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Assessment of Rare Earth Elements Accumulation by Willow (*Salix spp.*) in Floating Treatment Wetlands

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Introduction.

- The demand for Rare Earth Elements (REEs) is rising globally due to their usage in advanced technologies. The reliance on clean energy minerals for imports prompts worries about supply chain weaknesses and geopolitical threats. The second most frequent REEs, Lanthanum (La), is gaining recognition as a critical environmental problem that could compromise ecosystems and public health. Neodymium (Nd) is a significant and globally demandable REE with generous financial advantages.

- Floating treatment wetlands (FTW) are nature-based solutions used to clean up open water systems like ponds, lakes, and rivers that have been contaminated by partially treated home wastewater and agricultural discharge.

- Willow species (*Salix* spp.) were selected for this study due to their fast growth, high biomass production, and exceptional capacity to uptake and tolerate heavy metals, making them ideal candidates for phytoremediation in floating treatment wetlands.

Aims

This study was designed to investigate the impact of combined doses of La and Nd on a) willow growth (height and biomass yield, b) phytoextraction efficiency of *Salix schwerinii* and *Klara* to accumulate La and Nd in willow biomass and translocate them into root and shoot under FTW.

Materials and Methods

- One willow species, "*Salix schwerinii*" and its cultivar "Klara" were grown under different concentrations of La and Nd amended water in ½ x Hoagland's solution (3 L/container) during May-June 2019 for a period of 8 weeks.

- Weekly height was measured using a scale. The leaves, stems, and roots were separated and oven dried for 48 hours at 50°C and weighed using a digital scale.

- The dehydrated and ashed willow samples were analyzed in a chemical lab at the University of Eastern Finland Kuopio, using ICP-MS according to the standard operating procedures and EPA methodology (EPA 3051).

Results

Table 1. *Salix schwerinii* (SW) and Klara (KL) total dry weight (TDW), tolerance index (Ti), and dry biomass allocation (shoot: root %) determined in different treatments (T0–T3) for 8 weeks ($n = 4$).

Treatment	Cultivars	TDW (g)	Ti	Shoot (%)	Root (%)
T0	SW	22.78[a]		90	10
	KL	32.45[b]		92	8
T1	SW	25.91[a]	1.14[a]	91	9
	KL	17.92[b]	0.55[b]	93	7
T2	SW	21.59[a]	0.95[a]	90	10
	KL	31.23[b]	0.96[a]	94	6
T3	SW	24.65[a]	1.08[a]	91	9
	KL	29.54[a]	0.91[b]	93	7

Table 2. Translocation factor (TF) and bioconcentration factor (BF) values of willow under different doses of La and Nd.

		TF		BF	
Treatment	**Willow**	**La**	**Nd**	**La**	**Nd**
T1	SW	0.01	0.01	6.04	3.82
	KL	0.01	0.01	4.82	2.98
T2	SW	0.01	0.01	7.11	4.84
	KL	0.01	0.01	8.35	5.46
T3	SW	0	0	12.97	8.76
	KL	0	0	13.81	8.95

