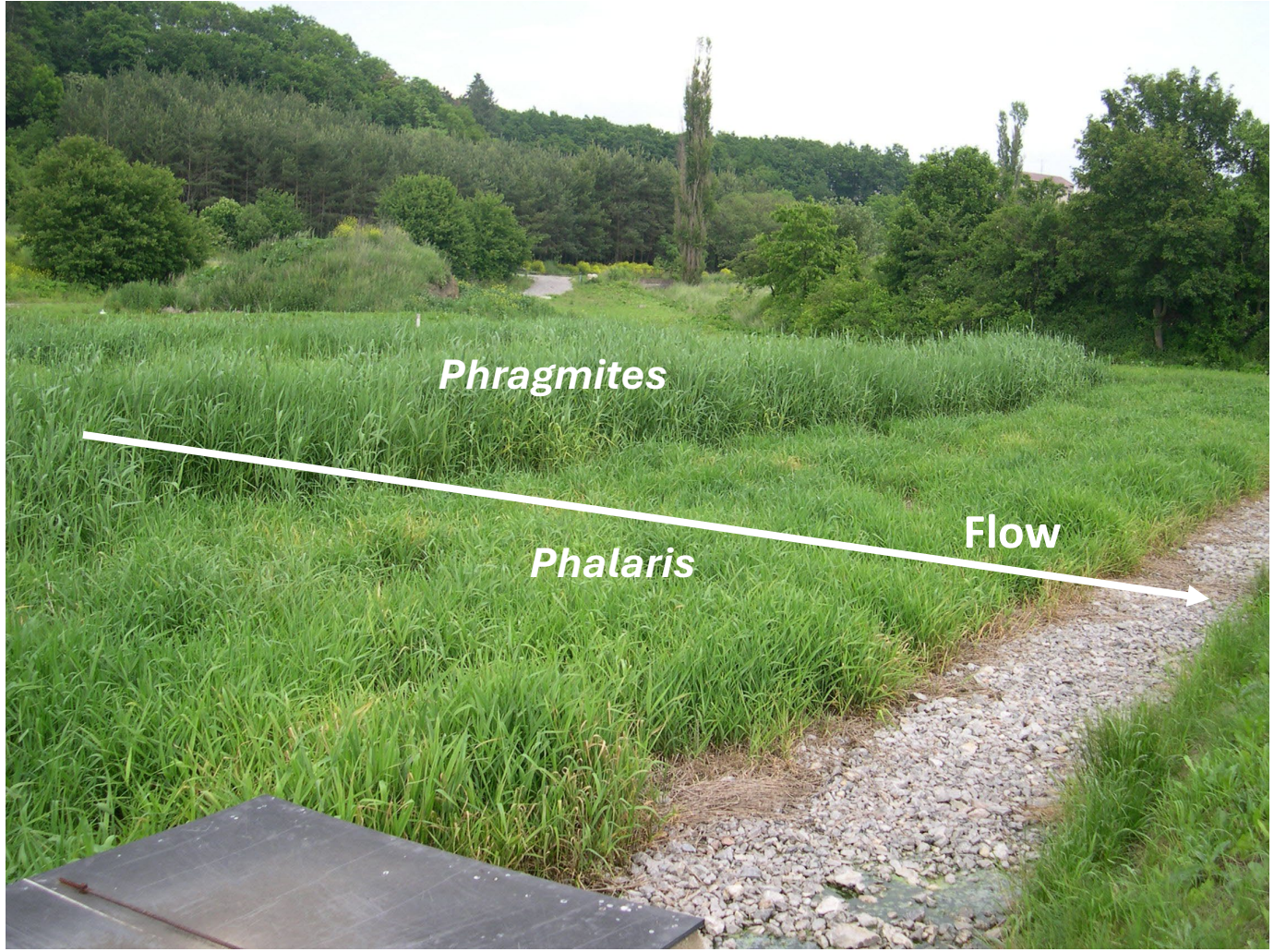
# Distribution of heavy metals in plants growing in constructed treatment wetlands

Jan Vymazal, Tereza Dvořáková Březinová
*Czech University of Life Sciences Prague*
Lenka Kröpfelová
*ENKI, o.p.s. Třeboň, Czech Republic*

# Objectives

To evaluate the distribution of heavy metals in above- and belowground biomass of plants growing in constructed wetlands treating municipal sewage

