Fate of Heavy Metals in Activated Sludge : Sorption of Heavy Metal Ions by *Nocardia amarae*

Dong Wook Kim

Water Environment Research Center
Korea Institute of Science and Technology
P.O.Box 131, Cheongryang, Seoul, 130-650, Korea

Proliferation of Nocardia amarae cells in activated sludge has often been associated with the generation of nuisance foams. Despite intense research activities in recent years to examine the causes and control of Nocardia foaming in activated sludge, the foaming continued to persist throughout the activated sludge treatment plants in United States. In addition to causing various operational problems to treatment processes, the presence of Nocardia may have secondary effects on the fate of heavy metals that are not well known. For example, for treatment plants facing more stringent metal removal requirements, potential metal removal by Nocardia cells in foaming activated sludge would be a welcome secondary effect. In contrast, with new viosolid disposal regulations in place (Code of Federal Regulation No. 503), higher concentration of metals in biosolids from foaming activated sludge could create management problems.

The goal of this research was to investigate the metal sorption property of Nocardia amarae cells grown in batch reactors and in chemostat reactors. Specific surface area and metal sorption characteristics of N. amarae cells harvested at various growth stages were compared. Three metals examined in this study were copper, cadmium and nickel.

Nocardia amarae strain (SRWTP isolate) used in this study was obtained from the University of California at Berkeley. The pure culture was grown in 4L batch reactor containing mineral salt medium with sodium acetate as the sole carbon source. In order to quantify the sorption of heavy metal ions to N. amarae cell surfaces, cells from the batch reactor were harvested, washed, and suspended in 30mL centrifuge tubes. Metal sorption studies were conducted at pH 7.0 and ionic strength of 10-2M. The sorption isotherm showed that the cells harvested from the stationary and endogenous growth phase exhibited significantly higher metal sorption capacity than the cells from the exponential phase. The sequence of preferential uptake of metals by N.amarae cells was Cu>Cd>Ni. The specific surface area of Nocardia cells was determined by a dye adsorption method. N.amarae cells growing at ewponential phase had significantly less specific surface area than that of stationary phase, indicating that the lower metal sorption capacity of Nocardia cells growing at exponential phase may be due to the lower specific surface area.

The growth conditions of Nocardia cells in continuous culture affect their cell surface properties, thereby governing the adsorption capacity of heavy metal. The comparison of dye sorption isotherms for Nocardia cells growing at various growth rates revealed that the cell surface area increased with increasing sludge age, indicating that the cell surface area is highly dependent on the steady-state growth rate. The highest specific surface area of 199m2/g was obtained from N.amarae cell harvested at 0.33 day-1 of growth rate. This result suggests that growth condition not only alters the structure of Nocardia cell wall but also affects the surface area, thus yielding more binding sites of metal removal. After reaching the steady-state condition at dilution rate, metal adsorption isotherms were used to determine the equilibrium distributions of metals between aqueous and Nocardia cell surfaces. The metal sorption capacity of Nocardia biomass harvested from 0.33 day-1 of growth rate was significantly higher than that of cells harvested from 0.5- and 1-day-1 operation, indicatng that N.amarae cells with a lower growth rate have higher sorpion capacity. This result was in close agreement with the trend observed from the batch study.

To evaluate the effect of Nocardia cells on the metal binding capacity of activated sludge, specific surface area and metal sorption capacity of the mixture of Nocardia pure cultures and activated sludge biomass were determined by a series of batch experiments. The higher levels of Nocardia cells in the Nocardia-activated sludge samples resulted in the higher specific surface area, explaining the higher metal sorption sites by the mixed luquor samples containing greater amounts on Nocardia cells. The effect of Nocardia cells on the metal sorption capacity of activated sludge was evaluated by spiking an activated sludge sample with various amounts of pre culture Nocardia cells. The results of the Langmuir isotherm model fitted to the metal sorption by various mixtures of Nocardia and activated sludge indicated that the mixture containing higher Nocardia levels had higher metal adsorption capacity than the mixture containing lower Nocardia levels. At Nocardia levels above 100mg/g VSS, the metal sorption capacity of activate sludge increased proportionally with the amount of Nocardia cells present in the mixed liquor, indicating that the presence of Nocardia may increase the viosorption capacity of activated sludge.