PLANNING for closure 2024

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Nature-Based Solutions for the Closure and Rehabilitation of Metal(loid)-Contaminated Mining Land

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Context

Nature-based Solutions for Environmental Rehabilitation

Mine closure process entails significant environmental challenges such as soil contamination and ecosystem impacts, as well as landscape fragmentation. Nature-based solutions prioritize natural processes and ecosystem-centric approaches to achieve remediation goals.

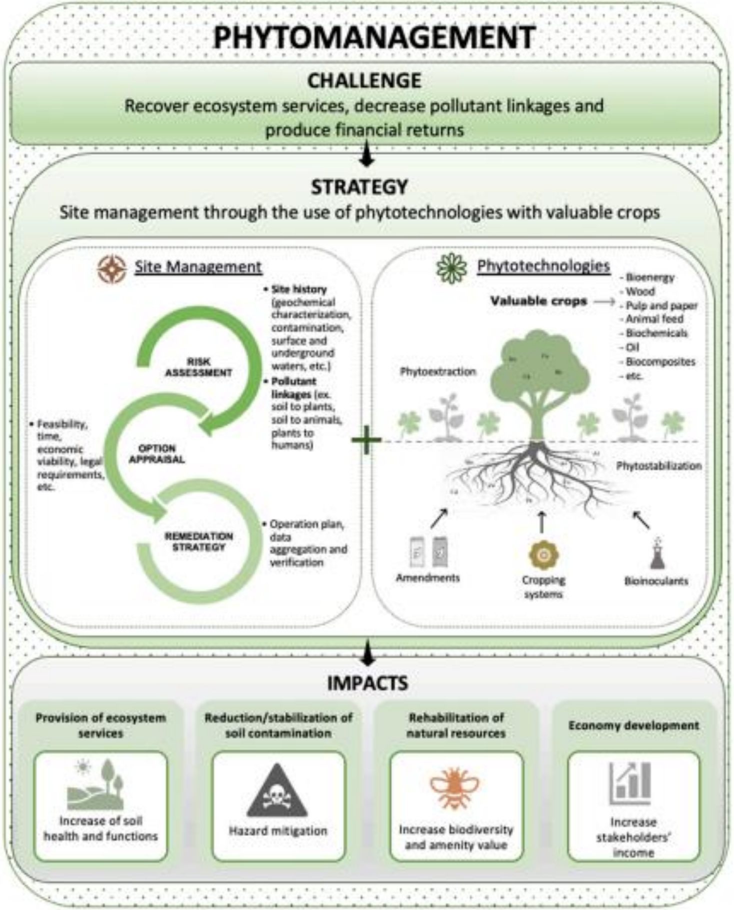
Long-term stability and resilience

Cost-efficient

Future land uses

Nature positive

(United Nations Environment Programme, 2003).



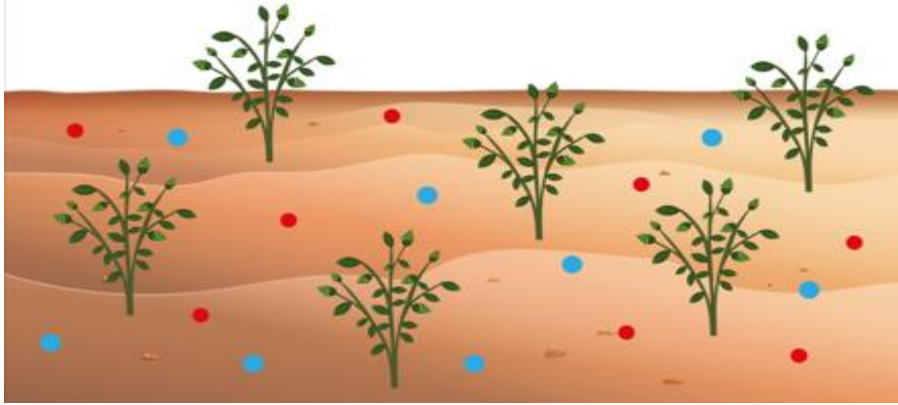
(Moreira *et al.*, 2021)

