	n.f.	n.f.
Hypochaeris radicata L.	Asteraceae	AN/PE	HE	589±90 ^{c}	112±9 ^{*fgh}	n.f.	n.f.
Paspalum urvillei Steud.	Poaceae	PE	HE	128±12 ^{mnopq}	697±180 ^{*de}	n.f.	n.f.
Spergularia capillacea (Kindb.) Willk.	Caryophyllaceae	AN/PE	HE	n.f.	n.f.	354±29 ^{efgh}	2,440±557 ^{*a}
Verbascum virgatum Stokes	Scrophulariaceae	PE	HE	707±109 ^{b}	85±15 ^{*gh}	n.f.	n.f.
B							
Atriplex prostrata Boucher ex DC.	Chenopodiaceae	AN	BU	1,503±219 ^{a}	889±46 ^{*cd}	n.f.	n.f.
C							
Aster squamatus (Spreng.) Hieron.	Asteraceae	PE	HE	525±35 ^{cd}	262±20 ^{*fgh}	n.f.	n.f.
D							
Solanum nigrum L.	Solanaceae	AN	HE	280±16 ^{ghijkl}	1,079±27 ^{*c}	128±7 ^{mnopq}	1,079±27 ^{*c}

Results/Discussion

Bioconcentration Factor
(plant section/soil)

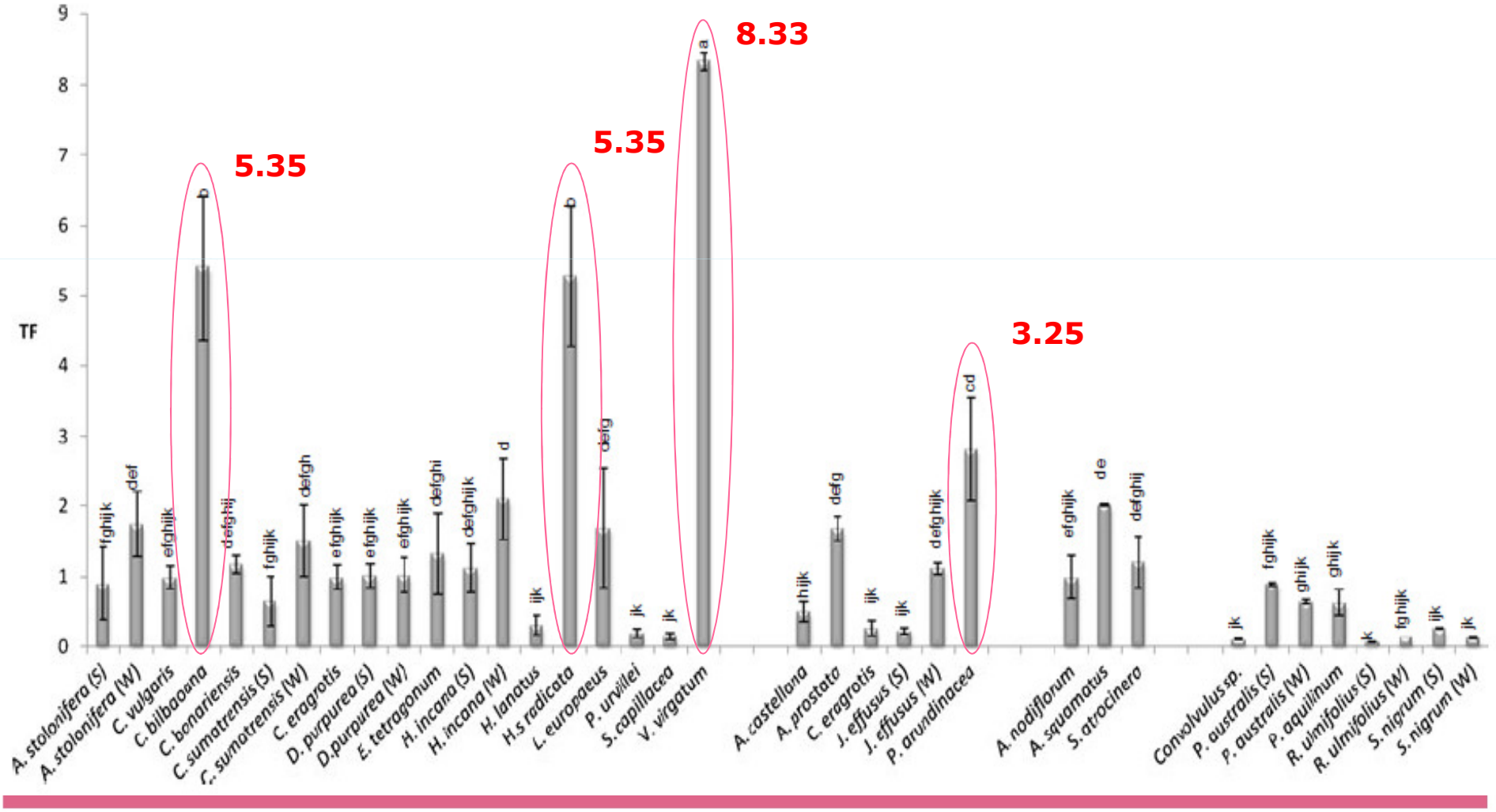
- Several species with BCF values above 1



Results/Discussion

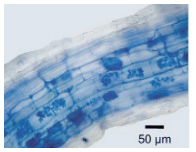
Translocation Factor
(Shoot/root)

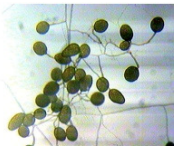
- Several species with TF values above 1;
- 4 species with significantly higher factors



Results/Discussion

Mycorrhization coverage



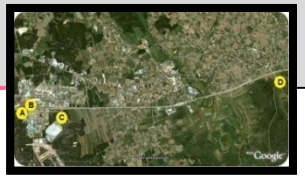


✓ 8 species - 26%

Plant Species	Percent colonisation (%)	Collection site
Aster squamatus	69±1	C
Paspallum urvillei	47±4	A
Pteridium aquilinum	39±1	D
Digitalis purpurea	37±2 (Summer)/31±3 (Winter)	A
Conyza sumatrensis	16±1 (Summer)/22±3 (Winter)	A
Epilobium tetragonum	22±6	A
Hirschfeldia incana	34±5	A
Conyza bilbaoana	27±3	A

Low – 90 to 95% of land plants form some type of mycorrhizal associations (mostly AMF)

Results/Discussion



Soil

Location	Total Zn (mg Kg^{-1})	N/P (mg Kg^{-1})	pH	OM
A	38 to **7023**	15 to 244/ 14 to 710	6.35	3.3 to 43.2
B	102 to 2139	27 to 142/ 34 to 446	6.03	1.9 to 40
C	27 to 3796	12 to 37/ 29 to 42	7.15	0.9 to 38.9
D	298 to 992	2233 to 3959/ 9 to 259	6.62	8.2 to 15.4

High (values of 70 to 400 are already toxic to plants)

Low

Slightly acidic: favours bioavailability

Low

Conclusions

- No correlation was found between mycorrhization and metal accumulation;
- None of the collected plants was a hyperaccumulator - ↙10000 $mg \cdot kg^{-1}$ at roots or shoots (Baker et al, 2000);
- ***V. virgatum***, ***H. radicata***, ***C. bilbaoana***, ***P. urvillei*** and ***A. squamatus*** with higher Zn shoot accumulation, bioconcentration and translocation;





Phytoextraction

- ***S. capillacea*** – tolerant plant (excluded the metal from the aboveground tissues and concentrate it at the root zone to very high levels).

Phytostabilisation