



**Phytoextraction of
cadmium, zinc and nickel
from contaminated biosolids
by willows grown
under field conditions.**



Pop = 3.7 million



Melbourne's Sewage Treatment

2 sewage catchments

WTP

est. 1890's

11,000 ha



Western Treatment Plant

Sewage 480 ML day⁻¹



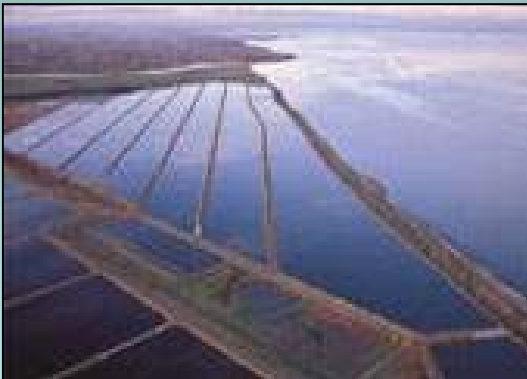
Industrial Sources



Domestic sources



Lagoon Treatment



Aerobic / Anaerobic



Activated Sludge



WTP Biosolids

- Lagoons de-sludged
- 20 K tons per annum
- ~1 M ton stockpile



Biosolids - Nutrient Value

	BIOSOLID	SOIL
pH	4.8	4.9
EC (mS cm ⁻¹)	3.1	0.8
Total C (%)	12	5
Total N (%)	1.9	0.6
Available P (mg kg ⁻¹)	154	104
Exch. Ca (meq 100g ⁻¹)	25	7
Exch. Mg (meq 100g ⁻¹)	8	5
Exch. Na (meq 100g ⁻¹)	4	4
Exch. K (meq 100g ⁻¹)	2.6	0.8

Biosolid Contaminants

Environmental Protection Agency Victoria

Upper limits for contaminants in unrestricted biosolids

C1

Upper limits for contaminants in **restricted** biosolids

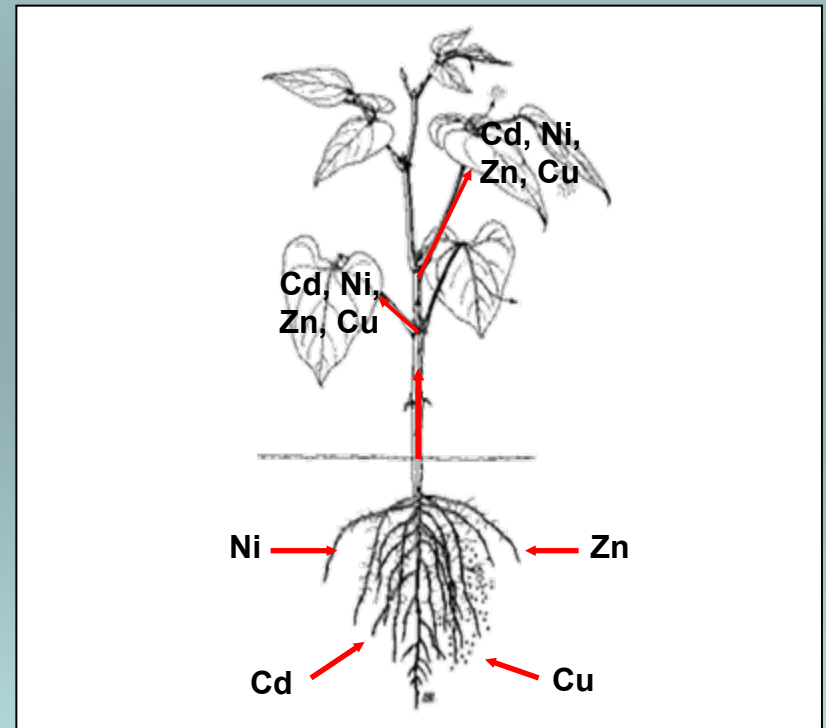
C2



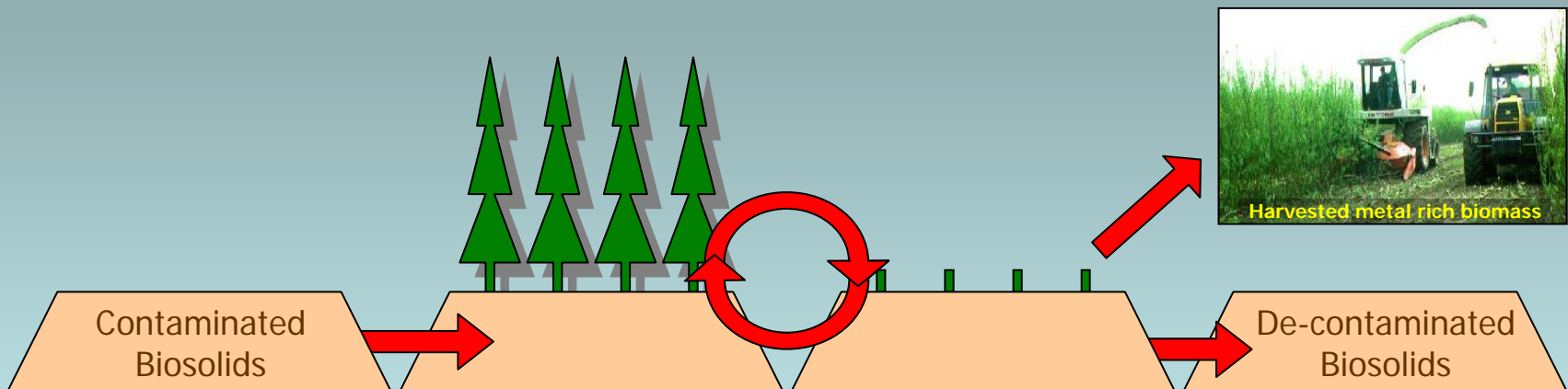
(mg kg ⁻¹)	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
C2	<i>20</i>	<i>1</i>	<i>400</i>	<i>100</i>	<i>1</i>	<i>60</i>	<i>300</i>	<i>200</i>
WTP	27	24	870	760	5	180	520	1710

What options do we have?