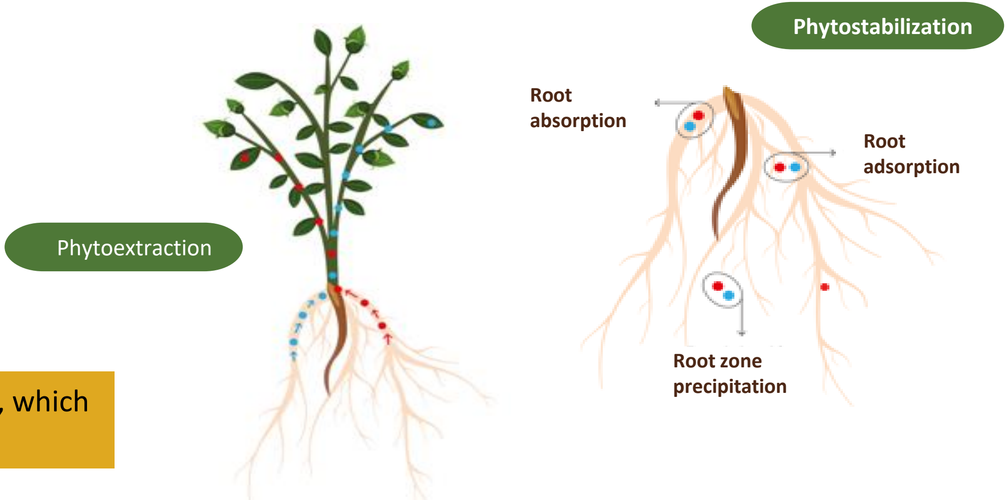
Phytomanagement

- Is a remediation strategy that combines reducing the risk associated with pollutants with creating value through the generation of ecosystem products and services.
- Wood, resin, bioenergy, and ecosystem services like carbon sequestration, erosion control, and biodiversity maintenance.

Phytoremediation

- Phytoremediation is the use of plants and their associated microorganisms for the functional improvement and recovery of contaminated soils.
- This study considers 2 main phytoremediation strategies: Phytoextraction and Phytostabilization





Prevents wind and water dispersion towards surrounding areas, which is of utmost relevance in arid or semi-arid climates.

Objective

Assess the ability of plant species to phytoaccumulate metals and metalloids in soils characterized by elevated total concentrations of As, B, Cu, and Mo within a pilot plot.

Site Characterization

- Pilot plot of 145 hectares cultivated with tolerant plant species for over 10 years, under an arid climate.
- Mining soils with the following average concentration: As (16.4 mg/kg), B (80.2 mg/kg), Cu (38.4 mg/kg), and Mo (4.7 mg/kg).
- Neither the crops nor the products are permitted for human or animal consumption.
- Identification of native species for spontaneous colonization.

Crops in the pilot plots

The plant species studied were:

1. *Acacia saligna* (Acacia)
2. *Simmondsia chinensis* (Jojoba)
3. *Salicornia bigelovii* (Salicornia)
4. the native species *Tessaria absinthioides* (Brea), identified *in situ* as spontaneous growth.

Methodology

Plant Sampling and Analysis

Visual assessment of specimens to be sampled (e.g., phytosanitary condition) → Sampling plant tissues → Analysis of the total concentration of As, B, Cu and Mo

Phytoremediation Indices

To assess the absorption and translocation capacity of metal(loid)s by cultivated species.

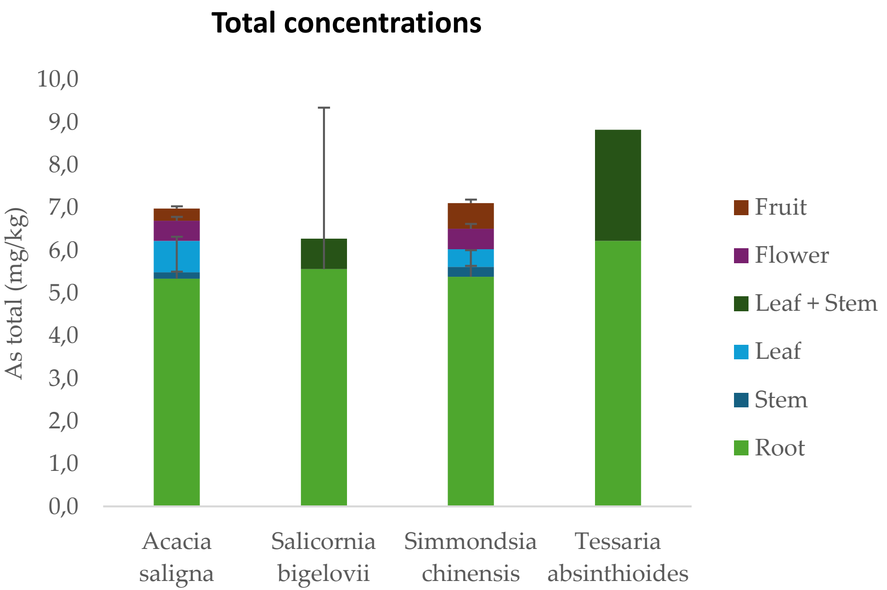
$$BCF = \frac{Total\ concentration\ of\ metal(loid)\ in\ aerial\ or\ root\ part\ (mg\ kg^{-1})}{Total\ concentration\ of\ metal(loid)\ in\ soil\ (mg\ kg^{-1})}$$

