

Biosorption and Elution of Lead by *Undaria pinnatifida*

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Abstract

Biosorption of lead by marine algae, *Undaria pinnatifida*, was examined. The biosorption capacity of lead by *U. pinnatifida* was above 30% of its own weight and proportional to the initial lead concentration. However, the opposite result was shown in different initial weight of biomass. The mechanism of biosorption was accorded to the ion exchange process.

Introduction

Heavy metals contaminated wastewaters are originated from mining, metal plate, dyestuff, electronic, and petroleum industries. Although conventional heavy metal treatment processes such as chemical precipitation, chemical oxidation and reduction, electrochemical treatment, evaporative recovery, filtration, ion exchange, and reverse osmosis can remove heavy metals from wastewater easily in its high concentration condition, it is difficult to be an attractive alternative in low concentration condition, especially below 10 mg/L of heavy metal.

To remove low concentration heavy metal ions from the water solution effectively, biosorption process has been proposed recently. Biosorption is a removal and/or recovery method, which is based on the metal-sequestering properties of certain natural materials of biological origin. The mechanisms of biosorption for sequestering heavy metals by biomaterial origins have been known as adsorption, inorganic precipitation, complexation, ion exchange (Lee, 2000), active transport, and passive uptake.

Lead could be called as big one because the three important and severely toxic heavy metals, lead, cadmium, and mercury, have been notoriously called as big three. Many researchers have developed a lot of biosorbents to remove lead, such as bacteria, fungi (Suh, 1999), and algae. Among these biosorbents, especially, marine brown algae was known as a good biosorbent for removing lead ions in aqueous solution, and it contains extracellular

polymeric substances (EPS) such as alginate in cell surface above 30% of the cells in weight (Lee, 1997), which offers biosorption site for sequestering heavy metal ions. The main advantages of the biosorption process are as follows (Kuyucak, 1990); (1) metals at low concentration can be selectively removed (2) biosorbent has very low affinity for calcium and magnesium ions (3) effluent concentrations meet the regulations (4) the system operates over the broad pH range (pH 3 to 9) (5) the system is effective over a temperature range of 4 to 90 degree (6) the system offers low capital investment and low operation costs (7) the cost and liability of toxic sludge disposal are eliminated by converting pollutant metals to a metal product.

In this study, the availability of *Undaria pinnatifida* as a biosorbent for removing lead ions in aqueous solution was examined, which is grown and collected in Korean beach, The effects of pH, initial lead and biomass concentration, and biosorption isotherm were investigated.

Materials and Methods

Marine brown algae and Lead ion solution

Raw *Undaria pinnatifida* used in this experiment was collected and sun-dried on the beach near Kijang, east coast of Korea. Dried raw biomass was washed with distilled water. 5 g of raw biomass was added to 1L of 0.5M $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$ (100 rpm shaking overnight at room temperature). Biomass was filtered off and washed with the same volume of distilled water and then dried overnight at 60.

Lead ion solutions of desired concentration were prepared by dissolving analytical grade of $\text{Pb}(\text{NO}_3)_2$ in distilled and deionized water.

Biosorption and desorption experiments

Biosorption experiments were performed by suspending 100 mg of biomass in 100 mL of lead solution and shaking on a gyratory shaker. 0.1N HCl or 0.1N NaOH were used for pH adjustments. During the experiment, samples were taken and filtered using 0.45 Millipore membrane and the filtrates were analyzed by AAS(Shimatsu AA 680, Japan) for the analysis of metal content. The filtered biomass was washed with distilled water, dried overnight at 60C, and weighed for desorption experiment. Metal uptake was calculated as q (mmol/g)= $V(C_i-C_e)/M$ where: C_i and C_e are the initial and equilibrium lead concentration in the solution, respectively (mM), V is the solution volume (L), and M is the initial mass of the biosorbent used (g). Desorption experiments were performed by suspending 100 mg of lead-loaded biomass in 100 mL of 0.1N HNO_3 solution and shaking on a gyratory shaker for 8 hours. At the end of the experiment, samples were filtered and the filtrate was analyzed by AAS. The filtered biomass was washed with distilled water, and dried overnight at 60C.

