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Removal of Rare Earths from Contaminated Water by Natural Marine Sponges: Optimization by Response Surface Methodology

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Extended Abstract

The transition from traditional to greener energy sources (e.g., wind turbines) and countless high-tech devices rely on rare-earth elements (REE), whose mining and processing are environmentally unfriendly [1]. Increasing REE concentrations in water bodies due to ineffective treatment in wastewater treatment plants and leaching from untreated e-waste have been reported worldwide [2]. Recent studies have shown that REE have toxic effects on aquatic organisms, underscoring the importance of removing these emerging contaminants from water [3].

This work aimed to develop a simple, eco-friendly, and sustainable method for removing REE from contaminated waters, based on the use of natural marine sponge (MS), an abundant and inexpensive material with large surface area [4]. Further goals of the work were to understand the influence of key operating parameters (pH, REE initial concentration and MS dose) and to optimize the removal process.

The MS was first evaluated in a mixture of 9 REE: yttrium, lanthanum, cerium, praseodymium, neodymium, europium, gadolinium, terbium, and dysprosium, in ultrapure and spring water; and then the process was optimized using the Response Surface Methodology with a Box-Benhken design of 3-factors in 3 equidistant levels: pH (4 – 8), REE initial concentration (1 – 5 µM) and MS dose (20 – 180 mg/L). The concentrations of REE in water were determined by ICP-MS.

The results showed a very promising removal capability of MS (up to 90 % removal in 24 h). A positive effect of increasing pH and particularly sorbent dose on removal was observed. Model equations describing the removal as a function of the significant variables were successfully developed, which allowed to predict the optimal conditions. Optimal experimentally validated conditions allowed virtually 100 % removal of Y and Eu in just 6 h. The MS can be regenerated and reused, allowing the REE to be recovered. The proposed approach brings a double benefit: decontamination of water and recovery of REE (elements of high economic and technological interest, currently classified as critical raw materials).

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