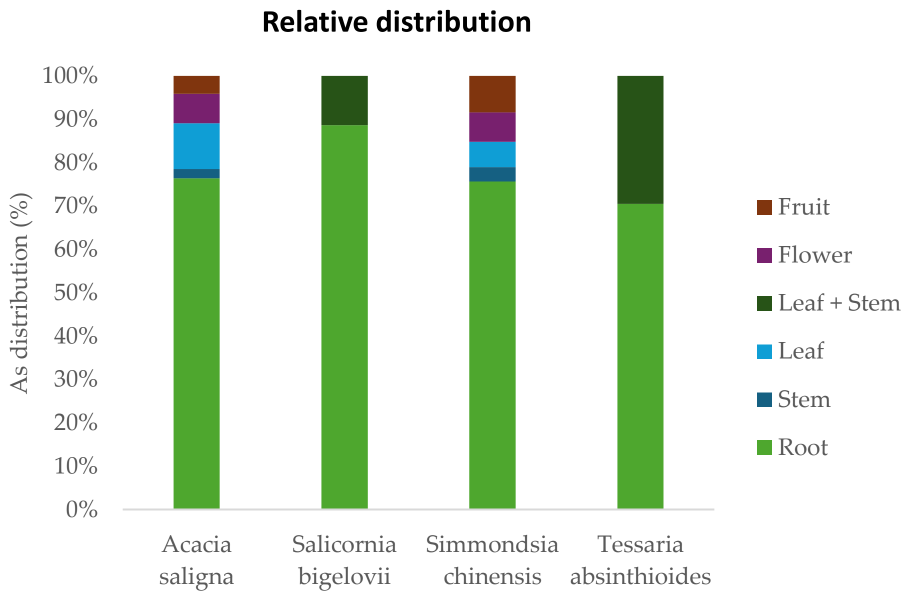
$$TF = \frac{Total\ concentration\ of\ metal(loid)\ in\ aerial\ part\ (mg\ kg^{-1})}{Total\ concentration\ of\ metal(loid)\ in\ roots\ (mg\ kg^{-1})}$$

BCF values > 1 indicating bioaccumulation and TF > 1 indicating high translocation capacity.