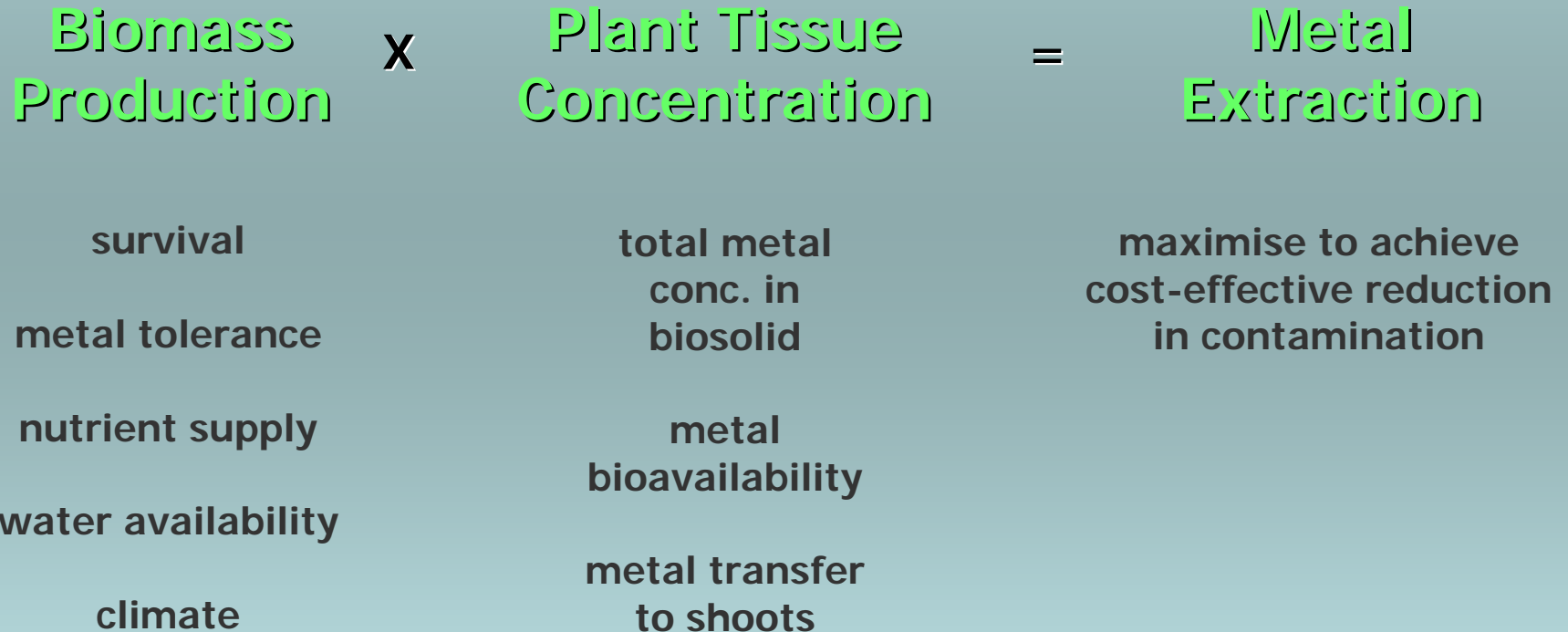
- Decontaminate biosolids by 'phytoextraction'



- metal accumulating plants eg. Willow
- short rotation coppice crop



Phytoextraction



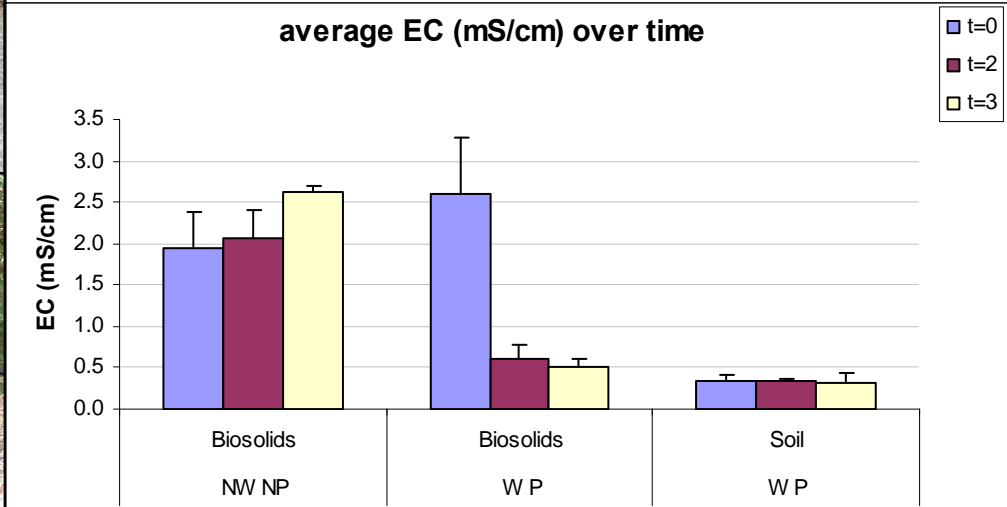
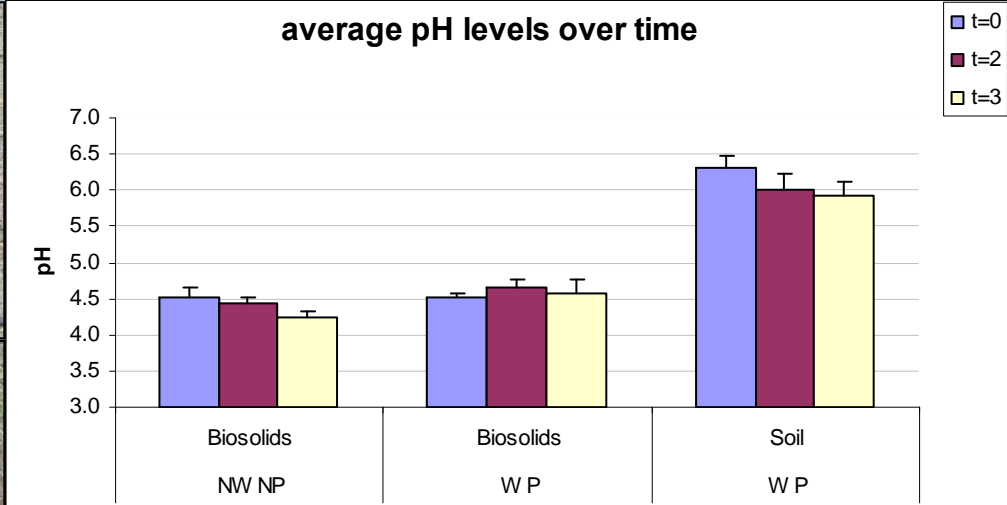
- **7 *Salix* species**
- **Drip irrigation, potable water**
- **Soil trial**
- **Biosolids trial**

- **Above-ground biomass**
 - Leaf & stem
- **Metal analysis, ICP-AES**



mg kg ⁻¹	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
SOIL	10	2	121	62	<1	30	54	213
BIOSOLIDS	27	24	869	757	5	182	516	1714

