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Sorption of Cr(VI), Cu(II) and Pb(II) by growing and non-growing cells of a bacterial consortium

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Abstract

This paper reports the sorption of three metallic ions, namely Cr(VI), Cu(II) and Pb(II) in aqueous solution by a consortium culture (CC) comprising an acclimatised mixed bacterial culture collected from point and non-point sources. Metal sorption capability of growing and non-growing cells at initial pH of between 3 and 8 in the 1–100 mg/L concentration range were studied based on Q_{max} and K_f values of the Langmuir and linearised Freundlich isotherm models, respectively. Maximal metal loading was generally observed to be dependent on the initial pH. Growing cells displayed significant maximal loading (Q_{max}) for Pb(II) (238.09 mg/g) and Cu(II) (178.87 mg/g) at pH 6 and at pH 7 for Cr(VI) (90.91 mg/g) compared to non-growing cells ($p < 0.05$). At the pH range of 6–8, growing cells showed higher loading capacity compared to non-growing cells i.e. 38–52% for Cr, 17–28% for Cu and 3–17% for Pb. At lower metal concentrations and at more acidic pH (3–4) however, non-growing cells had higher metal loading capacity than growing cells. The metal sorption capacity for both populations were as follows: Pb(II) > Cu(II) > Cr(VI).

Keywords: Bacterial consortium; Sorption; Metal loading; Heavy metal

1. Introduction

Metal based and metal finishing industries generate effluents containing heavy metals, inorganic anions as well as organic compounds. Unregulated direct disposal, discharge of untreated wastewaters, accidental spills and surface run-offs cause pollution of the waterways, rivers and ultimately the seas. Heavy metals are of general concern as they are persistent and able to accumulate in the ecosystem posing serious environmental and health hazard (Forstner et al., 1991; Viguri et al., 1999).

Conventional physico-chemical treatment techniques for metal related remediation strategies include, amongst others, chemical precipitation, reversed osmosis, ion exchangers, cementation and electro-dialysis. These methods generally require high reagent use, are cost intensive, waste specific, inefficient at low concentrations of metals (⩽100 mg/L) and produce toxic sludge or other waste by-products (Eccles, 1999). A more practical and dynamic approach is the use of biological agents i.e. micro-organisms which include bacteria, fungi, yeast and their products (Stephan and Macnaughton, 1999; Filali et al., 2000; Puranik and Paknikar, 1997; Salinas et al., 2000), algae and seaweeds (Holan and Volesky, 1994; Hamdy, 2000) or plant and agricultural waste biomass (Senthilkumar et al., 2000). Although most bio-materials have the ability to bind metals, only biosorbents with a high uptake/loading capacity and broad selectivity are suitable for application purposes (Chang et al., 1997).

The ability of microbial biomass to remove metals can be described as active (energy dependent) or passive

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