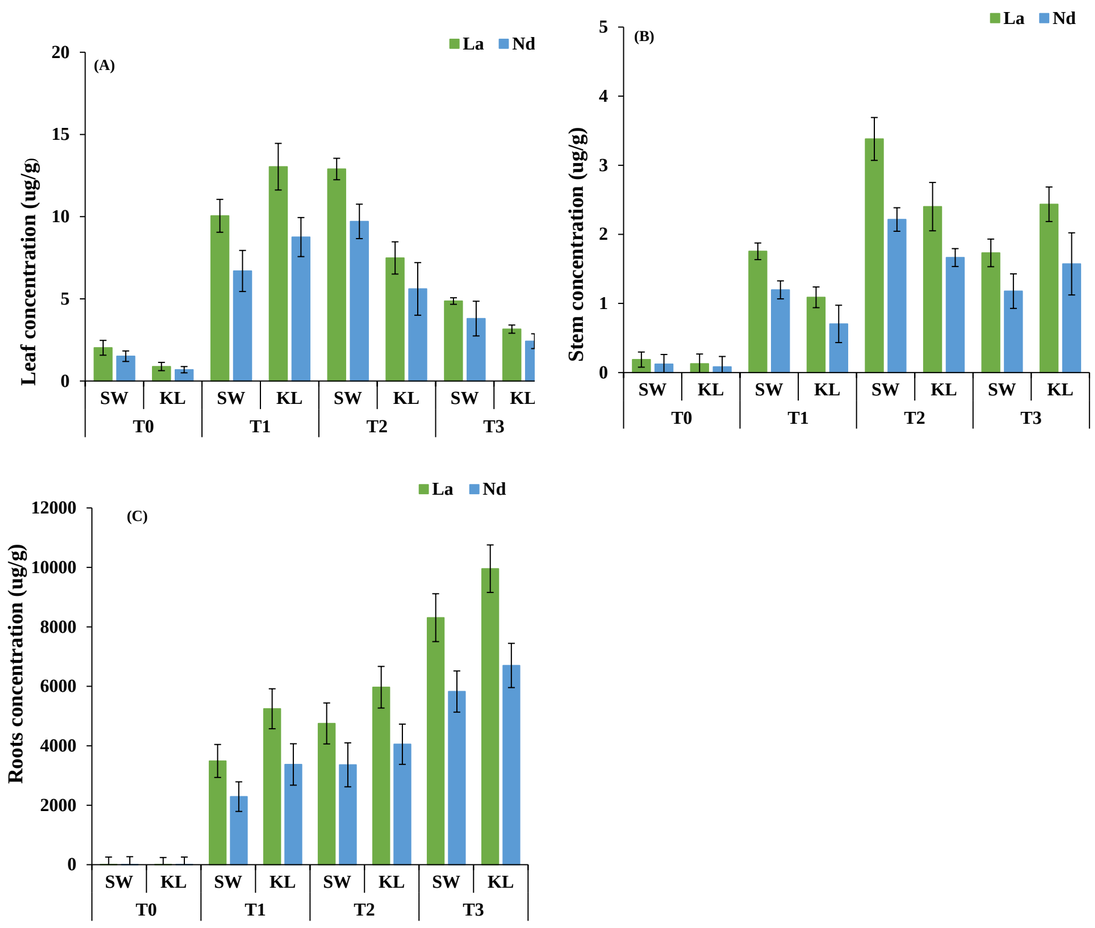

Figure 2. Mean comparisons of Lanthanum (La) and Neodymium (Nd) concentrations in *Salix schwerinii* (SW) and Klara (KL) leaves **A)** stem **B)** and roots **C)** under different doses of La and Nd (T0–T3) for 8 weeks.

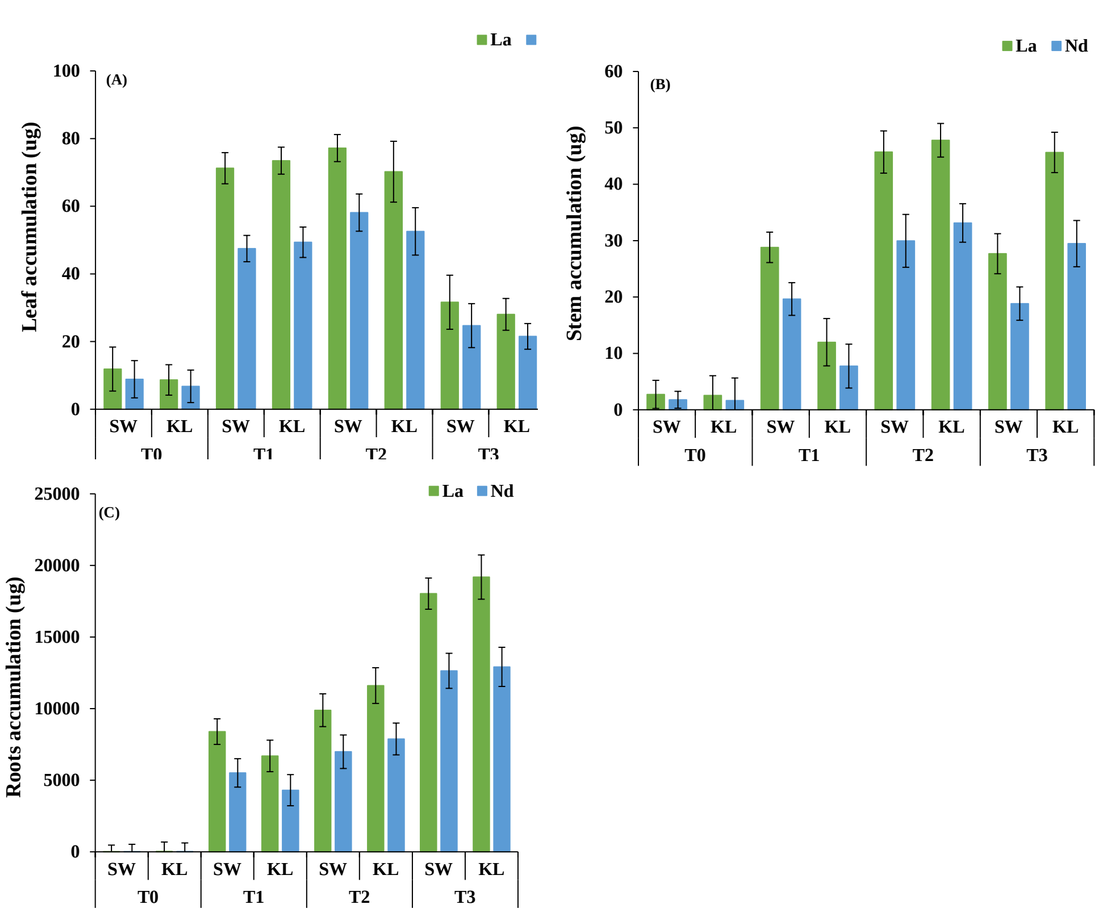

Figure 3. Mean comparisons of Lanthanum (La) and Neodymium (Nd) accumulation in *Salix schwerinii* (SW) and Klara (KL) leaves A) stem B) and roots C) grown under different doses of La and Nd (T0–T3) for 8 weeks.

Conclusions

The findings reveal that La and Nd were primarily retained in the roots of willow, limiting their translocation to the shoots. These results suggest that willow holds strong potential as a candidate for the remediation of REEs, as well as for treating industrial and mining wastewater, by helping to prevent metal percolation into freshwater resources.

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