# Study sites

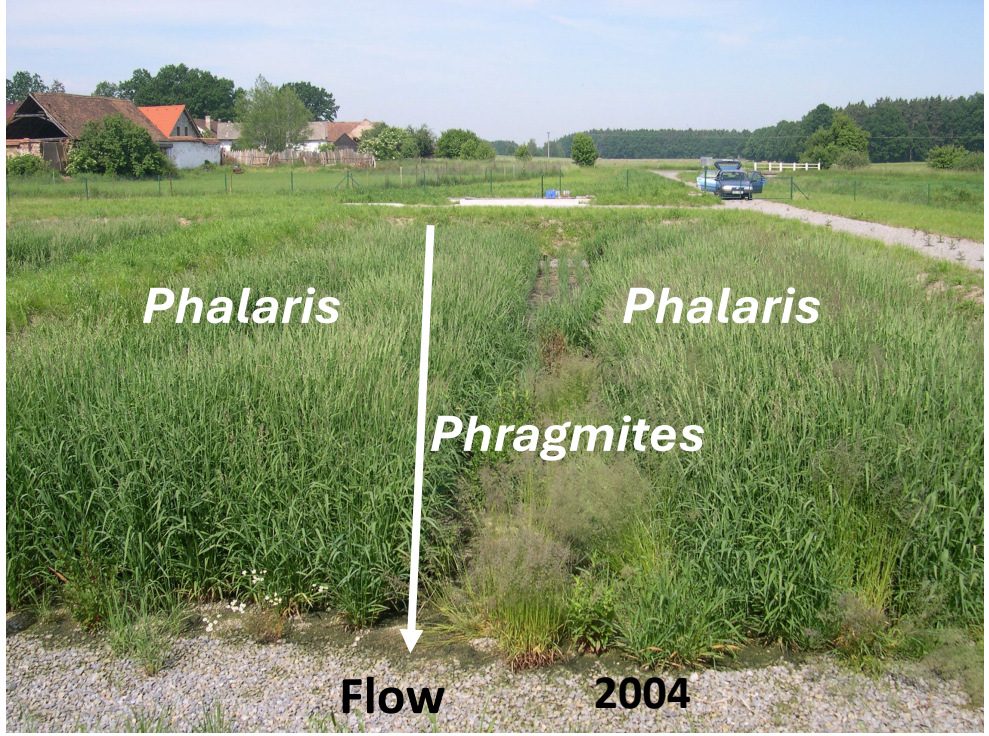


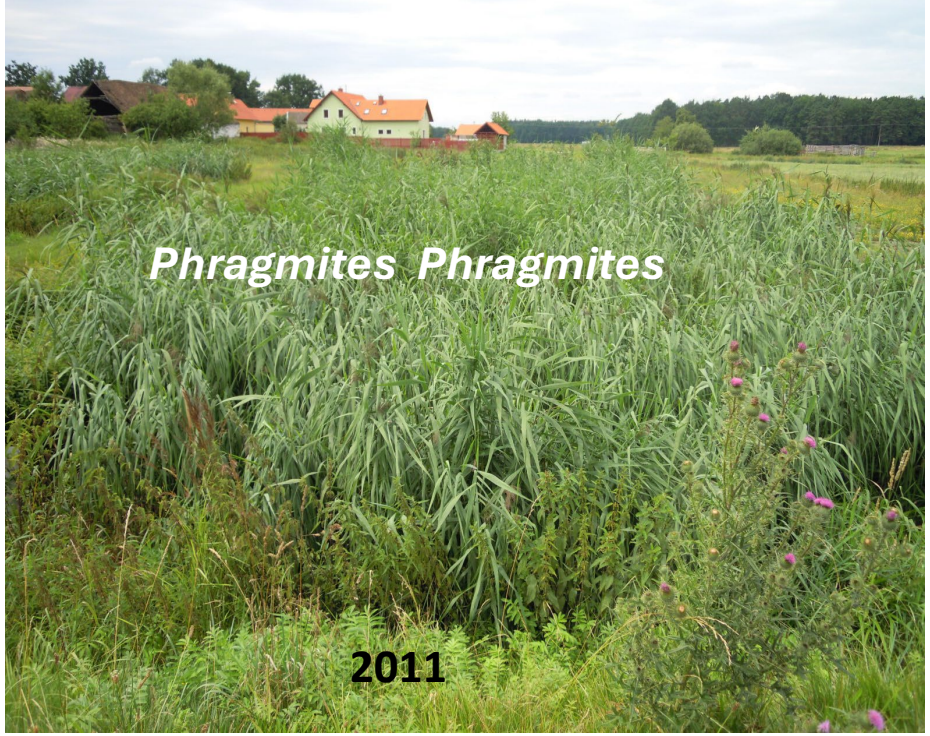

## CW Mořina

**Start of operation: 2000 Area: 3 520 (4 beds) PE: 700**

***Phragmites australis* and *Phalaris arundinacea* (bands perpendicular to flow)**

**Sampling: 2002, 2004, 2006, 2007, 2008, 2014**




## CW Břehov

**Start of operation: 2003 Area: 504 m² (2 beds) PE: 100**

***Phragmites australis*** **and** ***Phalaris arundinacea*** **in bands (parallel with water flow)**

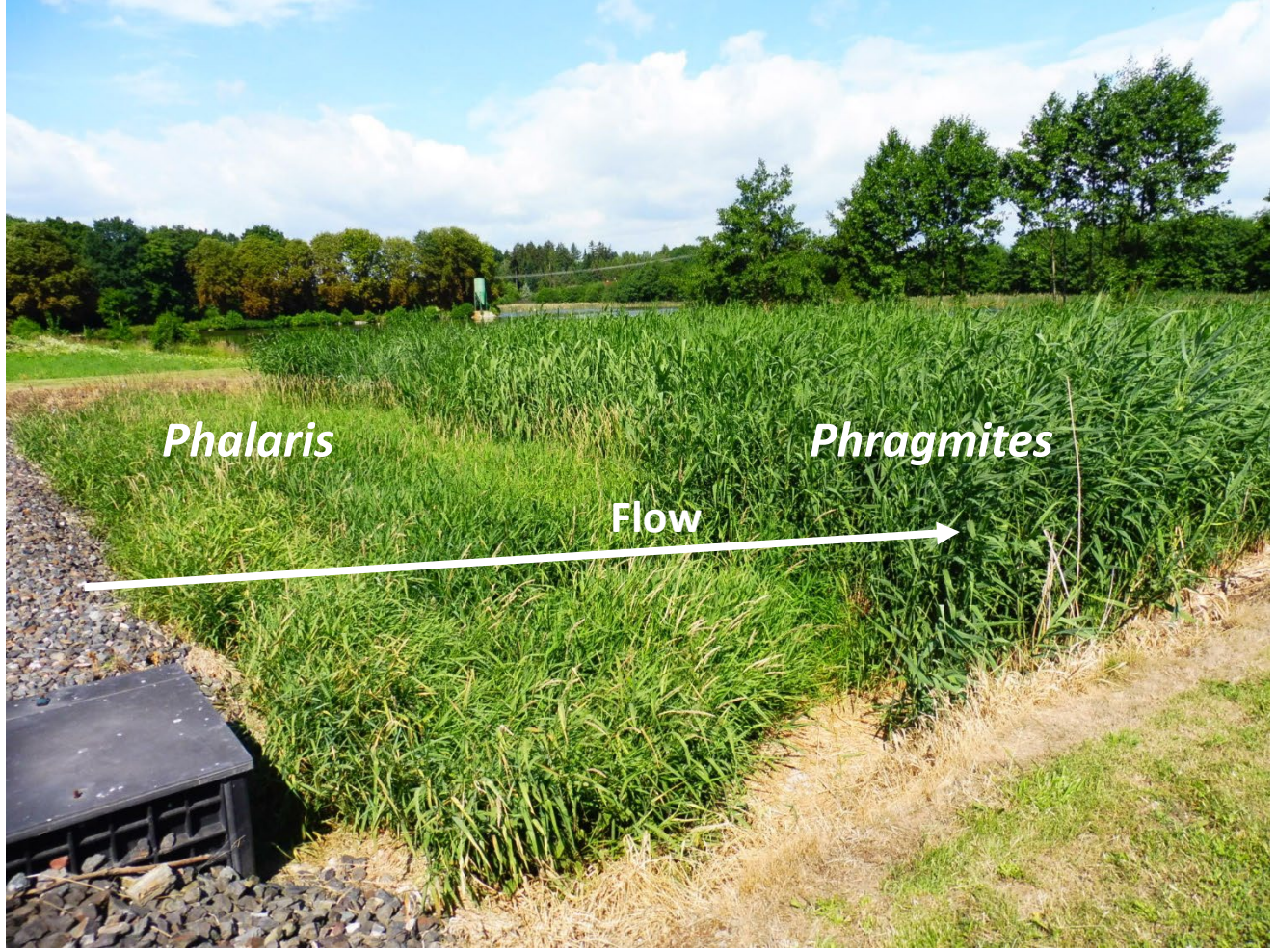
**Sampling: 2004, 2005, 2006, 2007, 2008**

## CW Slavošovice

**Start of operation: 2001** **Area: 748m$^2$ (2 beds)** **PE: 150**

***Phragmites australis***

**Sampling: 2004, 2006, 2007, 2008, 2014**




## CW Zbenice

**Start of operation: 1996 Area: 1 000 (2 beds) PE: 200**

***Phragmites australis*** **and** ***Phalaris arundinacea*** **(bands perpendicular to flow)**

**Sampling: 2014**

## CW Čičenice

**Start of operation: 2010** **Area: 2 400m$^2$ (4 beds)** **PE: 480**

***Phalaris arundinacea***

**Sampling: 2011**

## CW Radotín

**Start of operation: 1996** **Area: 240m$^2$ (1 bed)** **PE: 200**

***Phragmites australis***

**Sampling: 2011**

# Methods

## Sampling (at the peak biomass, end of July for *Phalaris*, end of August for *Phragmites*)

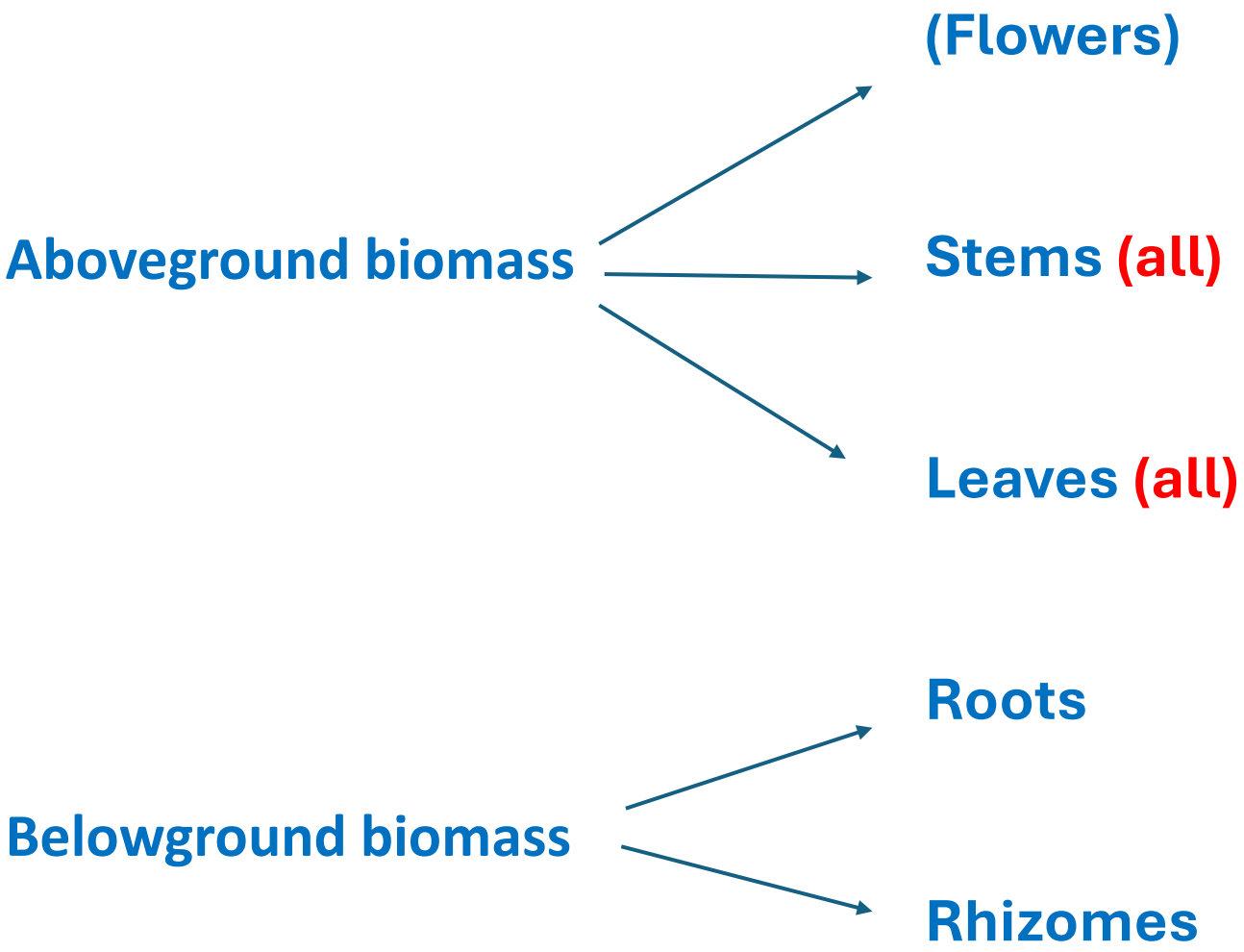
## 4 quadrants 50 x 50 cm in the inflow and outflow zones (total of 8 samples)