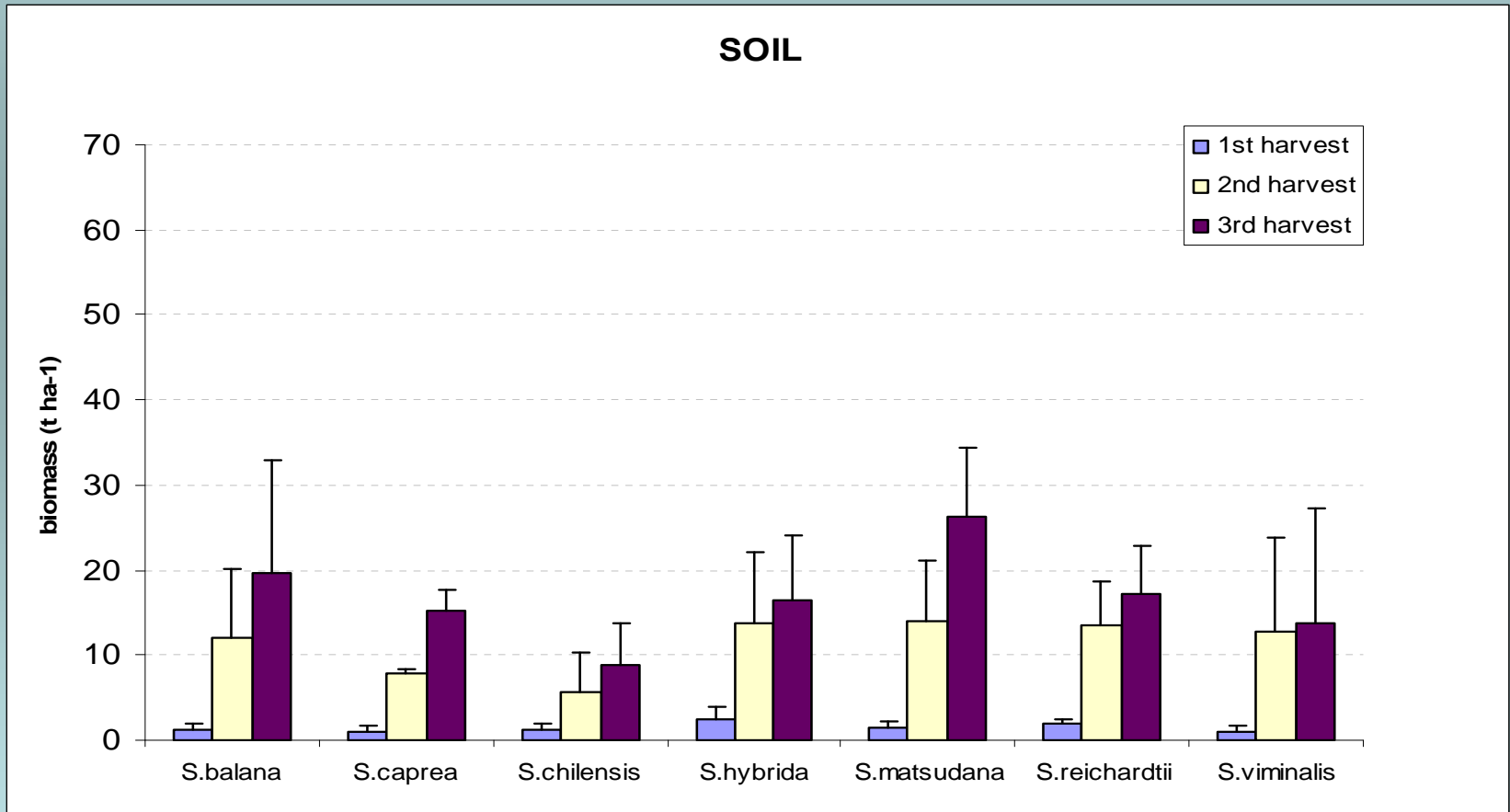
pH and EC



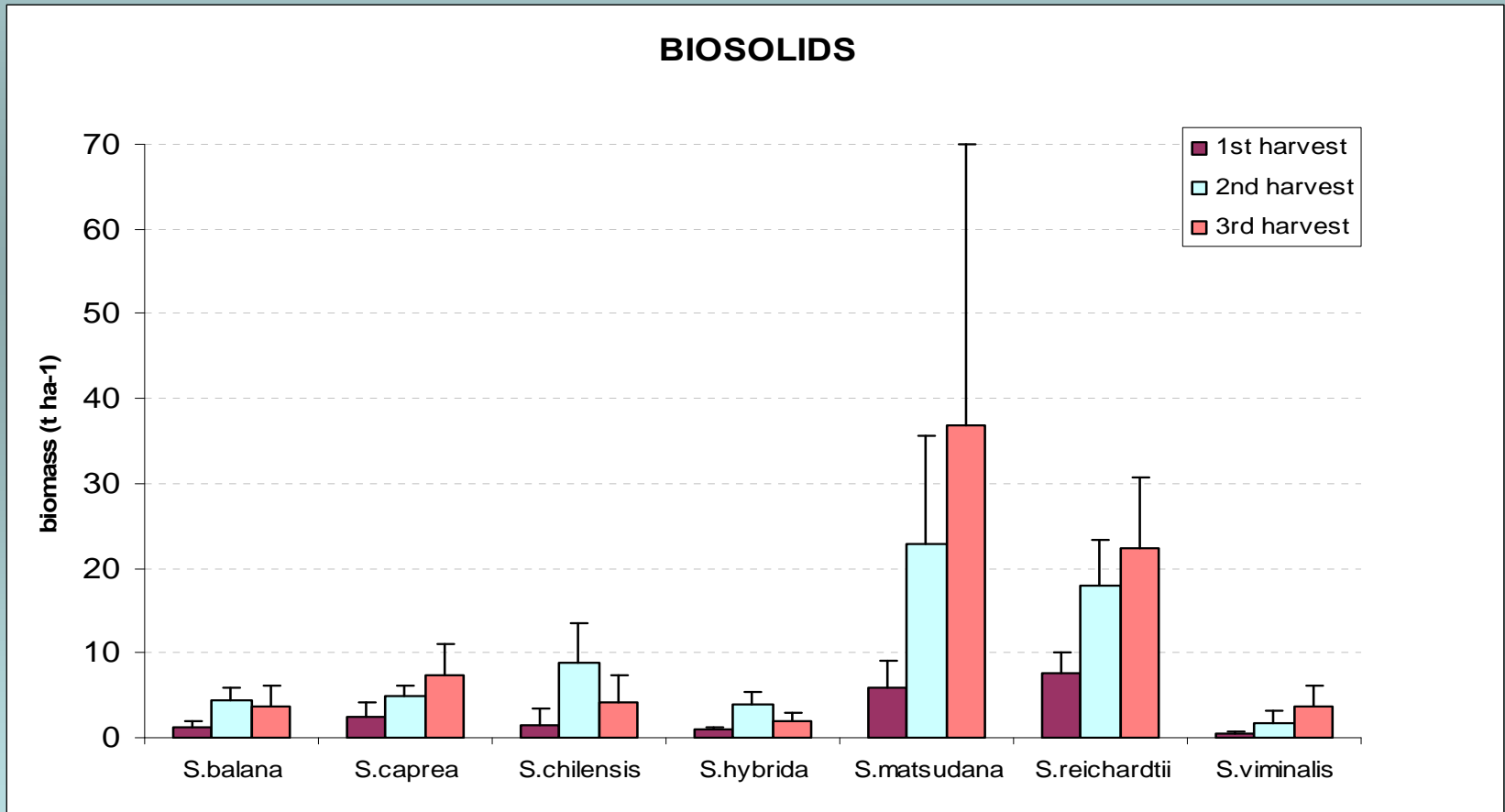
Phytoextraction

$$\text{Biomass Production} \times \text{Plant Tissue Concentration} = \text{Metal Extraction}$$