Results

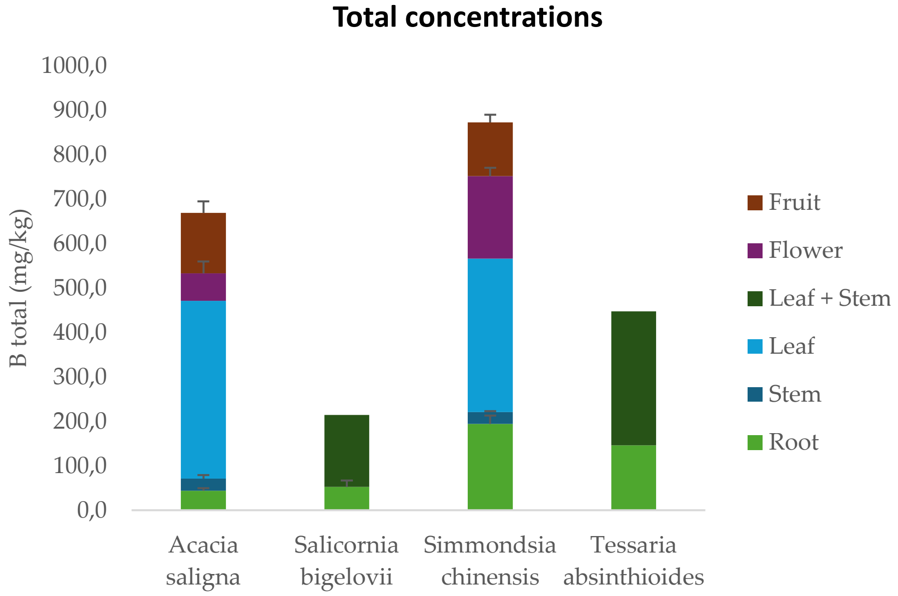
Arsenic in plants

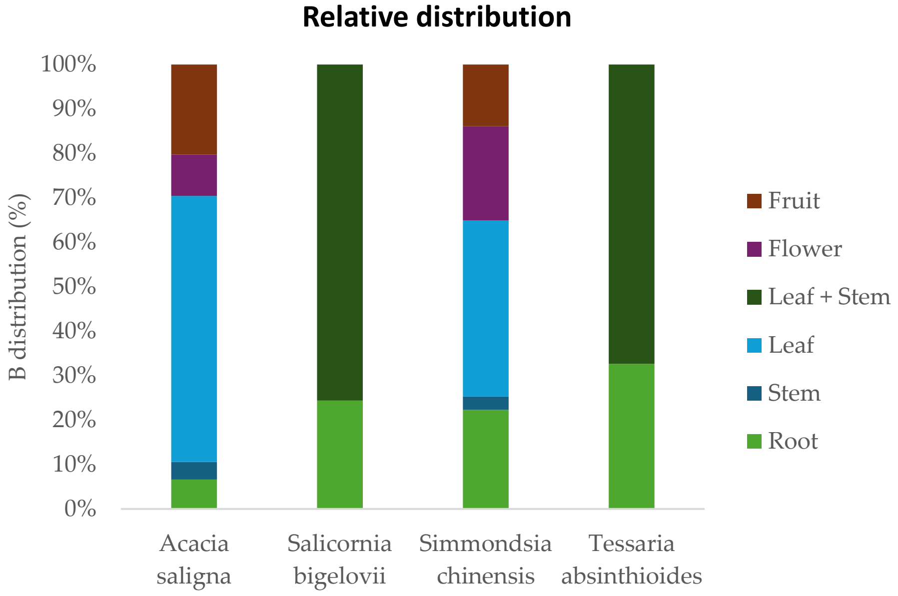




As in plants < than those found in soils, suggesting that As tends to remain preferentially in the soils, possibly adsorbed.