### Phalaris/Zbenice: inflow/outflow

*Phalaris*

## Belowground biomass

Phragmites




**Examples of methods used to analyse plant biomass:**

**„mature leaves picked randomly from the culm“**

**„the upper leaves and the whole stem“**

**„five leaves from the top of the shoot“**

# Analytical procedures

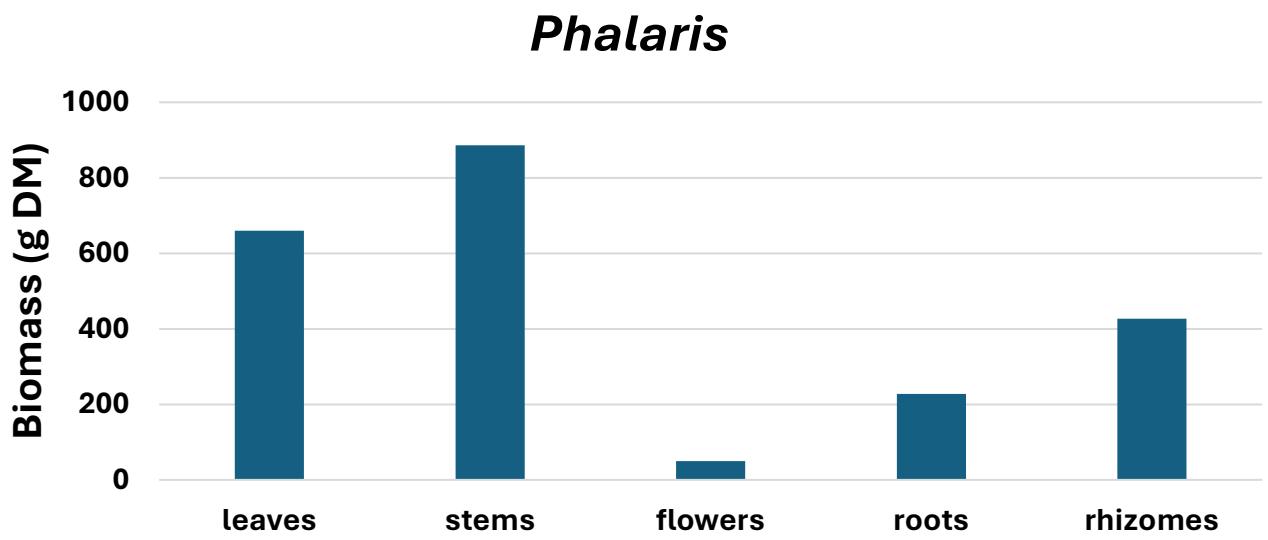
**Drying to a constant weight at 60°C (for Hg at 30°C)**

