Remediation of Soil Contaminated with Uranium using a Biological Method

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1. Introduction

Bioremediation is a method to cleanup contaminants in soil or ground water with microorganisms. The biological method can reduce the volume of waste-solution and the construction cost and operation cost of soil remediation equipment. Bioremediation can be divided into natural attenuation, bioaugmentation, biostimulation. Biostimulation is technology to improve natural purification by adding nutritional substances, supplying oxygen and controlling pH.

In this study, penatron, that is a nutritional substances, was mixed with soil. Optimum conditions for mixing ratios of penatron and soil, and the pH of soil was determined through several bioremediation experiments with soil contaminated with uranium. Also, under optimum experiment conditions, the removal efficiencies of soil and concrete according to reaction time were measured for feasibility analysis of soil and concrete bioremediations.

2. Methods and Results

400g of soil/concrete contaminated with uranium was put in a 500ml beaker. Several beaker samples were used to obtain optimum experimental conditions for bioremediation. The soil/concrete was mixed with penatron, that is organic enzyme bacterial system, and then the mixed soil/concrete was put in an incubator for bioremediation at 25 ℃. 20 g of soil/concrete was extracted from the beaker per 15～30 days, which was put on sieve of 0.075 mm and was washed with distilled water for removal of bacterial cells including uranium from the soil and concrete. The washed soil/concrete was dried and its radioactive concentration was measured by MCA (Multi-Channel Analyzer).

2.1 An Optimum mixing ratio of penatron

An optimum mixing ratio of penatron was obtained through bioremediation experiments for soil contaminated with uranium. Fig. 1 shows uranium concentration according to reaction time under different injection ratio of penatron. On injection of 0.5 % penatron, the uranium in soil was removed by 45.8 % for 30 days. On injection of 1 % penatron, the uranium in soil was removed by 76.4 % for 30 days. And on injection of 2 % penatron, the uranium in soil was removed by 62.7 % for 30days. That is, on injection of beyond 2 % penatron, the removal efficiency of uranium from soil was reduced. Therefore it was found that an optimum mixing ratio of penatron for bioremediation of uranium soil was 1 %.

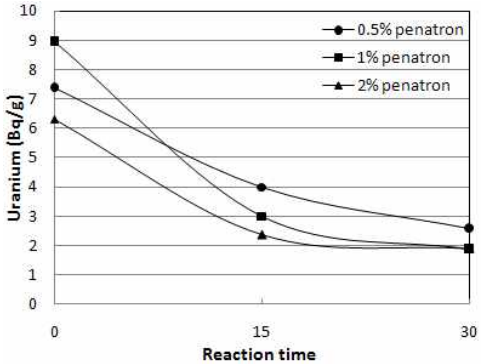

Fig. 1. Uranium concentration according to reaction time under different injection ratio of penatron

2.2 The effect of bioremediation according to pH

The optimum pH for soil contaminated with uranium was obtained through several bioremediation experiments with different pH soils. Fig. 2 shows uranium concentration according to reaction time under different pH conditions. In the pH 6.0 soil, the uranium was removed by 77.0 % for 30 days. In the pH 7.5 soil, the uranium was removed by 79.2 % for 30 days. In the pH 8.5 soil, the uranium was removed by 66.0 % for 30 days. That is, in soil with the pH greater than 7.5, the removal efficiency of uranium from soil was reduced. Therefore it was found that the optimum pH condition for bioremediation of uranium soil was 7.5.

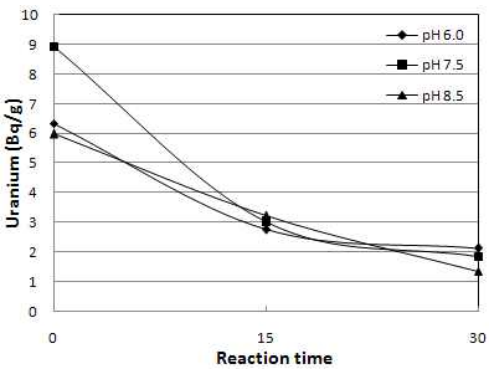

Fig. 2.Uranium concentration according to reaction time under different pH conditions

2.3 The effect of bioremediation according to initial uranium concentration of soil

The effect of bioremediation according to initial concentration of soil was analyzed through several bioremediation experiments with different uranium initial concentration of soils. Fig. 3 shows uranium concentration according to reaction time under different initial concentrations. With lower uranium concentrations, the uranium in soil was removed by 80.0 % for 30 days. With higher uranium concentrations, the uranium in soil was removed by 60.5 % for 30 days. That is, under higher uranium concentrations, the removal efficiency of uranium from soil was reduced. The reason was thought to be that bacterium in soil under higher uranium concentration died due to higher radioactivity.