Boron in plants

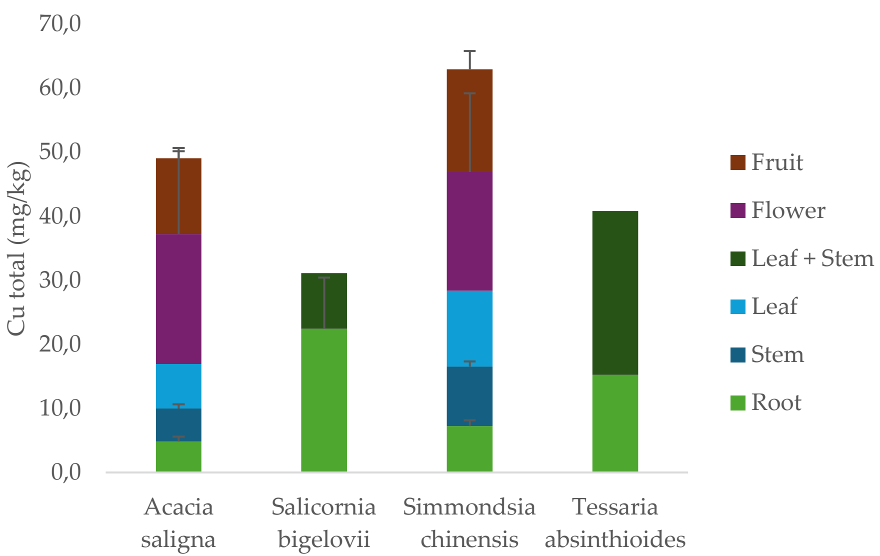




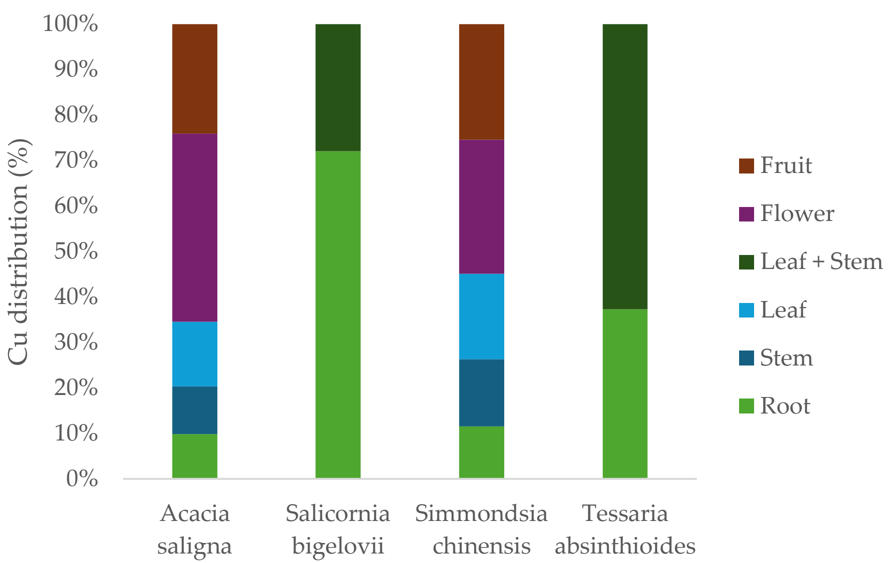
The minimum concentration of this element in the plants (200 mg/kg in *S. bigelovii*) was higher than the average content of B in subsurface soils (80 mg/kg), demonstrating the high capacity of these plant species to extract B from the soil.

Copper in plants

Total concentrations



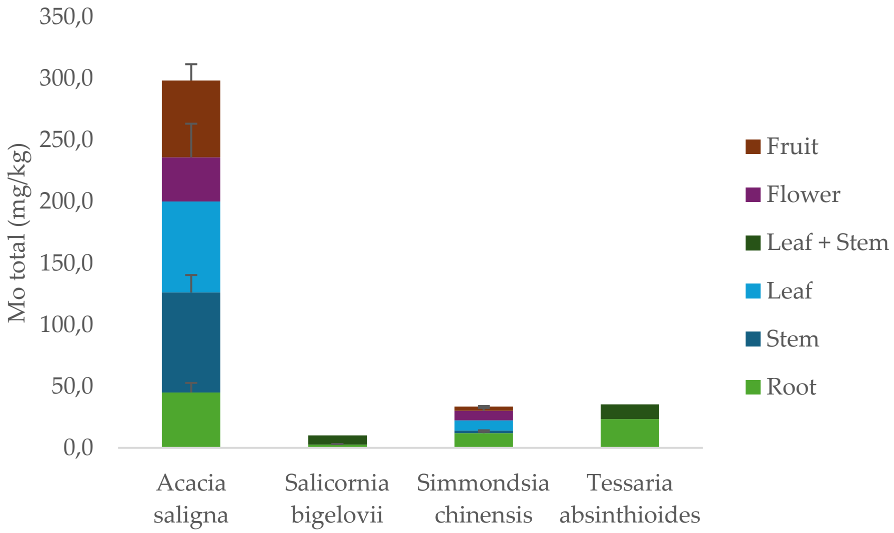
Relative distribution



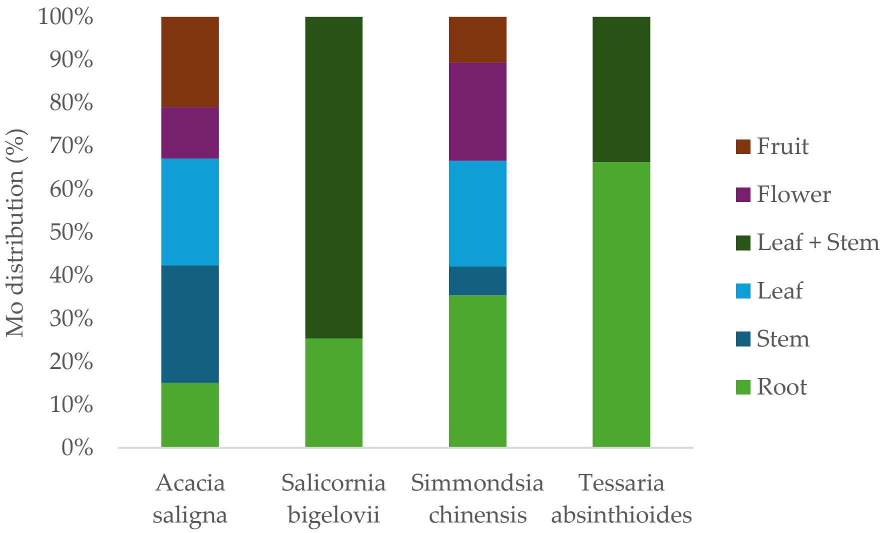
Generally, the concentrations of Cu found in the plants is at a sufficient or normal level according to the literature.

