Journal of Radioanalytical and Nuclear Chemistry
https://doi.org/10.1007/s10967-019-06514-9

Application of tracer technique in remediation of Sr(II) from simulated low level radioactive waste

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Received: 1 March 2019

Abstract
Uptake of Sr(II) from simulated low level radioactive waste, employing radiotracer $^{85+89}$Sr, has been carried out with humic acid by a batch equilibration biosorption study. The process exhibited rapid kinetics and at optimized parameters, Sr(II) was biosorbed from simulated reactor and reprocessing waste by 84 ± 2% and 75 ± 2% respectively. Kinetic modelling revealed that the process follows Ho and McKay's linear pseudo second order kinetics, indicating chemisorption mechanism of binding. Thermodynamic studies ascertain the exothermic, spontaneous and feasible nature of the process. This work proved the viability of humic acid for Sr(II) removal as an eco-friendly, cost effective alternative to conventional techniques.

Keywords Biosorption · Strontium · Low level radioactive waste · Humic acid · Tracer technique

Introduction

^{90}Sr is a persistent fission product present in our ecosphere due to its long half-life of 28.8 years. Anthropogenic activities such as nuclear fission, past atmospheric nuclear weapons tests, nuclear accidents, spent fuel reprocessing plants and radiation research laboratories are major sources of ^{90}Sr, which, along with ^{137}Cs forms an abundant part of Low Level Radioactive Waste (LLRW). These radionuclides contribute significantly to the overall radiation dose of an LLRW disposal facility [1] and must be treated with caution due to their hazardous nature.

This article focusses on the removal of radioactive Sr(II) from LLRW. The well-known toxic nature [2] of ^{90}Sr, as well as its applications in Radioisotope Thermoelectric Generators (RTGs) [3], medical sciences, and industries, demand its extraction from nuclear effluents of reactor and reprocessing plants by an environmentally cautious and green technique. Out of the existing green methods, there has been a tremendous amount of attention given to the technique of biosorption, which employs natural and modified substances for the removal of radionuclides and heavy metals from solutions [4–7].

Literature survey reveals that Sr(II) and its radioactive counterparts like ^{90}Sr and ^{85}Sr have been separated from aqueous solutions by employing water imbibed seeds of *Ocimum basilicum* [8], chemically modified biosorbents derived from *Azolla filiculoides* [9], immobilized moss [10], lichen like *Hypogymnia physodes* [11], modified eggshell waste [12], saponified orange juice residue [6], roots of *Taraxacum officinale* [13] and dry cowdung powder [14]. A diverse range of microbial cultures including *Scenedesmus spinosus* [15], *Aspergillus terreus* [16], *Saccharomyces cerevisiae* [17], *Oscillatoria homogenea* cyanobacterium [18], among several others [19–21] have also been employed for the biosorption of Sr(II). Most of these sorbents require extensive pre-treatment processes and longer durations of reaction time, some require living microbial flora for uptake of metal ions, which adds on to the sludge produced, questioning the green nature of the process. From the aforementioned biosorbents, dry cowdung powder (DCP) [14] is a notch over the others as it is a humified biological waste matter, not requiring any pre-treatment. Its notable high affinity for Sr(II) is intriguing, thus the present investigation attempts to explore the potentiality of humic acid, a prime component of DCP, for the uptake of Sr(II).

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s10967-019-06514-9) contains supplementary material, which is available to authorized users.

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Published online: 15 April 2019