Biomass - Soil



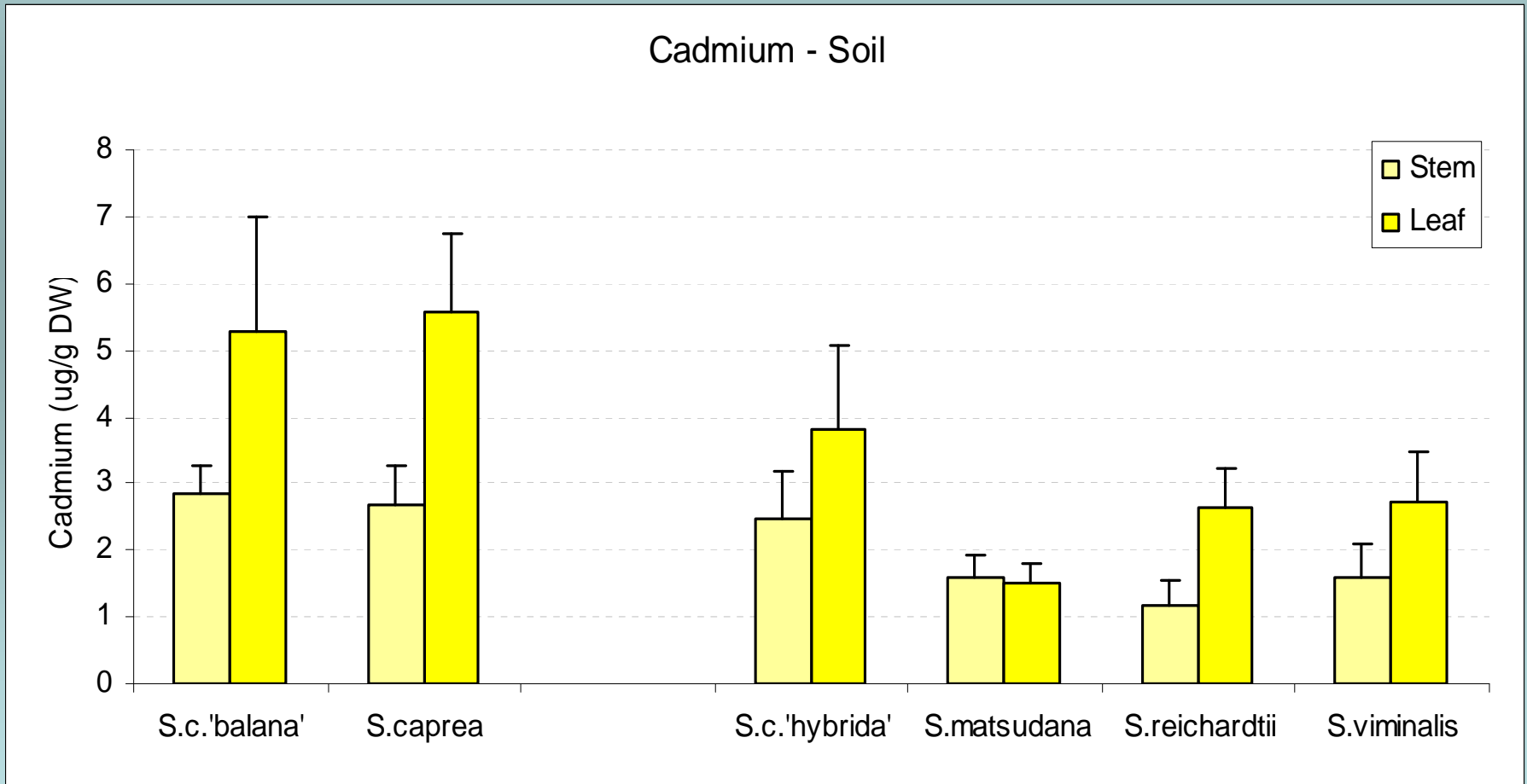
Biomass - Biosolids



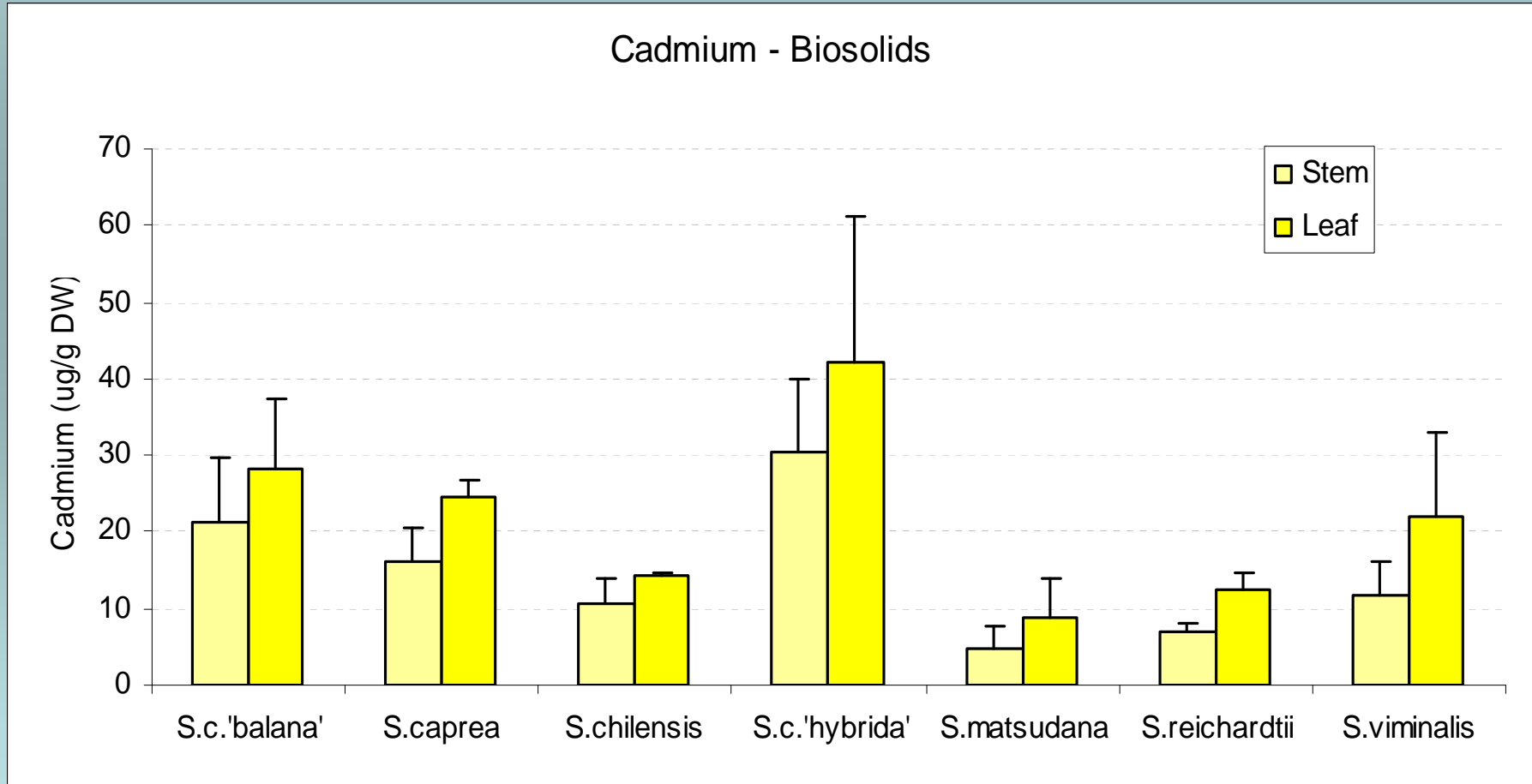
Phytoextraction

$$\text{Biomass Production} \times \text{Plant Tissue Concentration} = \text{Metal Extraction}$$

