Innovative Biological Method to Remove Cesium-137

Seung Yeop Lee*, Jae Kwang Lee, Min Hoon Baik, and Bum Kyoung Seo
Korea Atomic Energy Research Institute, 111, Daedeok-daero 989beon-gil, Yuseong-gu, Daejeon, Republic of Korea
*seungylee@kaeri.re.kr

1. Introduction

Nuclear accidents such as Chernobyl and Fukushima reactors' breakdown can cause an enormous emission of various radioactive nuclides into the environments. The main nuclides that were released from the reactor were radioactive I and Cs. The Cesium-137, one of them, could give an impact on ecosystem and human beings in the long-term period due to its long half-lives of 30 y.

Thus, we need to have an effective method to remove radioactive Cs-137. Recently, various exchanger and getter materials have been developed to uptake radioactive cesium from wastewaters. The adsorbent materials that have been developed usually showed a nice performance under fresh water conditions. However, the adsorption amounts were not large in seawater conditions. Furthermore, the cost to synthesize the adsorbents was high and their final waste volumes were not small.

Our new method that is proposed here offer great cost cutting by using bacteria, which are isolated from underground. This method is to crystallize soluble cesium into a solid matter through biochemical reactions. The biological selectivity of cesium in cation-rich seawater is relatively high and thus radioactive waste volume is very small. We think that it is an innovative and environment-friendly method that removes Cs-137 by both effective and low-cost way.

2. Methods & results

2.1 Methods

The SRB (sulfate reducing bacteria) isolated from natural bentonite or groundwater [1] were used in our experiment. To study the selective cesium removal and biomineralization from some cation-rich fresh or seawaters, we anaerobically prepared various solutions in serum bottles. From the cesium stock solution, 0.01-10 ppm of cesium were aseptically injected into the serum bottles containing other components, such as SO_4^{2-}, which was used as a basic chemical to biologically form "pautovite ($CsFe_2S_3$)", a cesium-mineral.

To perform a practical test using cesium radioisotope, a stock solution of radioactive cesium-137 (half-life of 30 years) was prepared and injected into serum bottles to be initially 133 Bq/ml radioactivity. Finally, cells were injected into the serum bottles providing ca. 0.75 mg/l cell protein, to determine the microbial effect on the removal of cesium. The prepared serum bottles were put into a shaker with 120 rpm at 30℃ in the dark for 5 days.

2.2 Removal of Aqueous Cesium

Among the additives, some organic matters were used as electron donors to reduce sulfate to sulfide by the activity of bacteria. When sulfide (S^{2-}) is produced by the reduction of sulfate (SO_4^{2-}) [2], it combined with metals to form 'sulfide minerals'.

In our experiment in a freshwater, about 95% of cesium was removed from the solution in a condition of Cs 0.1 ppm (Fig. 1). In 0.01 ppm concentration, most of cesium (nearly 100%) was removed from the solution after 1 day of the reaction. This result shows that our method is very effective to remove cesium compared with other previous technologies. This way has an additional advantage to produce a very small waste volume that is less than 0.1 g/l.

The traditional method to remove cesium was based on the adsorption of cesium onto the adsorbents. Thus, the selectivity of cesium is limited in the cation-rich wastewater such as seawater due to the competitive effect of various cations. However, our method is to make soluble cesium precipitated as a solid matter, "pautovite". In the process, the cesium removal is very selective and its byproduct is a solid sulfide mineral, which is stable at natural field (e.g., undergournd).

In seawater condition, our method was compared to the traditional way of using an adsorbent (IONSIV R9160-G), which is currently used as the practical adsorbent for removing radioactive cesium in Fukushima, Japan. The test was performed by injecting Cs-137 into seawater for 5 days under the same condition. As a result, it showed that the way that used bacteria was very powerful to effectively remove radioactive Cs-137.

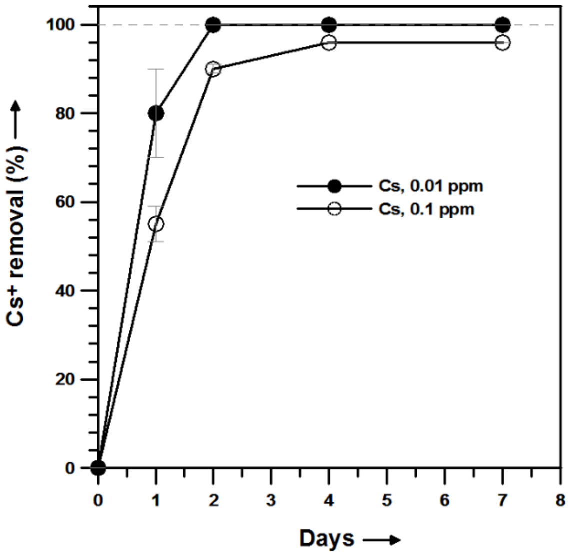

Fig. 1. Characteristic cesium removal patterns for Cs-containing freshwaters by microbial cesium biomineralization.

3. Conclusion

After the Fukushima reactor accident, many studies for the removal of Cs were carried out to make and develop very effective adsorbents. However, they have ignored the practical environment that highly costs to purify the wastewater and dispose a large volume of wastes, only focusing on the rapid removal of cesium. With our innovative biotechnology, we overcame such problems by using natural bacteria, by which soluble cesium can be easily transformed into a stable and solid matter with a compact volume even in seawater conditions.

REFERENCES

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