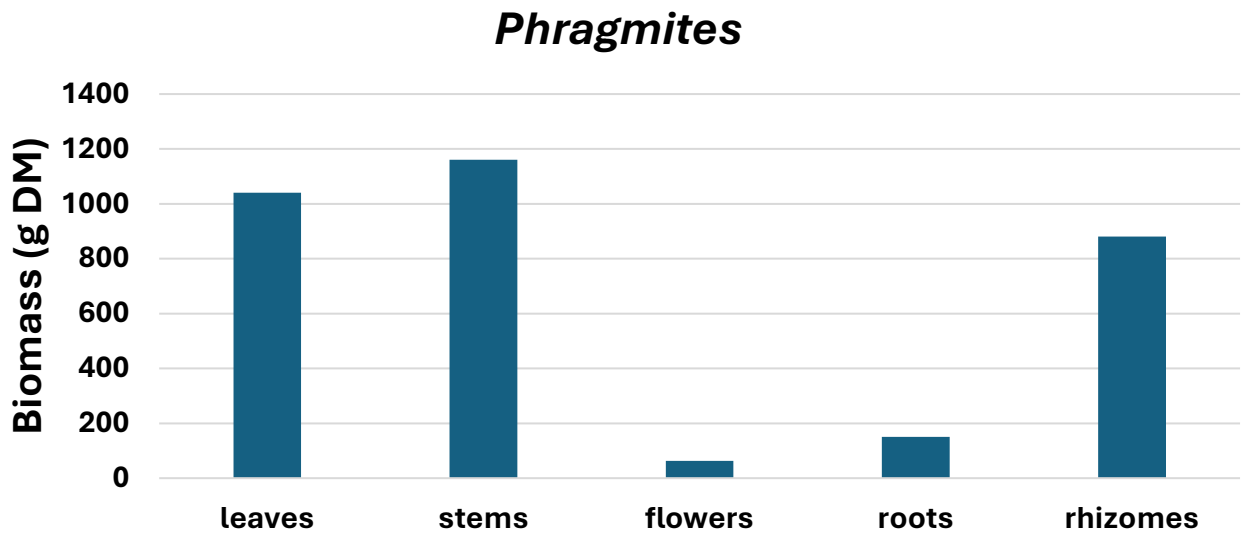
**Homogenization in a cutting mill**

**Mineralization in a pressure microwave using Ultrapure $HNO_3$**

**ICP MS (Thermo)**

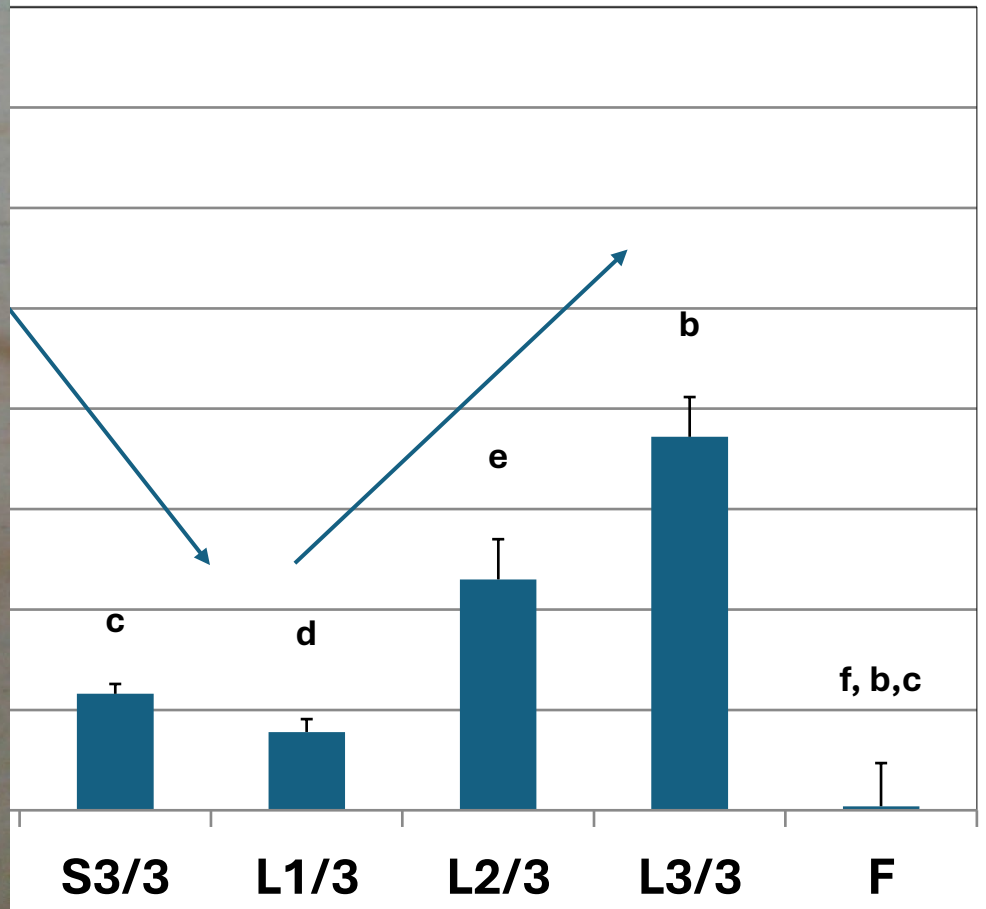
**For Hg, cold vapor method (AMA 254)**

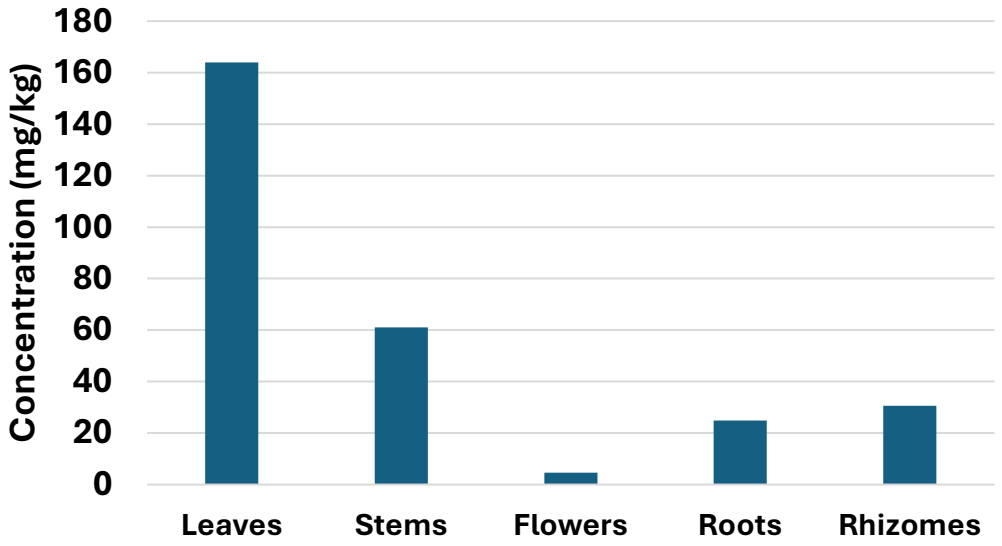

Phalaris
Biomass (g DM)
1000
800
600
400
200
0
leaves
stems
flowers
roots
rhizomes


Phragmites
Biomass (g DM)
1400
1200
1000
800
600
400
200
0
leaves
stems
flowers
roots
rhizomes