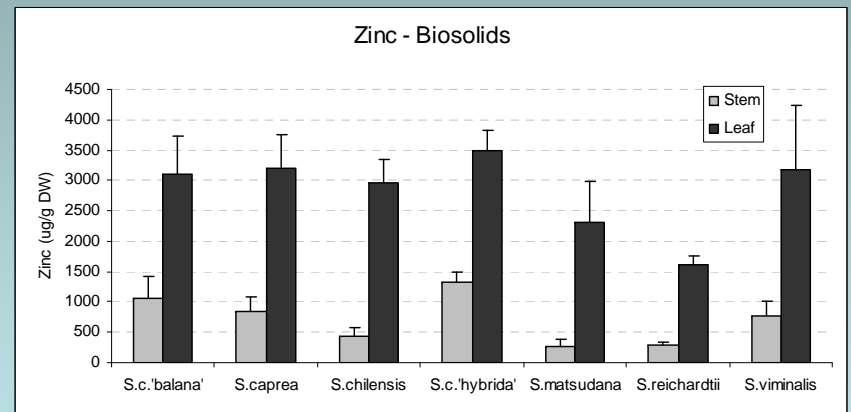
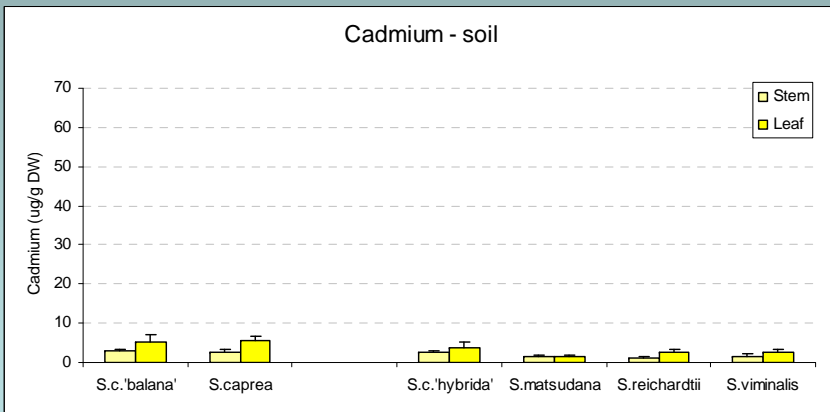
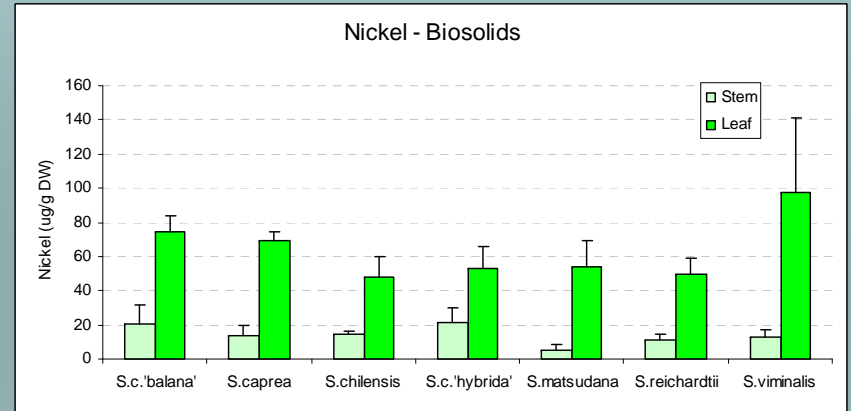
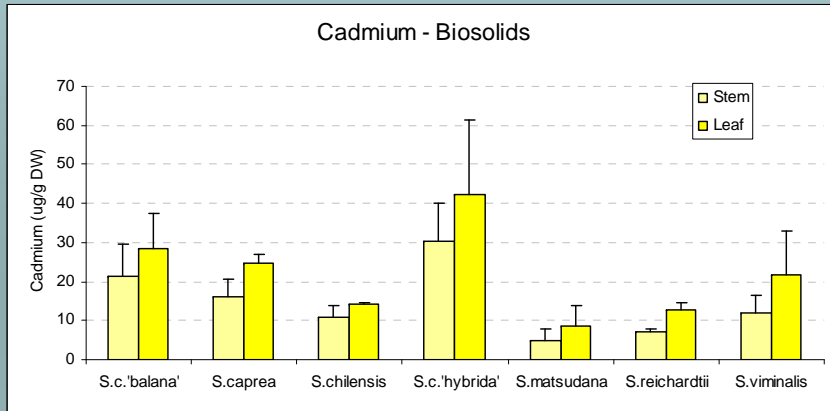
Leaf and Stem Cd Concentrations



