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Containment and Remediation of Cr^{3+} by Bacterial Biofilm Attached to Mineral Surface

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ABSTRACT

The biological removal of heavy metals through biosorption has distinct advantages over conventional methods; the process rarely produces undesirable or deleterious chemical byproducts, and it is highly selective, efficient, easy to operate, and cost-effective in the treatment of dilute metal-bearing solutions. Biofilms occur in most natural and wastewater systems covering solid surfaces in contact with water. Biofilms also can adsorb inorganic contaminants because adsorption sites are provided by extracellular polymeric substances, cell walls and cell membranes. Recently, natural biofilm barriers are considered to be an attractive alternative to traditional subsurface barrier technologies because they do not require excavation, utilized indigenous microorganisms, require minimal maintenance, have no depth limitations, and are cost-effective to install and operate. Biofilm barrier can also enhance the efficiency of remediation of groundwater pollution through retardation of the contaminant plume. It can decrease the rate of contaminant migration by reducing the hydraulic conductivity resulting in bacterial growth and thick biofilm production.

Despite of the significant potential of the biofilm barrier as a useful strategy for prevention of groundwater contamination with heavy metals, the understanding of the mechanisms of biofilms to mediate transport and fate of heavy metals was insufficient to date. This study was to investigate the mechanisms of interactions between Cr^{3+} and *Pseudomonas aeruginosa* biofilm developed on the surface of mineral particles using attenuated total reflection infrared (ATR-IR) spectroscopy.

The result of ATR-IR spectrum showed that the introduction of Cr^{3+} solution to the

bacteria biofilm resulted in pronounced increase in IR band absorbance of 1548 cm^{-1} and 1056 cm^{-1} which indicated amide II and phosphate peaks, respectively (Figure 1). The increase in absorbance upon the addition of Cr^{3+} is believed to be due to the Cr^{3+} binding to bacterial exopolymers. Binding of Cr^{3+} occur charge shielding of cell surface causing compression of the exopolymers and the movement of the bacterial cells closer to the substratum. When Cr^{3+}-free $NaNO_3$ solution was subsequently flowed over the biofilm the absorbance of the amide II peak did not change, indicating that the Cr^{3+} was not released from the biofilm. The results of this study mean that biofilms can strongly bind Cr^{3+} and thus remove it from groundwater effectively.

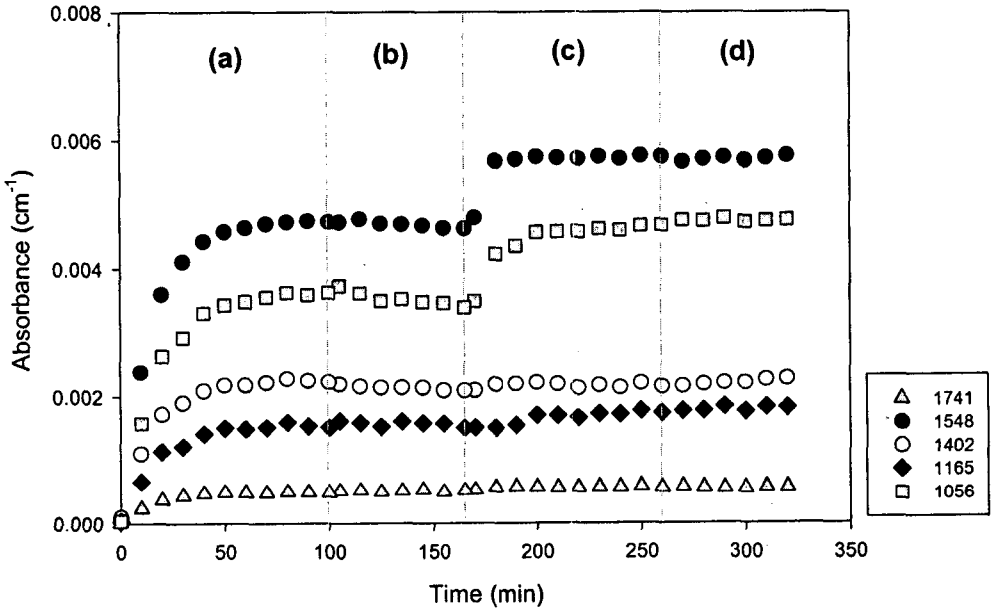

Figure 1. Absorbances of major *P. aeruginosa* IR bands during Cr^{3+} adsorption (a) attachment to the TiO_2 coated ZnSe prism, (b) washing with 0.03 mol L^{-1} $NaNO_3$ solution, (c) cation exchange with 0.005 mol L^{-1} $Cr(NO_3)_3$ solution and then (d) washing again with 0.03 mol L^{-1} $NaNO_3$ solution. All solutions adjusted to pH 5.0 in ionic strength 0.03 mol L^{-1}.

Key words biofilm, chromium, biosorption, ATR-IR spectroscopy