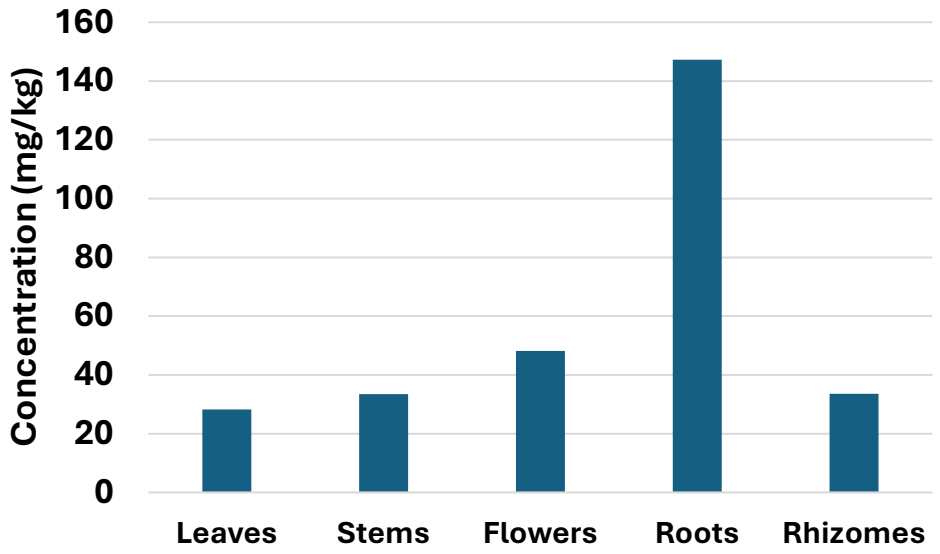
**CW Břehov**

in aboveground biomass of
W Břehov)
bottom, 2/3=midle, 3/3=top





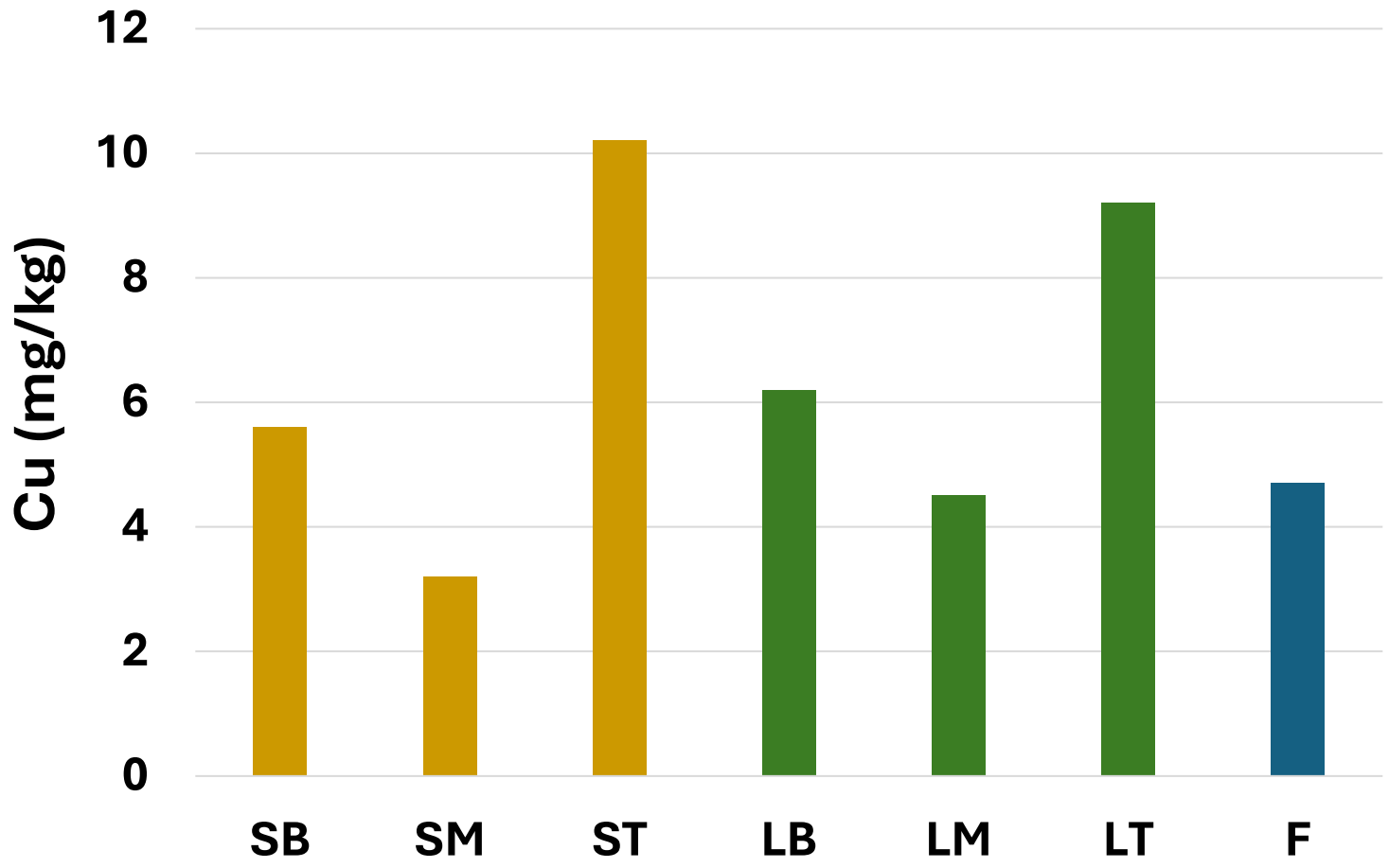

**Manganese**



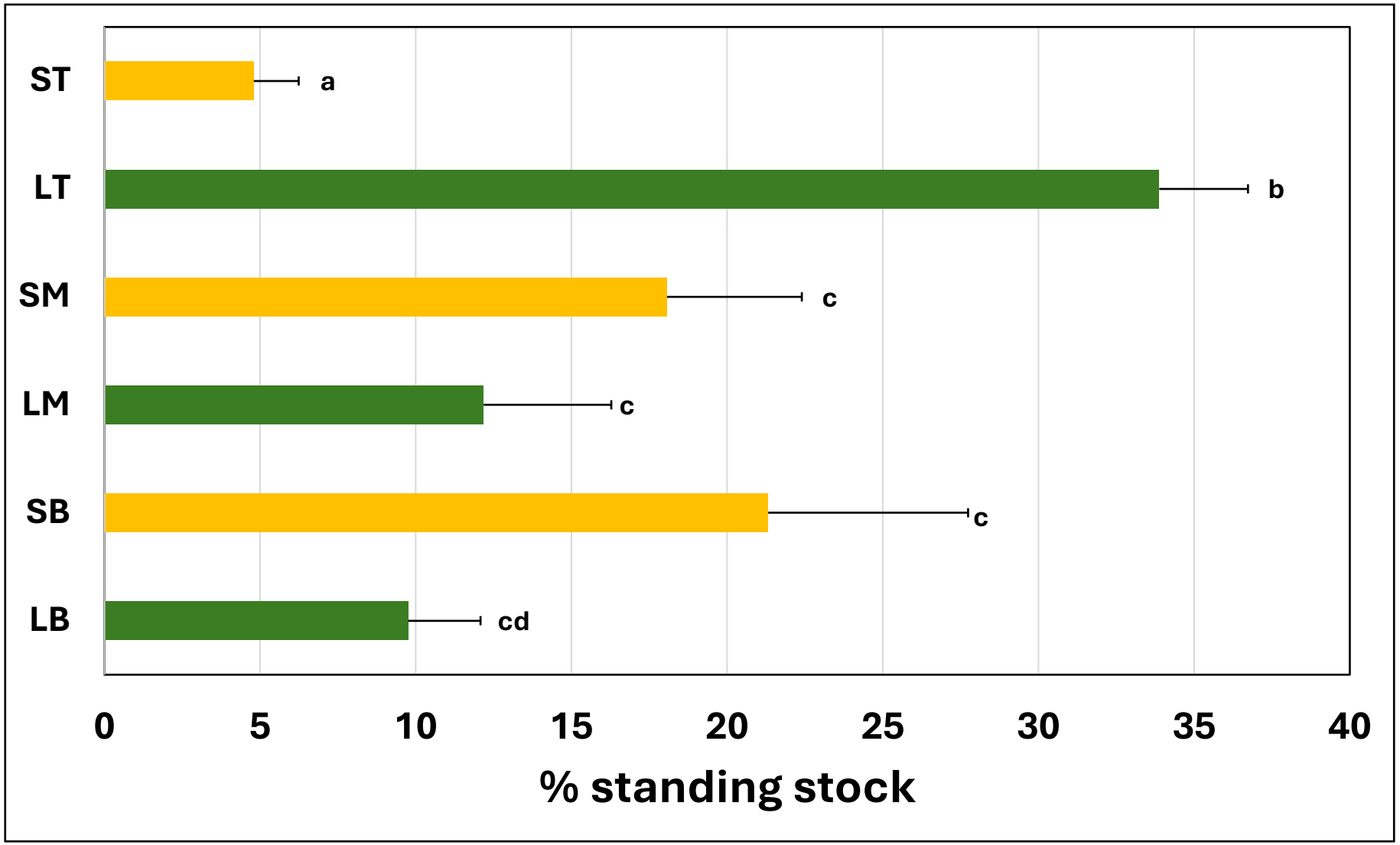

**Zinc**

**CW Břehov, *Phragmites***

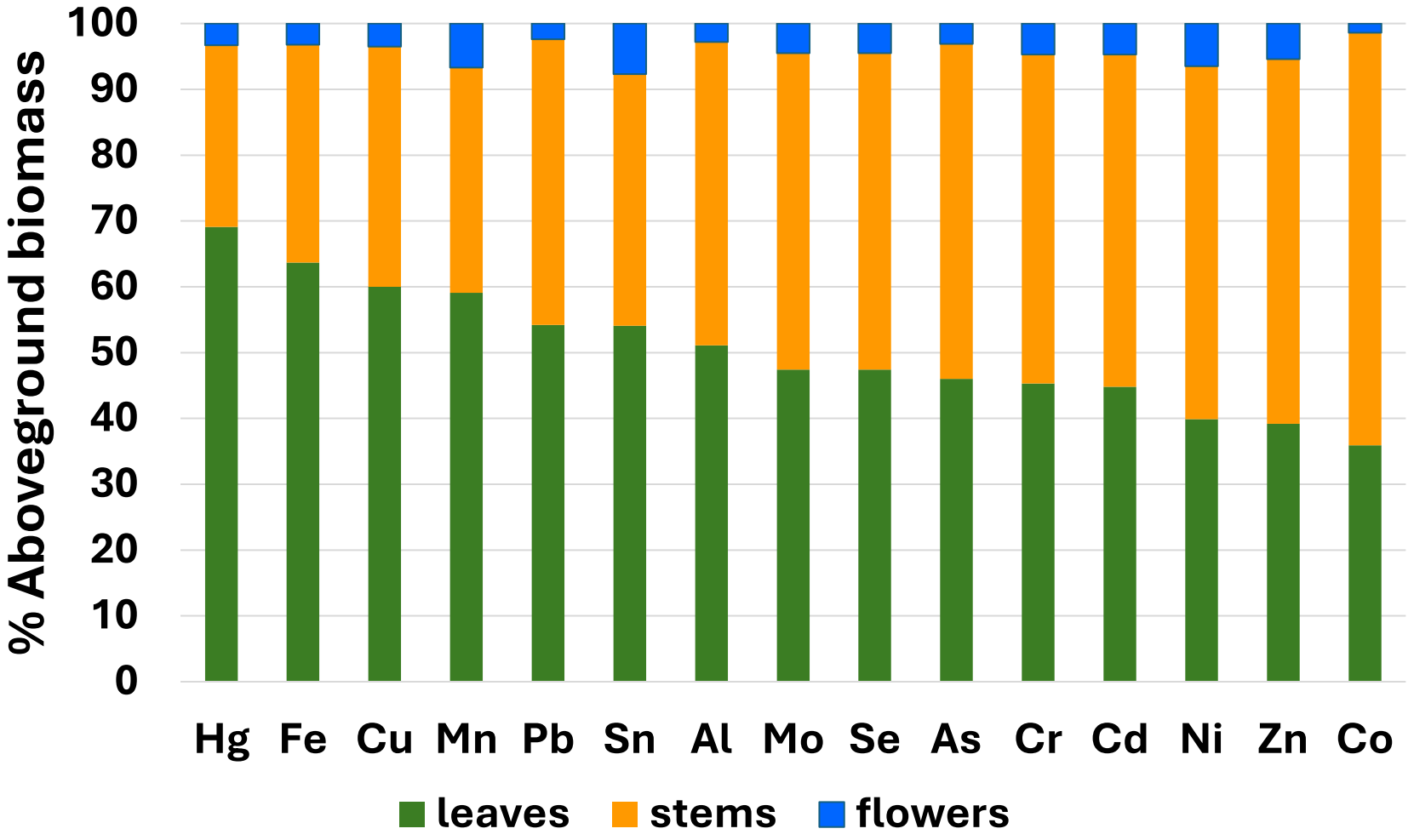
**Concentrations of copper in stems (S) and leaves (L) of *Phragmites australis*. B=bottom, M=middle, T=top, F=flowers**



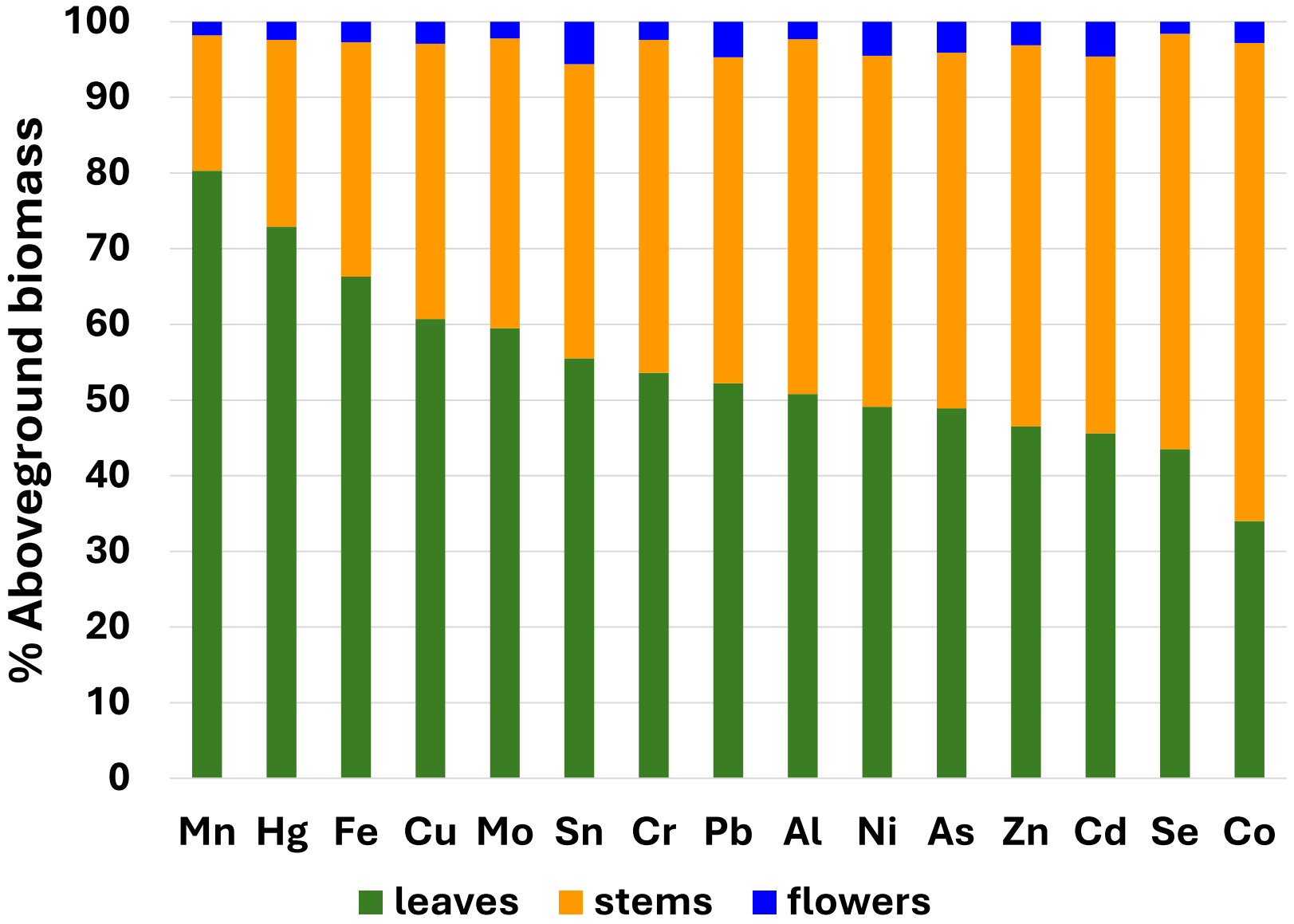
# Distribution of copper in shoots of *Phragmites australis*