Leaf and Stem Cd Concentrations



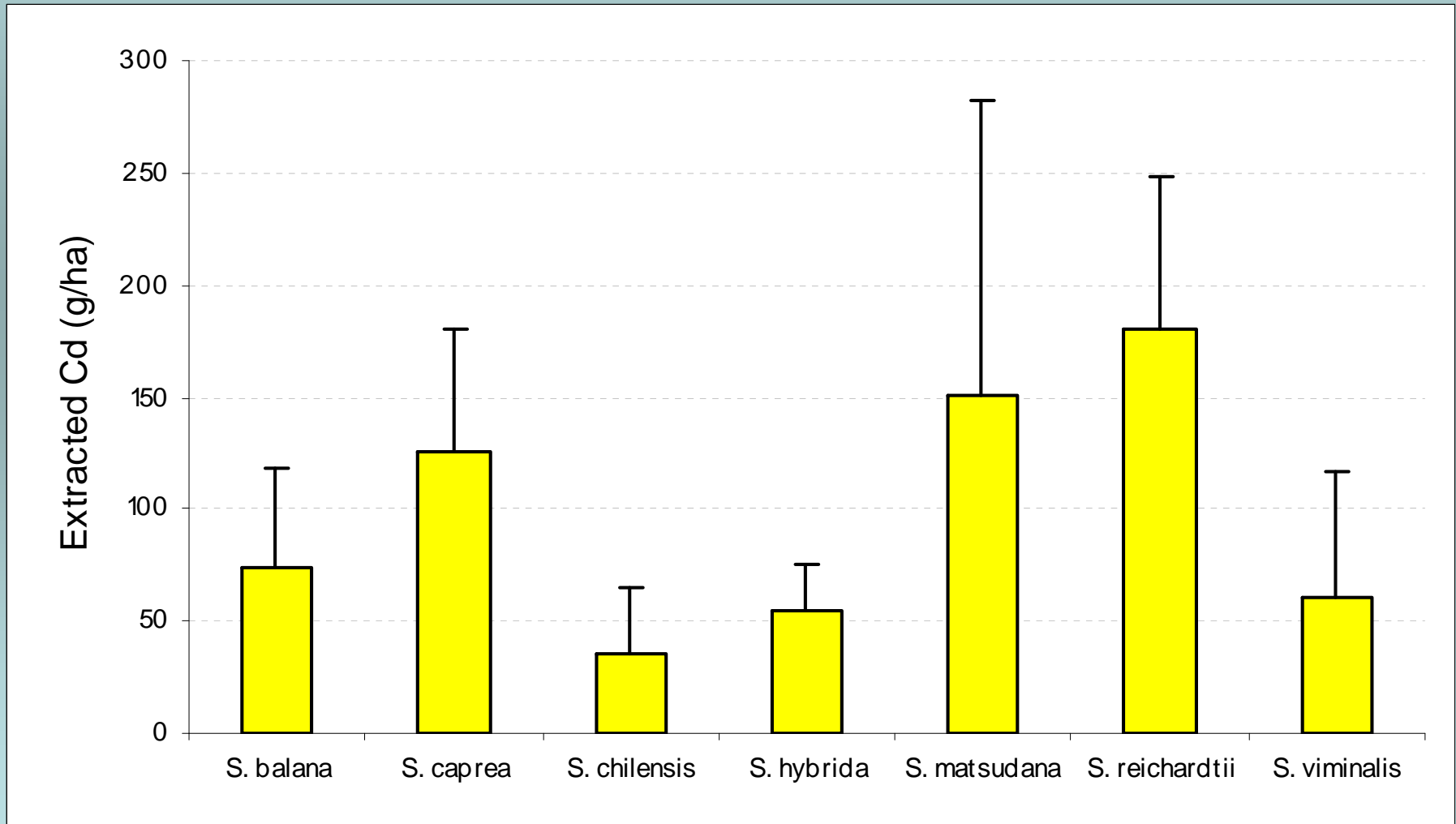
Leaf and Stem Metal Concentrations



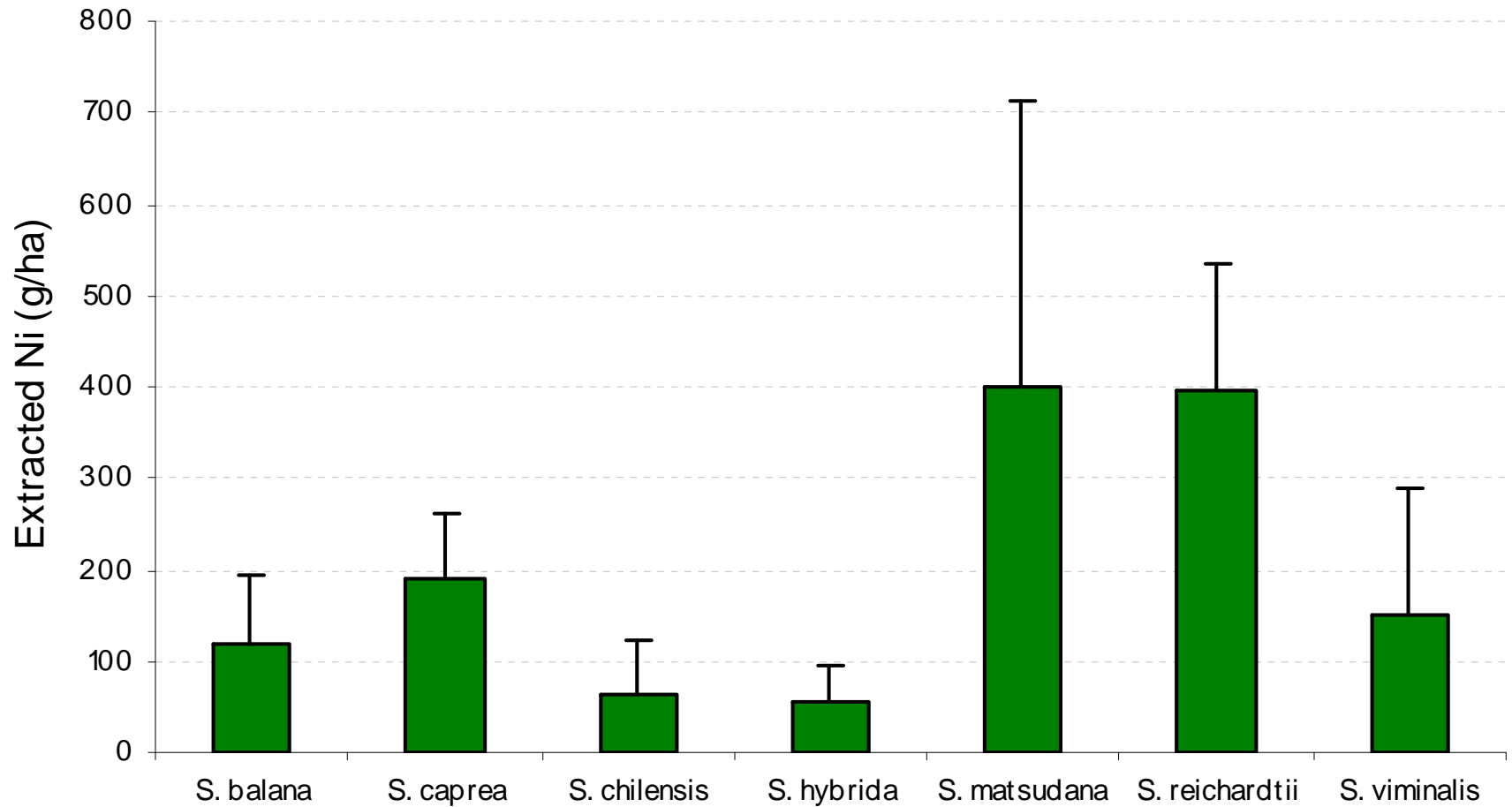
Phytoextraction

$$\text{Biomass Production} \times \text{Plant Tissue Concentration} = \text{Metal Extraction}$$