The amount of desorbed lead was calculated as q (mmol/g) = VC_f/M where: C_f is the final eluted lead concentration in the solution, V is the solution volume, and M is the initial mass of the biosorbent used.

Results and Discussion

Fig. 1 shows the pH dependence on the biosorption capacity of lead by *U. pinnatifida*. As shown in Fig. 1, the biosorption capacity was higher at higher pH than that at lower pH because of the competition effect with hydrogen ions in the solution (Suh, 1999). In Fig. 2, at pH 6, the biosorbed lead ions had an almost equal amount with eluted calcium ions. This result means that the biosorption in this experiment was accorded to the ion exchange process between lead and calcium ions.

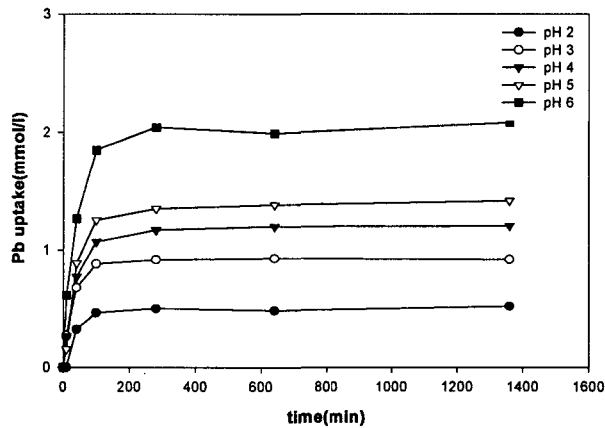


Fig. 1. pH effect on the biosorption capacity of lead by *U. pinnatifida*.

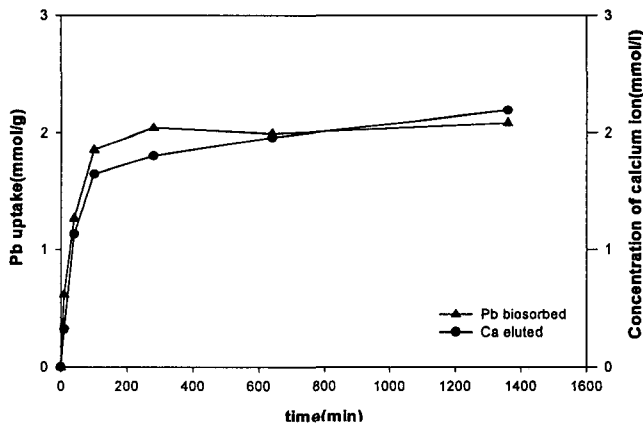


Fig. 2. Relation between bio sorbed Pb^{2+} and eluted Ca^{2+} during the biosorption of lead by *U. pinnatifida*

Fig. 3 shows the effect of initial lead concentration on the biosorption capacity by *U. pinnatifida*. The biosorption capacity of lead at high initial concentration was higher than that at low initial concentration. In Fig. 4, biosorption capacity of lead per unit mass of biomass was oppositely proportional to the amount of biomass used.

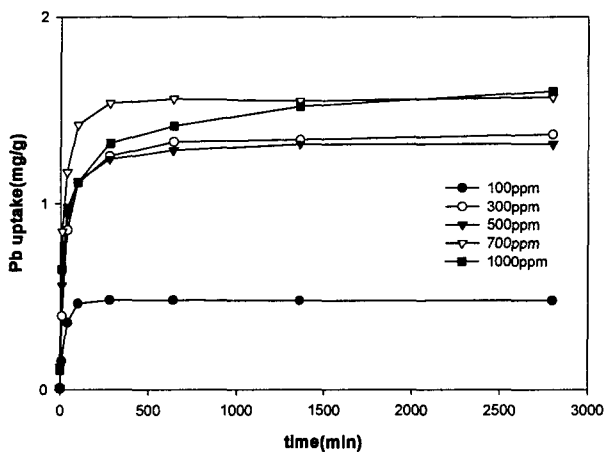


Fig. 3. Effect of initial lead concentration on its adsorption to *U. pinnatifida*.