**Distribution of metals and metaloids in aboveground parts of *Phalaris arundinacea* (n=9)**



**Distribution of metals and metaloids in aboveground parts of *Phragmites australis*(n=18)**



## *Phalaris arundinacea*

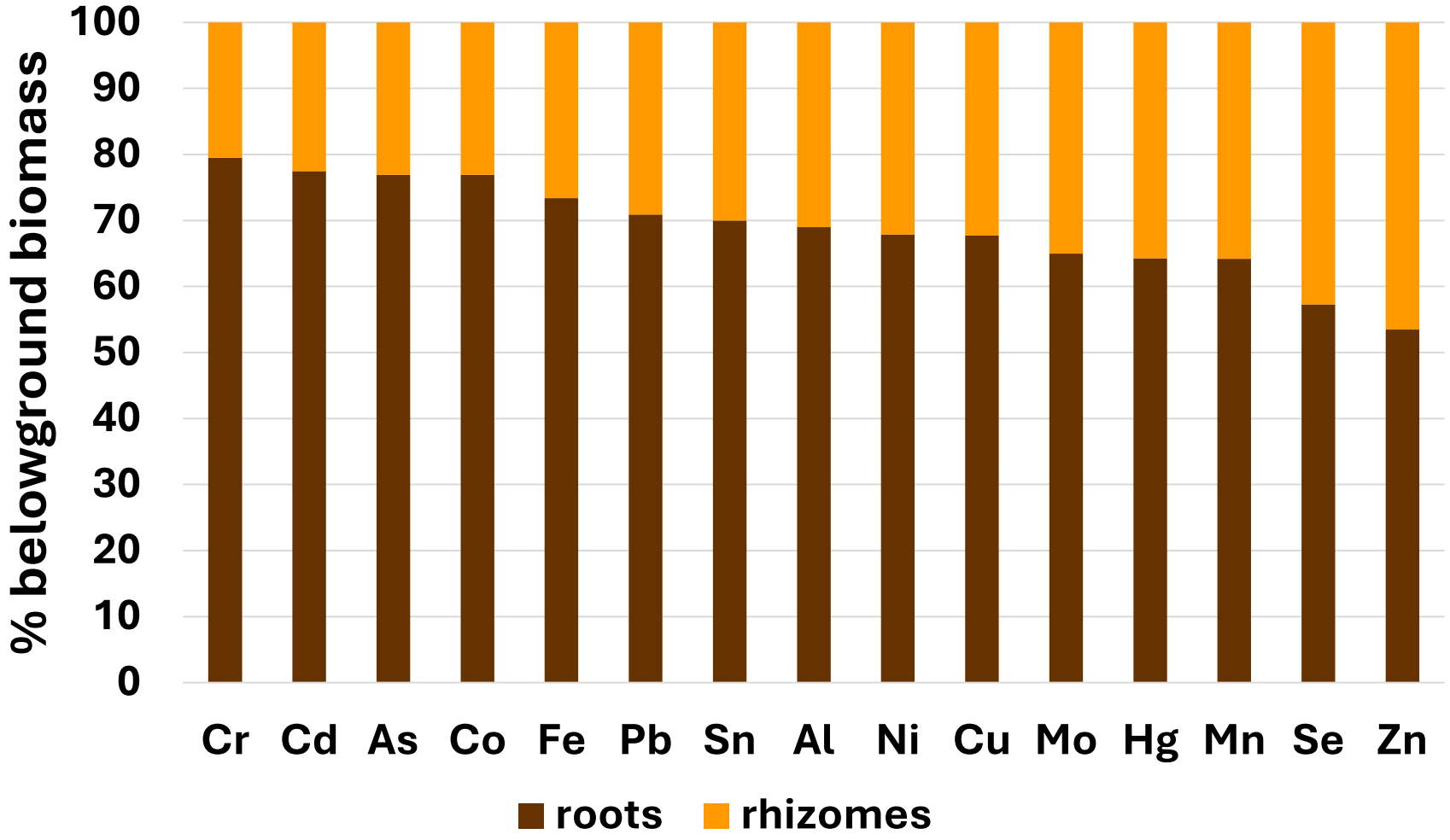
| | | |
|---|---|---|
| **Leaves:** | **69.1% (Hg) - 35.9% (Co)** | **Mean 50.5%** |
| **Stems:** | **62.7% (Co) – 27,6% (Hg)** | **Mean 45.2%** |
| **Flowers:** | **7.7% (Sn) – 1.4% (Co)** | **Mean 4.3%** |

## *Phragmites australis*

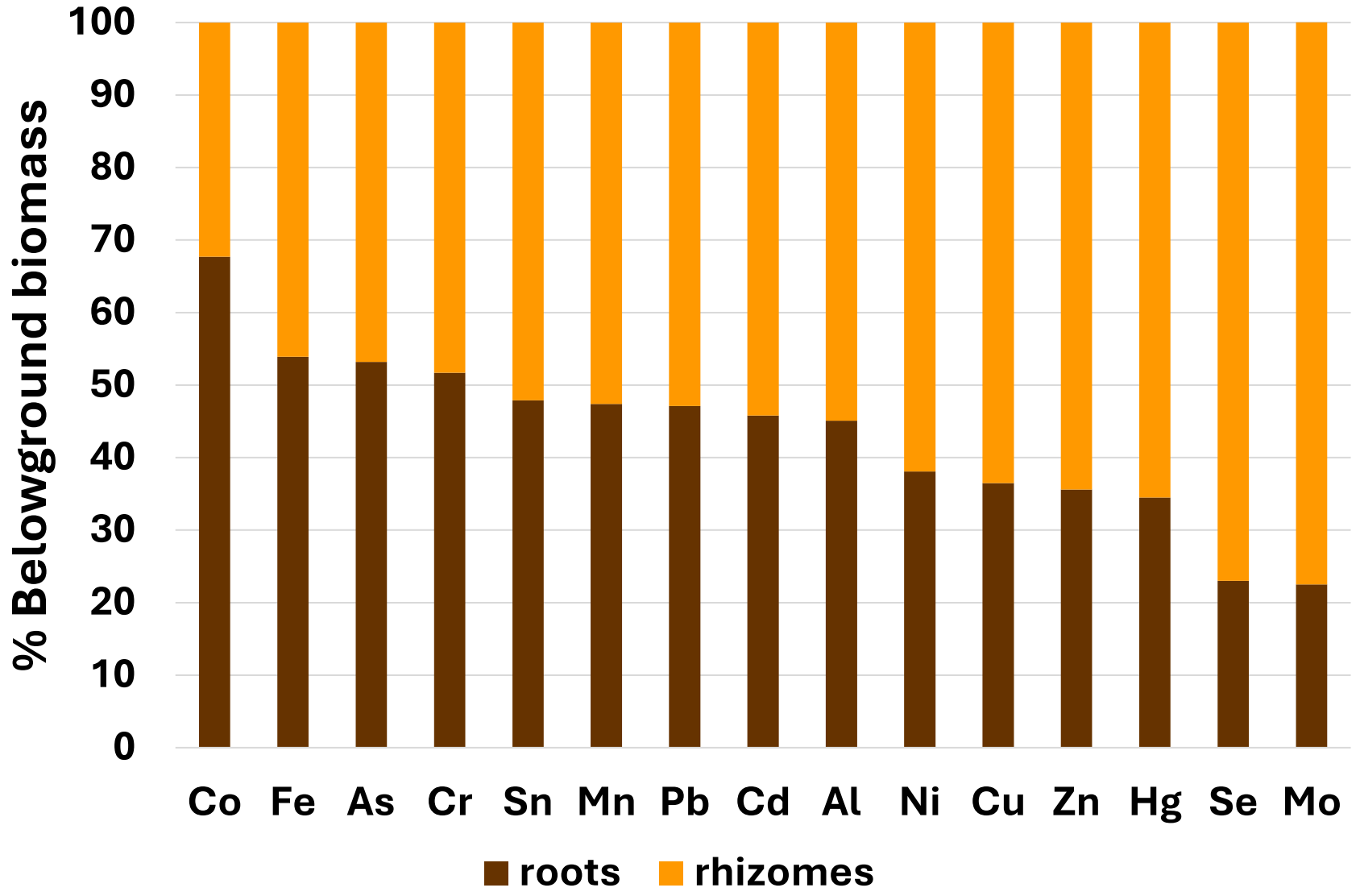
| | | |
|---|---|---|
| **Leaves:** | **80.3% (Mn) – 34.0% (Co)** | **Mean 54.6%** |
| **Stems:** | **63.2% (Co) – 17.9% (Mn)** | **Mean 42.2%** |
| **Flowers:** | **5.6% (Sn) – 1.6% (Se)** | **Mean 3.2%** |

