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Desorption of Hg(II) and Sb(V) on extracellular polymeric substances: Effects of pH, EDTA, Ca(II) and temperature shocks

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HIGHLIGHTS

- Adsorption–desorption behaviors of Hg(II) and Sb(V) on EPS were investigated.
- Effects of EDTA, Ca(II), pH and temperature shocks on desorption kinetics were studied.
- Hg(II) and Sb(V) were bound with polysaccharides and protein-like compounds, respectively.
- EPS–Hg complex is a time bomb that may release Hg(II) in short time period under shocks.

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ABSTRACT

Extracellular polymeric substances (EPS) existed ubiquitously in biological systems affect the mobility and availability of heavy metals in the environments. The adsorption–desorption behaviors of Hg(II) and Sb(V) on EPS were investigated. The sorption rates follow Sb(V) > Hg(II), and the desorption rates follow reverse order. Applications of ethylene diamine tetraacetic acid (EDTA), Ca(II) and pH shocks affect desorption rates and desorbed quantities of Hg(II) from EPS–Hg complex. Temperature shock minimally affects the desorption rate of Hg(II). Conversely, the EPS–Sb complex is stable subjected to EDTA, Ca(II), temperature or pH shocks. The excitation–emission matrix (EEM) fluorescence spectroscopy and fast-Fourier (FT-IR) analysis showed that Hg(II) and Sb(V) principally interacted with polysaccharides and protein-like compounds in the EPS, respectively. The EPS–Hg complex presents a time bomb that may release high levels of Hg(II) in short time period under environmental shocks.

1. Introduction

Extracellular polymeric substances (EPS) are main constituents of numerous natural or engineered biological systems. The EPS are high molecular weight mixture secreted by bacteria and are mainly composed of carbohydrates, proteins, lipids, nucleic acids and various heteropolymers (Tu et al., 2012; Alasonati and Slaveykova, 2012; Bourven et al., 2012). The mobility and availability of heavy metals in the environments may be strongly influenced by EPS due to their ubiquitous presence and great metal binding capacity. The metal binding capacity of EPS can be a result of several physico-chemical and biological processes such as ion exchange, complexation and surface precipitation due to a variety of metal binding functional groups on surface of EPS (Aquino and Stuckey, 2004). The functional groups, including hydroxyl, carboxyl, phosphoric amine and amidocyanogen of proteins, polysaccharides and phospholipids (Morris and Meyer, 2006), can generate a negative surface charge and act as metal binding sites to form organo-metal complexes (Pagnanelli et al., 2009).

Mercury (Hg) is one of the most commonly found and most toxic heavy metals in the environment (Castro-Gonzáleza and Méndez-Armentab, 2008) and could be bound tightly to EPS of activated sludge or biofilms (Zhang et al., 2010). The behavior of Hg in aquatic systems is mainly controlled by adsorption and desorption processes depending on pH and organic matter (Ravichandran, 2004; Gorski et al., 2006). However, the desorption characteristics of the adsorbed mercury on EPS have not been studied. Antimony (Sb), as a global emergent pollutant, is ubiquitous in urban road dust which may be introduced into the activated sludge system with storm runoff (Smichowski, 2007). Sb can be concentrated

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