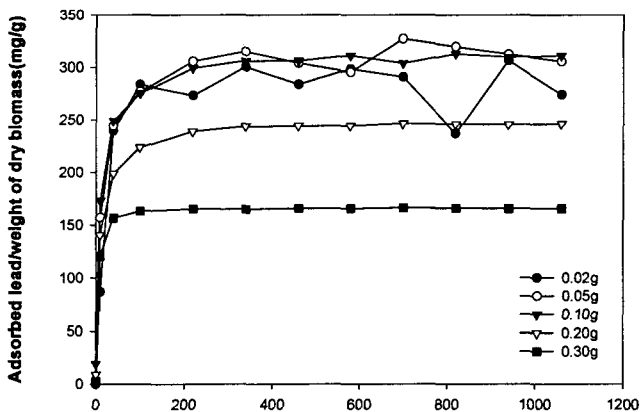


Fig. 4. Effect of biomass dry weight in lead adsorption to *U. pinnatifida* at initial lead concentration of 500ppm.

Fig. 5 shows the biosorption isotherm of lead by *U. pinnatifida*. The experimental data was not exactly accorded with both Langmuir and Freundlich isotherm. Therefore, the biosorption of lead by *U. pinnatifida* was considered with complex adsorption containing physical and chemical sorption mechanism. As shown in Fig. 6, the elution capacity of lead by HCl was higher at low final pH condition. At pH 1.0, the elution capacity was almost reached to 100%.

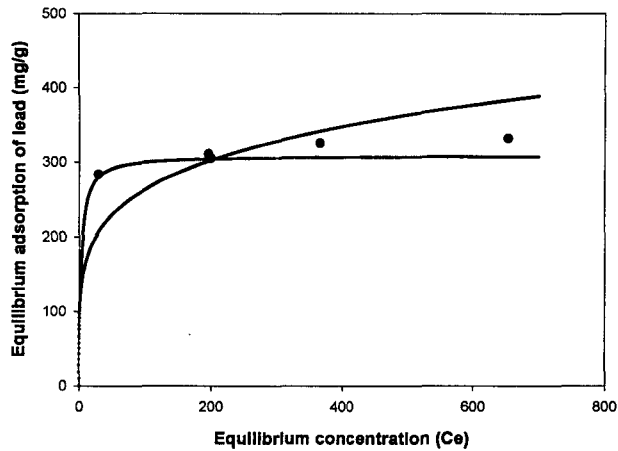


Fig. 5. Equilibrium isotherms of lead for *U. pinnatifida*.

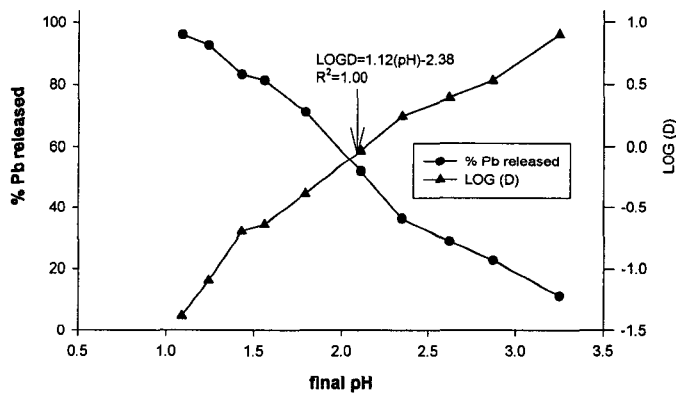


Fig. 6. Influence of pH on lead elution from *U. Pinnatifida* using HCl.

References

- Kuyucak Nural, 1990, Feasibility of Biosorbents Application, Biosorption of heavy metals, B. Volesky, CRC press, P. 371-378.
- Lee, H.S., Biosorption of Cr, Cu and Al by *Sargassum biomass*, *Biotechnol. Bioprocess Eng.*, 2, 126-131, 1997.
- Lee, H.S. and Suh, J.H., Continous biosorption of heavy metal ions by Ca-loaded *Laminaria japonica* in fixed bed column, *Korean J. Chem. Eng.*, Vol. 17, No. 4, 477-479, 2000.
- Suh, J.H., J.W. Yun and D.S. Kim, Effect of pH on Pb^{2+} accumulation in *Saccharomyces cerevisiae* and *Aureobasidium pullulans*, *Bioprocess Engineering*, Vol. 20, 471-474, 1999.