| | **Highest** | **Lowest** |
|---|---|---|
| **Phalaris leaves:** | **Hg, Fe, Cu, Mn, Pb** | **.....Cr, Cd, Ni, Zn, Co** |
| **Phragmites leaves:** | **Mn, Hg, Fe, Cu, Mo** | **.....As, Zn, Cd, Se, Co** |

**Distribution of metals and metaloids in belowground parts of *Phalaris arundinacea* (n=6)**



**Distribution of metals and metaloids in aboveground parts of *Phragmites australis*(n=9)**



*Phalaris arundinacea*

**Roots:** 79.5% (Cr) – 53.5% (Zn) **Mean 68.9%**

**Rhizomes:** 46.5% (Zn) – 20.5% (Cu) **Mean 31.1%**

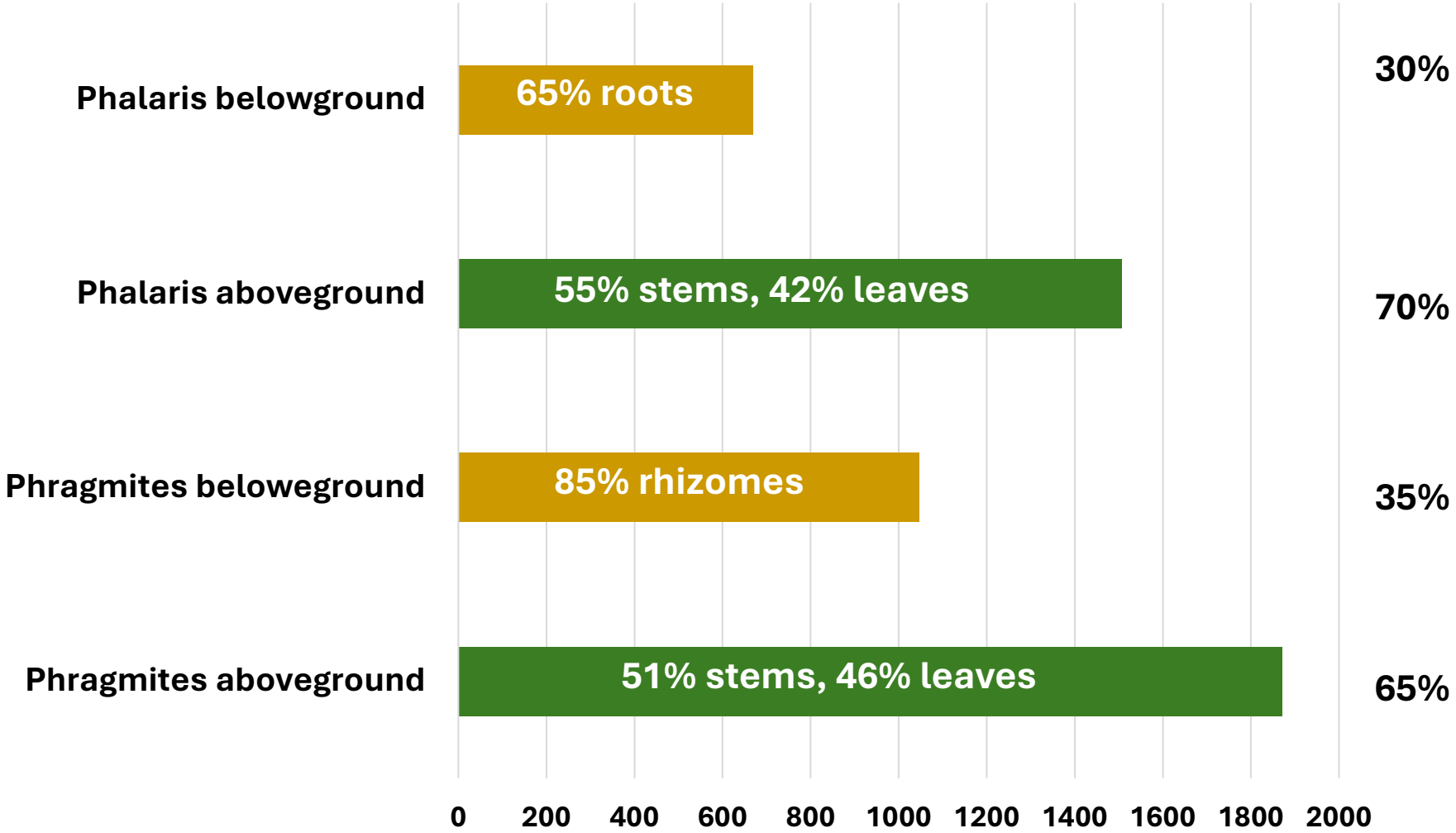
*Phragmites australis*

**Roots:** 67.7% (Co) – 22.5% (Mo) **Mean 43.3%**

**Rhizomes:** 77.6% (Mo) – 32.3% (Co) **Mean 56.7%**

| | Highest | Lowest |
|---|---|---|
| **Phalaris roots:** | **Cr,Cd,As,Co,Fe.....Mo,Hg,Mn,Se,Zn** | |
| **Phragmites roots:** | **Co,Fe,As,Cr,Sn.....Mo,Se,Hg,Zn,Cu** | |

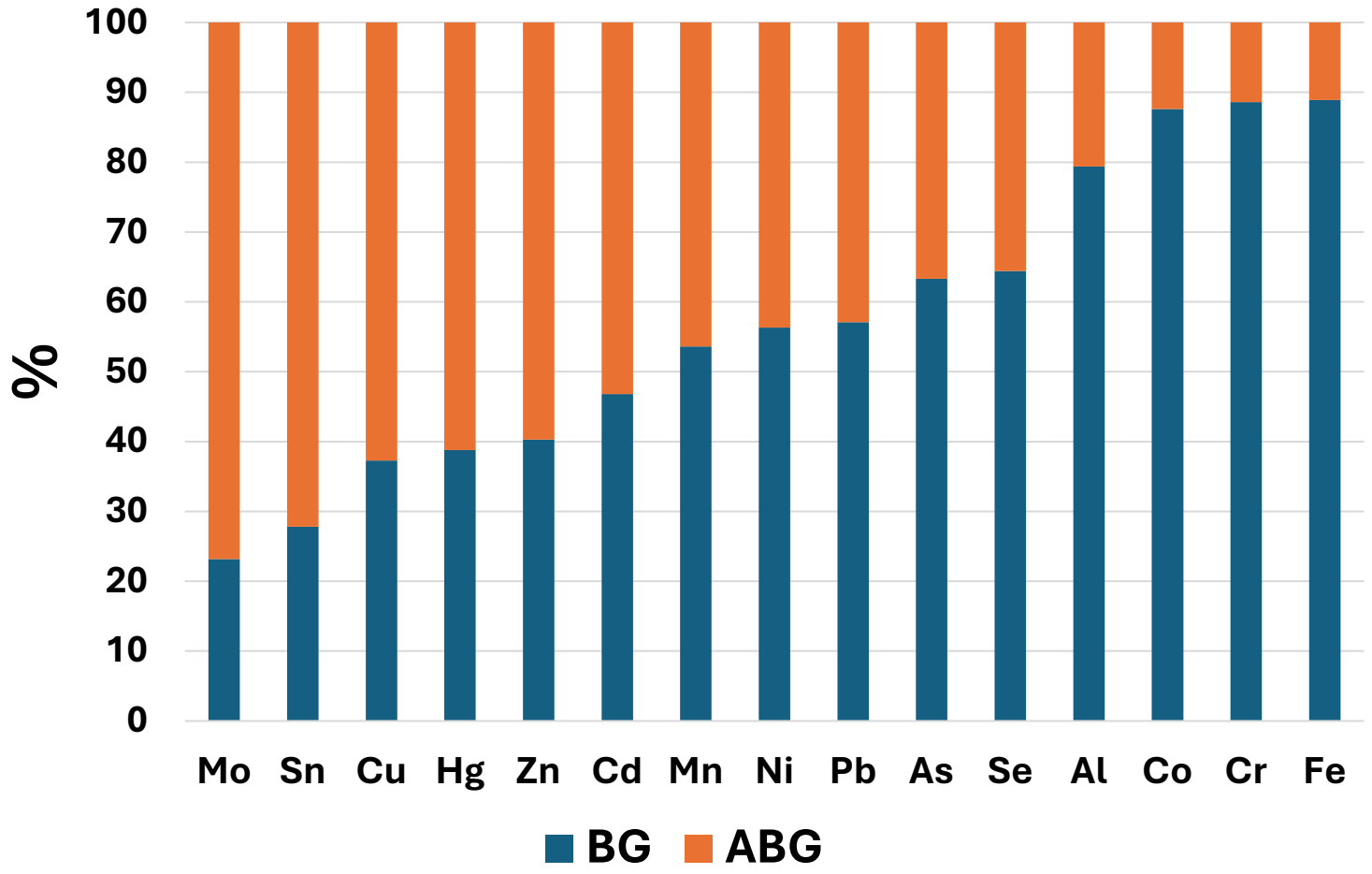
# Average biomass (g/m$^2$ DM) of *Phalaris* and *Phragmites* above- and belowground biomass