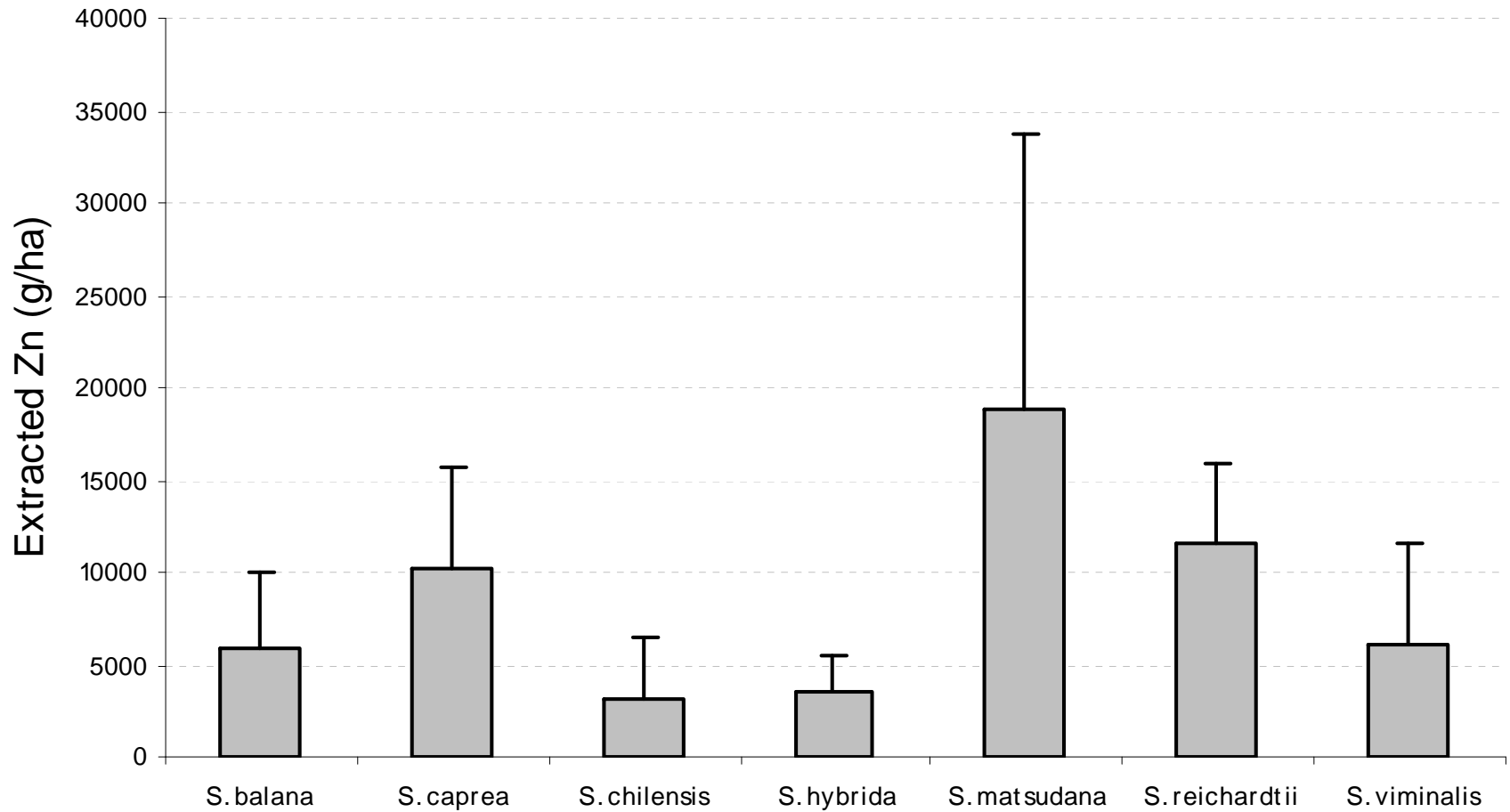
Extracted Cd



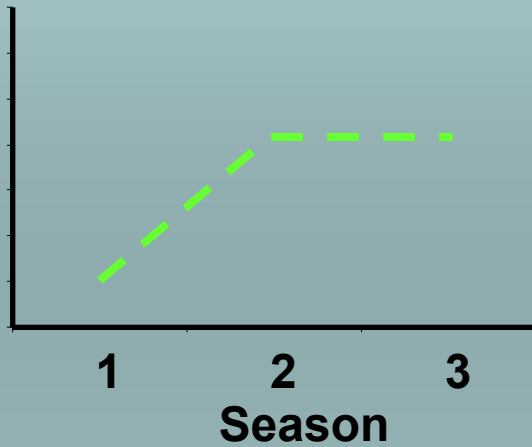
Extracted Ni



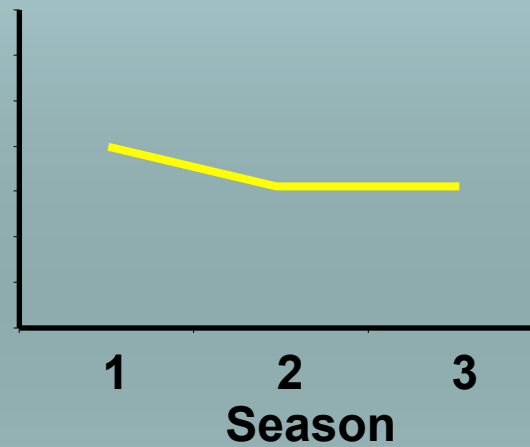
Extracted Zn



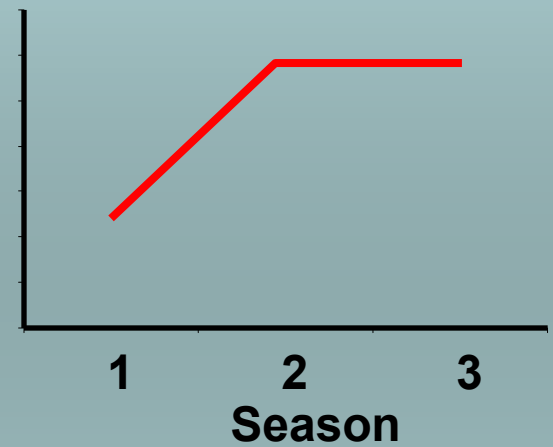
Harvested Biomass



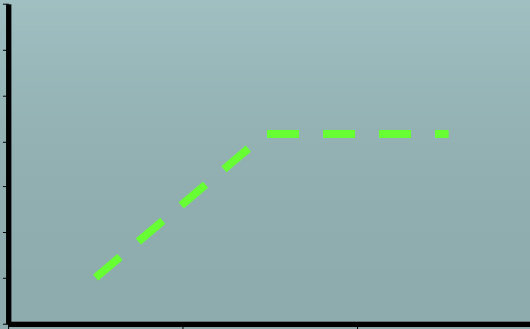
Metal Uptake



Extracted Metals



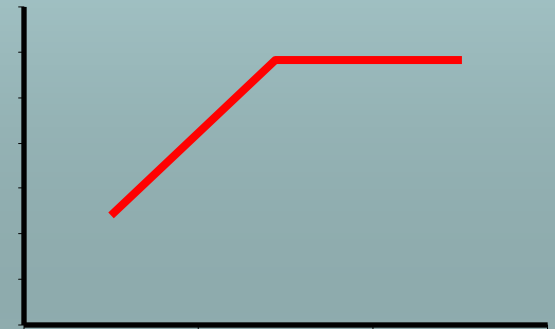
Harvested Biomass



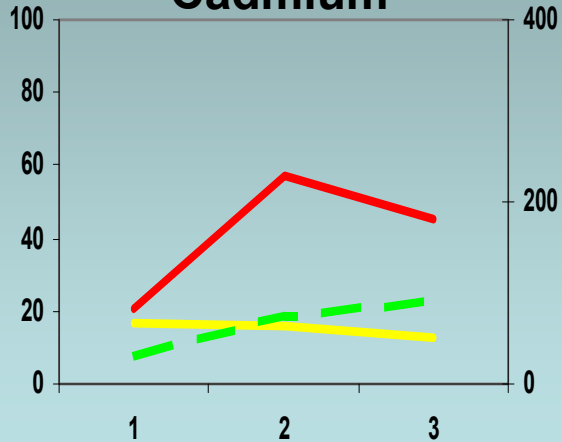
Metal Uptake



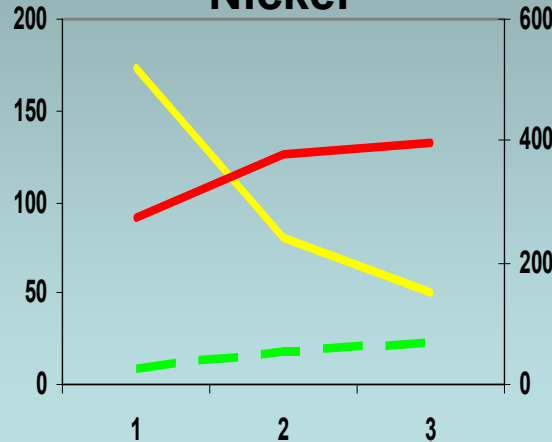
Extracted Metals



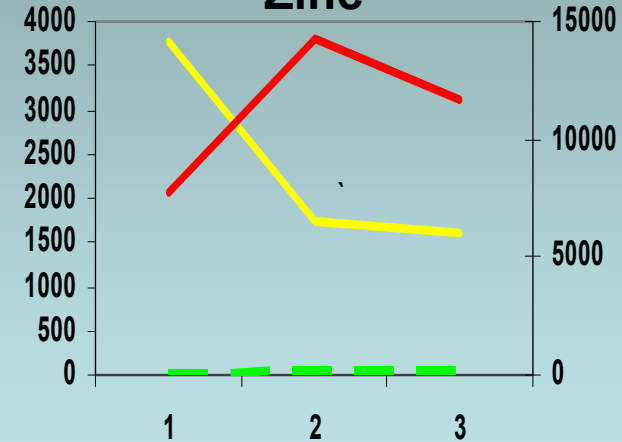
Cadmium



Nickel



Zinc



- **Willows**

- Metal extracted (Cd, Ni, Zn)
- Autumn ‘in leaf’ harvest
↑ metal removal
- Fresh water = unsustainable
- *S. reichardtii* - best biomass,
metal uptake and coppice regrowth



- Treated water discharged to Port Philip Bay
- Restrictions on fresh water use
- Large volumes of 'treated' water available



- Irrigation with ‘treated’ water
- 1.5-1.8 mS cm⁻¹
- Salinity?
- Metal bioavailability?
- Sustainable willow growth?



Acknowledgements

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Australian Government

Australian Research Council

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Thank you

