Cesium Removal From Aqueous Solution by Bioaccumulation of Microalgae

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1. Introduction

Radioactive cesium (Cs^+) in the environment has been a matter of serious concern because of its long half-life (30 yrs) and high water solubility. Thus, hazardous quantities of Cs^+ will remain in the environment for centuries and living organisms easily absorb Cs^+ mistaking it for harmless potassium [1]. Recently, increased attention has been directed on the use of biological technologies for the removal of radionuclides as the cheap and eco-friendly alternative to the non-biological methods. Metal including radioactive compounds uptake by microorganisms can be occurred by metabolism – independent and/or -dependent processes. One involves biosorption based on the ability of microbial cells to bind dissolved metals; on the other involves bioaccumulation, which depends on the metabolic ability of cells to transport metals into the cytoplasm [2, 3]. The purpose of this work is to investigate the feasibility of microalgae in bioaccumulation system to remove cesium from solution. The effect of different environmental parameters on cesium removal was also examined. Finally, the Cs-containing microalgae can be easily separated from a treated solution using positively charged surfactant coated magnetic nanoparticles.

2. Materials and methods

2.1 Microalgae

All experiments were carried out with *Desmodesmus armatus* SCK, which was isolated from wastewater treatment plant as cesium-accumulating microalgae (Fig. 1). Cells used for the bioaccumulation system were cultured in TAP medium and incubated at 25℃ (Fig. 2).

Fig. 1. New algal strain, Desmodesmus armatus SCK.

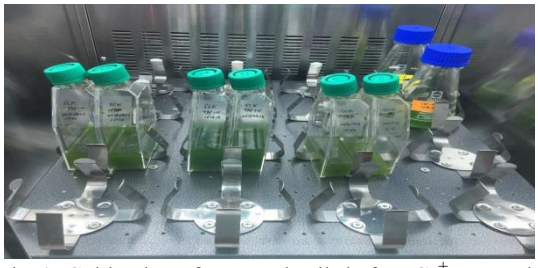

Fig. 2. Cultivation of prepared cells before Cs^+ removal tests.

2.2 Cs^+ removal experiments

For Cs^+ uptake tests, cells in the early stationary growth phase were collected by centrifugation and then suspended in 20 mM Tris buffer solution containing CsCl with 1 g/L biomass loading. All cell suspensions were incubated at 25℃ with rotary shaking (120 rpm). In order to measure the Cs^+ concentration, the medium was filtered through 0.2 micron filter and analyzed by inductively coupled plasma-mass spectrometry (ICP-MS). The Cs^+ removal efficiency was calculated as the difference in the Cs^+ concentration in the medium at initial and final condition.

2.3 Separation of Cs-containing microalgae

Cationic surfactant coated magnetic nanoparticles (MNP) were synthesized according to previously reported co-precipitation method using iron salts ($FeCl_3 \cdot 6H_2O$ and $FeCl_2 \cdot 4H_2O$), and polyethyleneimine (PEI) [4]. The microalgae-PEI coated MNP flocs were separated from the solution using an external magnet.

3. Results and discussion

3.1 Assessment of Cs^+ removal by D. armatus SCK

First of all, *D. armatus* SCK, cultivated in nutrient broth media amended with Cs^+, were able to survive Cs^+ concentration as high as 1 mM.

As shown in Fig. 2, Cs^+ uptake of the *D. armatus* SCK increased with increasing the initial Cs^+ concentration and reached a saturated value at 500 μM.

Maximum equilibrium uptake of Cs^+ ions was determined as 280 μM showing 70% removal efficiency at 400 μM.

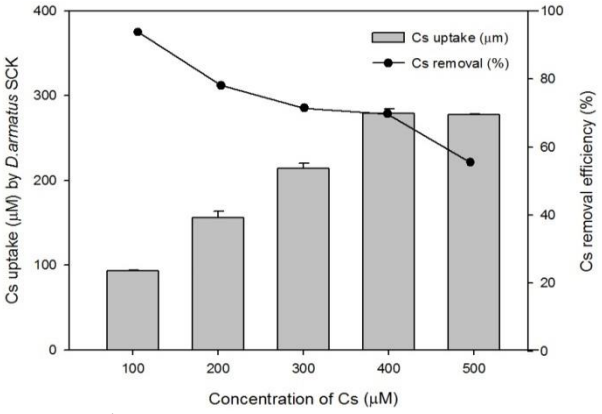

Fig. 3. Cs^+ uptake by *D. armatus* SCK with different Cs concentrations.

The chemical similarity of Cs^+ and other alkali monovalent cations, in particular K, is the key factor that governs the high mobility of Cs^+ in biological systems [5]. Cs^+ accumulation by *D. armatus* SCK was decreased at high K^+ concentrations as shown in Fig. 3, which can be explained by the inhibitory effects of K on microalgal Cs^+ uptake. In fresh water, however, K^+ concentrations are generally below 3 mg/L, and thus the inhibition of Cs^+ uptake by K^+ could be neglected.

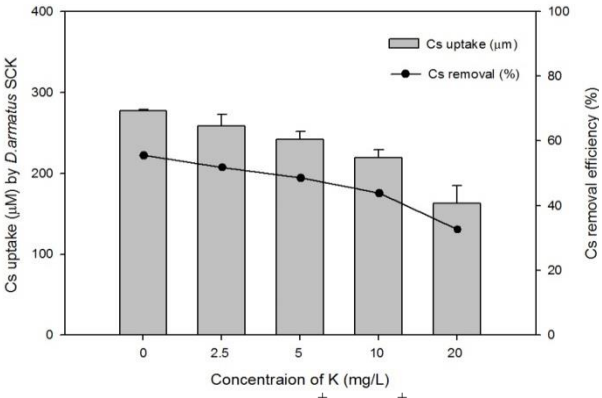

Fig. 4. Effect of potassium (K^+) on Cs^+ uptake by *D. armatus* SCK.

3.2. Separation of Cs-containing microalgae using PEI-MNP

Fig. 5 shows images of the flocculation of microalgae by PEI-MNP and the subsequent magnetic separation. The separation by the external magnetic field was completed within 3 min, as confirmed by the clear supernatant.

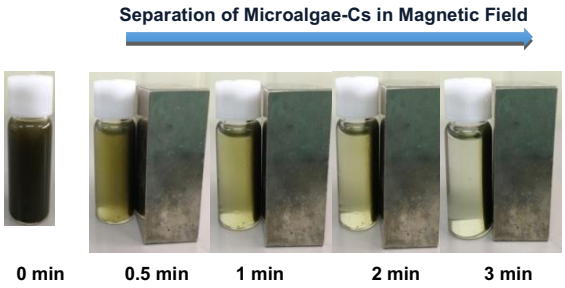

Fig. 5. Separation of Cs-containing microalgae using PEI-MNP.

4. Conclusion

The aim of this work is to confirm the possibility of selected one of microalgae in the uptake of Cs^+. The obtained results showed the maximum Cs^+ removal by *D. armatus* SCK was 280 μM indicating 70% removal efficiency. Also, *D. armatus* SCK could uptake Cs^+ in the presence of K^+, is particularly known to be transported into cells as an analog of Cs^+ in freshwater condition. Furthermore, the cationic surfactant coated magnetic nanoparticles were easily applied to separate Cs-containing microalgae from aqueous solution.

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