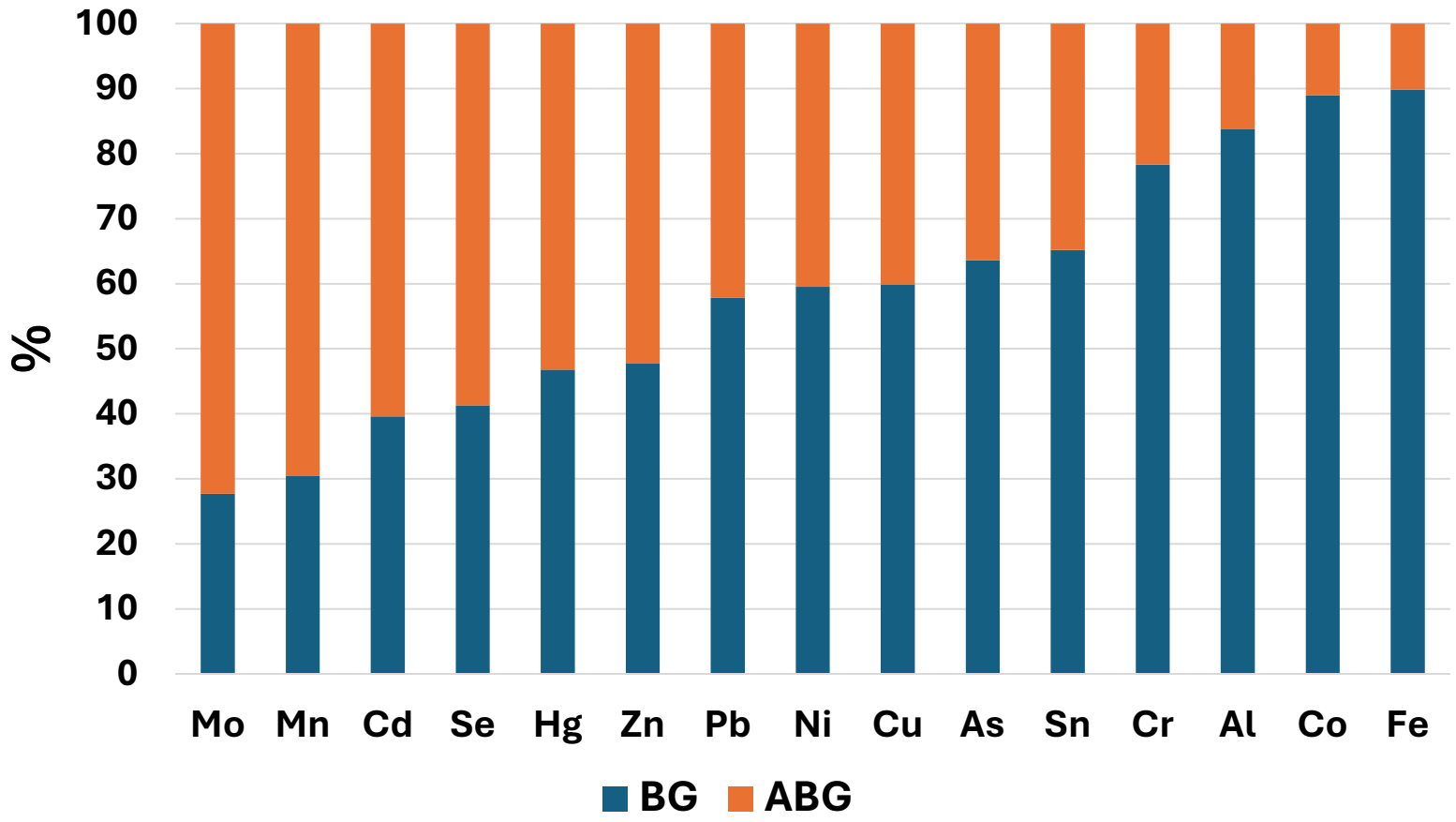
# Range of concentrations in various parts of *Phalaris* and *Phragmites*

| | Leaves | Stems | Flowers | Roots | Rhizmes |
|---|---|---|---|---|---|
| Al | 9.5-61.3 | 7.5-74.5 | 15-80 | 41-305 | 24-74.8 |
| As | 0.07-1.36 | 0.06-1.02 | ND-0.99 | 1.8-11.5 | 0.25-0.97 |
| Cd | 0.003-0.37 | 0.001-0.29 | ND-0.34 | 0.13-0.43 | 0.09-0.13 |
| Co | 0.004-0.25 | 0.02-0.93 | ND-0.68 | 5.6-57.5 | 0.5-2.9 |
| Cr | 0.08-3.08 | 0.03-3.3 | ND-2.63 | 6.3-30.7 | 0.93-5.6 |
| Cu | 0.81-75.7 | 0.43-28 | ND-26.1 | 3.7-76.3 | 2.4-88.9 |
| Fe | 83.4-841 | 15-127 | ND-236 | 3685-11824 | 387-2108 |
| Hg | 0.017-0.10 | 0.004-0.02 | ND-0.025 | 0.04-0.08 | 0.009-0.038 |
| Mn | 17.5-304 | 8.5-58.5 | ND-137 | 123-411 | 19.6-71.9 |
| Mo | 0.09-3.7 | ND-4.41 | ND-6.2 | 0.19-2.55 | 0.17-3.05 |
| Ni | 0.65-38 | 0.27-6.65 | ND-8.8 | 7.1-21.8 | 0.13-18.8 |
| Pb | 0.001-5.8 | 0.01-7.5 | ND-6.02 | 5.16-19.3 | 0.42-10.6 |
| Se | 0.09-3.72 | 0.04-2.98 | ND-2.82 | 0.33-1.11 | 0.14-0.94 |
| Sn | 0.01-0-37 | 0.01-0.37 | ND-0.53 | 0.54-5.98 | 0.01-2.36 |
| Zn | 6.5-61.3 | 7.5-70.9 | 21.1-65.5 | 41-165 | 20-75.8 |

# Distribution of heavy metals and metalloids between above- and belowground biomass of *Phalaris arundinacea*



# Distribution of heavy metals and metalloids between above- and belowground biomass of *Phragmites australis*



*Phalaris arundinacea*

**ABG: 76.8% (Mo) – 11.1% (Fe) Mean 56.9%**

**BG: 88.9% (Fe) – 23.2% (Mo) Mean 43.1%**

*Phragmites australis*

**ABG: 72.3% (Mo) – 10.2% (Fe) Mean 58.7%**

**BG: 89.8% (Fe) – 27.7% (Mo) Mean 41.3%**

| | Highest | Lowest |
|---|---|---|
| **Phalaris ABG:** | **Mo,Sn,Cu,Hg,Zn.....** | **Fe,Cr,Co,Al,Se** |
| **Phragmites ABG:** | **Mo,Mn,Cd,Se,Hg.....** | **Fe,Co,Al,Cr,Sn** |

# Conclusions

- It is important to analyze all plant parts, i.e., stems, leaves, fowers, roots and rhizomes, separately

- It is important to consider all the plant shoot (aboveground) material

- The amount of heavy metals and metalloids sequestered in aboveground biomass is slightly higher in leaves as comparedto stems (51:45% in *Phalaris* and 66:43% in *Phragmites*)

- Belowground amounts of monitored metals and metalloids are higher in roots in *Phalaris* (69%) and in rhizomes in *Phragmites (57%)*

- There is slighty more metals and metalloids sequesterd in the aboveround biomass as compared to belowground biomass, cca 57:43 %

**For the evaluation of element distribution in various plan parts, it is necessary to take biomass in consideration**


Thank you for your attention