Molybdenum in plants

Total concentrations



Relative distribution



Generally, the concentrations of Mo found in the plants of the plot were higher than the concentrations of Mo found in the soils of the plot.

Phytoremediation Indices

Factor	Specie	As
BCF_{at}	*Simmondsia chinensis*	0.1 (0-0.2)
	Acacia saligna	0.1 (0-0.2)
	Salicornia bigelovii	0.1 (0-0.1)
	**Tessaria absinthioides*	0.1
BCF_r	*Simmondsia chinensis*	0.4 (0-2.1)
	Acacia saligna	0.3 (0.1-1.5)
	Salicornia bigelovii	0.3 (0-0.5)
	**Tessaria absinthioides*	0.2
TF	*Simmondsia chinensis*	0.3 (0-2.1)
	Acacia saligna	0.4 (0.1-1.3)
	Salicornia bigelovii	0.3 (0-0.4)
	**Tessaria absinthioides*	0.4

low bioaccumulation capacity
both BCF <1 and translocation TF <1

Phytoremediation Indices

Factor	Specie	B
BCF_{at}	*Simmondsia chinensis*	6 (0.3-21.5)
	Acacia saligna	5.8 (1.5-25.8)
	Salicornia bigelovii	3.6 (0-5.8)
	**Tessaria absinthioides*	1.6
BCF_r	*Simmondsia chinensis*	2.7 (0.1-8.8)
	Acacia saligna	0.6 (0.1-1.9)
	Salicornia bigelovii	0.8 (0-1)
	**Tessaria absinthioides*	0.8
TF	*Simmondsia chinensis*	5.4 (0.2-29.7)
	Acacia saligna	10.8 (3.8-25.3)
	Salicornia bigelovii	5.9 (0-10.5)
	**Tessaria absinthioides*	1.9

higher bioaccumulation BCFat > 1 (between ~2 and 10 times) than the BCFr

high capacity to translocation TF >1

Phytoremediation Indices

Factor	Specie	Cu
BCF_{at}	*Simmondsia chinensis*	0.8 (0.1-2.3)
	Acacia saligna	0.3 (0.1-0.7)
	Salicornia bigelovii	0.4 (0-0.5)
	**Tessaria absinthioides*	0.7
BCF_{r}	*Simmondsia chinensis*	0.2 (0.1-1.3)
	Acacia saligna	0.1 (0.1-0.4)
	Salicornia bigelovii	0.6 (0-0.9)
	**Tessaria absinthioides*	0.4
TF	*Simmondsia chinensis*	5.8 (0.4-20.5)
	Acacia saligna	3.1 (0.5-11)
	Salicornia bigelovii	0.8 (0-1.3)
	**Tessaria absinthioides*	1.7

low capacity
BCF < 1 high
and high capacity
to translocation
TF >1

Phytoremediation Indices

Factor	Specie	Mo
BCF_{at}	*Simmondsia chinensis*	3.4 (0.3-17.5)
	Acacia saligna	50.1 (11-95.9)
	Salicornia bigelovii	4.4 (0-7)
	**Tessaria absinthioides*	3.4
BCF_{r}	*Simmondsia chinensis*	3.8 (0-23.7)
	Acacia saligna	13.5 (0.8-44.5)
	Salicornia bigelovii	1 (0-1.2)
	**Tessaria absinthioides*	6.4
TF	*Simmondsia chinensis*	5.2 (0.3-14.9)
	Acacia saligna	4.6 (0.3-54.5)
	Salicornia bigelovii	1.1 (0-1.9)
	**Tessaria absinthioides*	6

higher bioaccumulation
BCF > 1
high capacity to translocation
TF >1

Conclusions

- The ability of plant species such as *Acacia saligna* and *Simmondsia chinensis* to absorb As, B, Cu y Mo from the soil, suggests their potential for use in contaminated soil rehabilitation programs.

- Considering species such as *Tessaria absinthioides* is crucial for the long-term success of rehabilitation initiatives, as it provides information on the adaptation and tolerance mechanisms of native species and contributes to biodiversity conservation.

- It is important to consider these findings in future studies in the field of biomass management and soil amendment programs. This will enable us to effectively address the environmental challenges associated with mine closure and move towards sustainable recovery of degraded soils.

- This approach highlights the potential of natural solutions for designing specific phytoremediation strategies rehabilitating metal(oid)-contaminated mining lands.

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Thanks

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