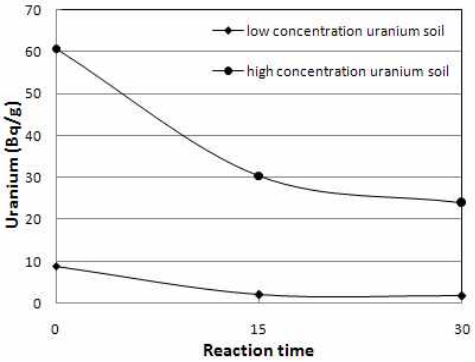

Fig. 3.Uranium concentration according to reaction time under different initial concentrations

2.4 Feasibility analysis of concrete bioremediation

A bioremediation experiment for the removal of uranium from concrete were carried out under injection of 1 % penatron at pH 7.5. Fig. 4 shows a comparison of uranium removal efficiencies in concrete and soil according to reaction time. The uranium in soil was removed by 79.2 % for 30 days, while the uranium in concrete was removed by 58.2 %. It was discovered that the removal of uranium in concrete by bioremediation is possible but the removal rate from concrete was slower than that from soil. The reason was thought to be that the number of bacterium in concrete was smaller than that in soil due to high pH of concrete.

Fig. 5 shows uranium radioactivity concentrations in soil and according to reaction time for 120 days. The uranium in soil was removed by 81.4 % for 120 days. The uranium in concrete was removed by 63.0% for 120 days. Beyond 30 days, removal rates of uranium from soil and concrete by bioremediation was very slow. Therefore, future study to increase removal efficiency by bioremediation after 30 days is needed.

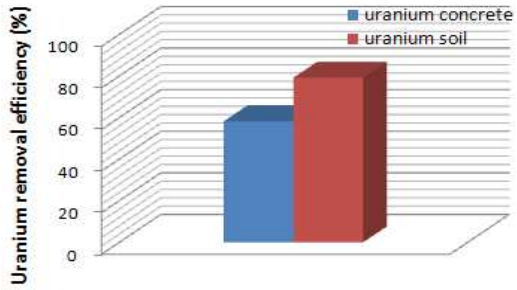

Fig. 4.A comparison of uranium removal efficiencies in concrete and soil according to reaction time during bioremediation

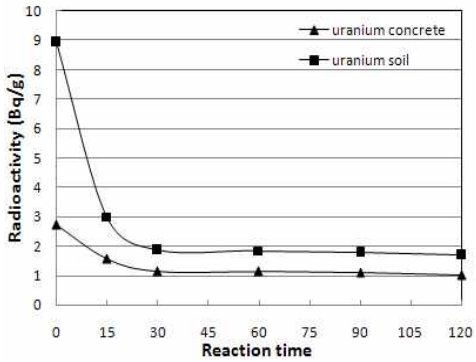

Fig. 5.Uranium concentration in concrete and soil according to reaction time

3. Conclusions

An optimum mixing ratio of penatron was obtained through three bioremediation experiments for soil contaminated with uranium. For injections of greater than 2 % penatron, the removal efficiencies of uranium from soil were rather reduced. Therefore, an optimum mixing ratio of penatron for bioremediation of uranium soil was 1%. Also, it was found that the optimum pH condition for bioremediation of soil contaminated with uranium and radium was 7.5. The removal efficiencies of uranium from higher concentrations of soil were rather reduced in comparison with those from lower concentrations of soil. Also, the removal of uranium in concrete by bioremediation is possible but the removal rate from concrete was slower than that from soil. Finally, the removal efficiencies of uranium from soil under injections of 1 % penatron at pH 7.5 for 120 days were 81.4 % and the removal efficiencies of uranium from concrete under the same condition were 63.0 %.

REFERENCES

[1] G.N. Kim, W.K. Choi, C.H. Jung, J.K. Moon, Development of a washing system for soil contaminated with radionuclides around TRIGA reactors, J. Ind. Eng. Chem., Vol,13 ,p.406, 2007.
[2] D.R. Lovley, E.J.P. Phillips, Bioremediation of uranium contamination with enzymatic uranium reduction, Environ. Sci. Technol., Vol. 26, p. 2228, 1992.
[3] C.White, A.K. Sharman, G.M. Gadd, An integrated microbial process for the bioremediation of soil contaminated with toxic metals, Nature Biotechnol., Vol. 16,p. 572, 1998.