VERSITA

Chemical Papers 68 (1) 112–120 (2014)
DOI: 10.2478/s11696-013-0427-4

ORIGINAL PAPER

Effect of exopolymeric substances on the kinetics of sorption and desorption of trivalent chromium in soil

[a]Cetin Kantar*, [b]Aydeniz Demir, [b]Nurcan Koleli

[a]*Department of Environmental Engineering, Faculty of Engineering, Canakkale Onsekiz Mart University, 170 20 Canakkale, Turkey*

[b]*Department of Environmental Engineering, Faculty of Engineering, Mersin University, 333 43 Mersin, Turkey*

Received 8 January 2013; Revised 23 March 2013; Accepted 11 April 2013

Laboratory batch sorption–desorption and column experiments were performed to better understand the effects of microbial exopolymeric substances (EPS) on Cr(III) sorption/desorption rates in the soil–water system. The experiments were carried out in two different modes: one mode (sorption) in which Cr(III) and EPS were applied simultaneously, and the other (desorption) included the sequential application of Cr(III) and EPS to the soil–water system. The batch sorption and desorption experiments showed that, while chromium(III) desorption was significantly enhanced in the presence of EPS relative to non-EPS-containing systems, the desorption rates were much smaller than the sorption rates, and the fraction dissolved by EPS accounted for only a small portion of the total chromium initially sorbed onto soil minerals. Similarly, the column experiments suggested that, while the microbial EPS led to an increase in Cr dissolution relative to non-EPS-containing systems, only a small portion of the total chromium initially added to the soil was mobilised. The differences observed in Cr sorption and desorption rates can be explained through the very low solubility and strong interactions of chromium species with soil minerals as well as the mass transfer effects associated with low diffusion rates. The overall results suggest that, while microbial EPS may play an important role in microbial Cr(VI) treatment in sub-surface systems due to the formation of soluble Cr–EPS complexes, the extent and degree of Cr mobilisation are highly dependent on the type of initial Cr sorption.

Keywords: chromium, adsorption, rate, transport, complexation, desorption

Introduction

Microbial processes have commonly been used to treat wastewater and sub-surface systems contaminated with chromium(VI) (e.g. Dogan et al., 2011). One of the end-products of microbial Cr(VI) reduction is the exopolymeric substances (EPS) produced by bacteria to protect the cells from the adverse effects of environmental stresses such as Cr(VI) (Aquino & Stuckey, 2004; Puzon et al., 2005; Sheng et al., 2005; Priester et al., 2006; Dogan et al., 2011). Despite the low solubility and highly sorptive characteristics of inorganic Cr(III) species, the interactions between Cr(III) and EPS may lead to the formation of highly soluble organo-Cr(III) end-products that may have a significant influence on chromium solubility, sorption and transport behaviour of Cr(III) in sub-surface systems (Puzon et al., 2005; Priester et al., 2006; Kantar et al., 2008; Cetin et al., 2009; Kantar et al., 2011a). For instance, Puzon et al. (2005) determined that microbial Cr(VI) reduction in the presence of cellular organic metabolites such as citrate led to the formation of highly stable and soluble organo-Cr(III) complexes. Priester et al. (2006) observed that Cr(III) was associated with the EPS released by *P. putida* during Cr(VI) reduction. Their results also demonstrated that cell lysis, cellular association and extracellular DNA-binding of Cr(III) led to the localised biotic stabilisation of

*Corresponding author, e-mail: ckantar@comu.edu.tr