Macroalgae as green sorbents to recover Rare-earth elements from contaminated solutions

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Introduction

- Rare-Earth Elements (REE) are virtually irreplaceable in modern industry. Despite this, REE production and supply is severely constricted by geopolitical factors.
- The development of efficient, environmentally friendly alternatives for the recovery of REE from secondary sources is the only way to avoid a continuous depletion of these resources
- Biological technologies have shown to be a promising alternative to conventional recycling methods.

Figure 1. Algae species utilized as sorbents in the present study (left to right): *Ulva lactuca, Fucus vesiculosus* and *Gracilaria gracilis*.

Methodology

The ability of living macroalgae to remove REEs from solution was evaluated through tests of exposure of the algae species *Ulva lactuca*, *Fucus vesiculosus* and *Gracilaria gracilis* (**Figure 1**) to mono-spiked saline solutions of Y, Ce, Pr, Nd, Eu, Gd, Tb and Dy for 72 hours. The design of the experiments is described in **Figure 2**.

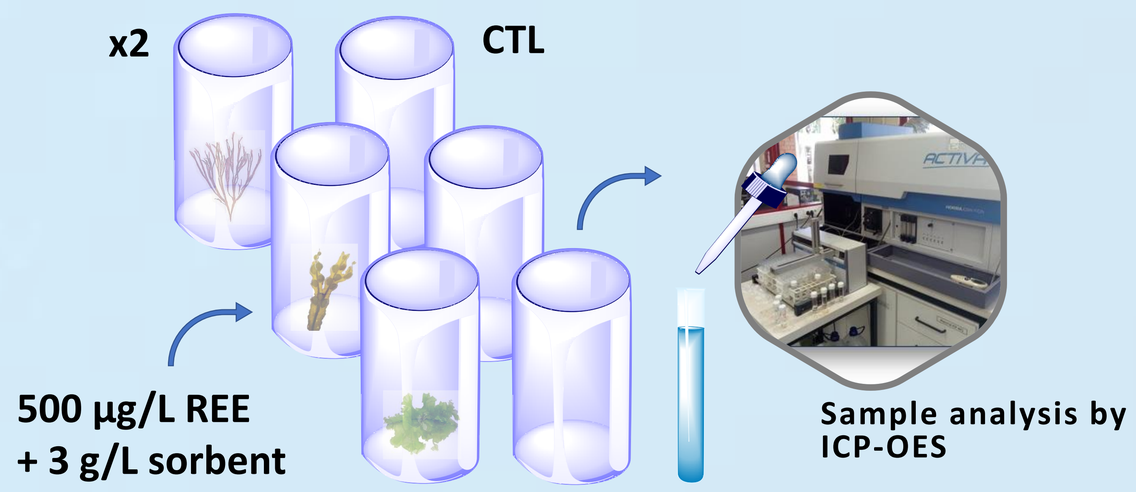

Figure 2. Experimental design of the sorption experiments

Results and discussion

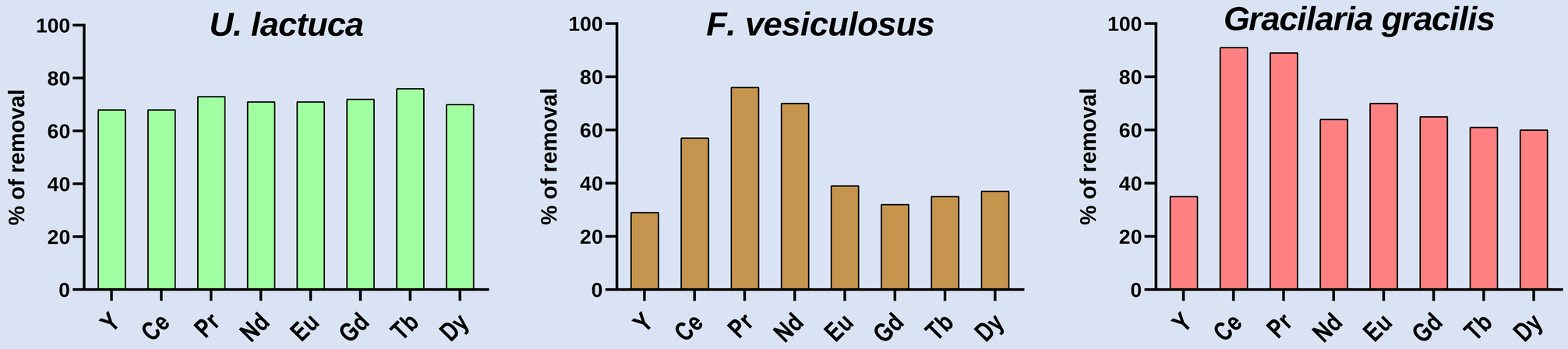

Figure 3. Removal efficiency of 500 µg/L of seven rare-earth elements by *Ulva lactuca, Fucus vesiculosus* and *Gracilaria gracilis*.

- *U. lactuca* removed all REE equally with efficiencies over 60%
- *F. vesiculosus* displayed lower efficiencies in general, with a preference towards REE with lower atomic number (Light REE)
- *G. gracilis* displayed high removal efficiencies for all elements, however, Light REE were more easily removed (note that Y is a Heavy REE).

Macroalgae efficiency

Algae growth and surface area can affect removal efficiency. Thus, since *U. lactuca* with high growth rates and a large surface area, it also has a high removal capacity. *G. gracilis* has a low growth rate but a high surface area, which can also justify its high capacity to remove these elements. *F. vesiculosus* is rich in alginates, known for their high metal uptake capacity. However, their compact structure may limit the binding of the elements in solution to the algae tissue.

Differences between elements

A preference towards Light REE was verified for G. gracilis and F. vesiculosus. These elements, have lower atomic mass and greater ionic radius, which can facilitate their sorption.

Conclusion

Algae can be an ecologically sustainable alternative to currently applied technologies. *U. lactuca* stands out as a sorbent compared to other algae, not only due to the high % removal it obtained, but also because it proved to be more resistant to laboratory conditions, presents higher growth rates and exists abundantly in the environment. The results obtained for *G. gracilis* reveal that this species is also a good alternative, however, its low growth rate may eventually prove to be a disadvantage. Results also indicate that light REE are more easily removed by species other than *U. lactuca*.

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