



Removal of mercury from aqueous solutions by malt spent rootlets

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HIGHLIGHTS

- ▶ Malt spent rootlets (MSR) are promising biosorbents for mercury removal.
- ▶ Malt spent rootlets (MSR) exhibit satisfactory sorption capacity and fast kinetics.
- ▶ Film diffusion and intra-particle diffusion play an important role on mercury sorption.

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ABSTRACT

Mercury poses a severe threat to environment due to its toxicity, even at low concentrations. Biosorption is a promising, low cost, and environmentally friendly clean up technique. Malt spent rootlets (MSR), a brewery by-product, were used as sorbents for the removal of mercury from aquatic systems. The effect of the solution pH, contact time between sorbent, solid to liquid ratio, and initial mercury concentration on mercury removal were investigated experimentally. It was found that the optimum pH for the mercury sorption onto MSR was approximately 5. Sorption kinetic experiments revealed that mercury sorption is a relatively rapid process, where film diffusion and intra-particle diffusion play an important role. The kinetic data were successfully described by both the pseudo-second-order and Elovich models. The isotherm data were adequately fitted by the Langmuir model determining a monolayer capacity q_{\max} equal to 50 mg/g and suggesting a functional group-limited sorption process. MSR were capable of removing significant amounts of mercury, mainly due to the carboxyl and phosphonate groups of their surfaces. Mercury desorption from the MSR was found to be most effective with HCl 0.1 M.

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1. Introduction

Mercury, even at low concentrations, is of particular concern due to its toxicity [1]. It is classified among priority hazardous compounds according to the European Union (EU) legislation [2,3]. The maximum allowable level for mercury in surface waters is 0.07 µg/L [3]. Mercury is released into the environment via natural processes (i.e. volcanic eruptions), anthropogenic activities (i.e. coal burning power plants), accidentally due to manufacture, breakage or disposal of products that contain mercury [4,5].

Removal of metal ions from aquatic systems has been practiced for decades, but commonly employed physico-chemical techniques, such as electrochemical treatment, ion exchange, reverse osmosis, precipitation, may exhibit serious drawbacks. For example, non-selective precipitation generates highly toxic metallic sludge; furthermore, ion exchange and reverse osmosis exhibit

low efficiency at low concentrations and high operational cost [6]. However, biotechnological approaches, especially biosorption, may be more desirable due to lower cost and higher efficiency [6,7]. The term biosorption refers to the accumulation of metal ions by materials of biological origin, and consists of two steps: contact of the biomass with the metal contaminated wastewater, and separation of the metal-loaded biosorbent from the metal-depleted effluent [8]. Biomaterials have proven capability to take up heavy metals from aqueous solutions mainly due to carboxyl, hydroxyl, and phosphate active groups, which can bind metal ions [6]. The major advantages of biosorption are the low cost, high removal efficiency, biosorbent regeneration, and metal recovery [6].

In recent years, considerable research efforts by numerous investigators were focused on the removal of Hg(II) from water by sorption processes, and the evaluation of sorption capacity of various materials. Activated carbon [9,10] or polymer-coated activated carbon [11] have been shown to effectively absorb Hg(II); however, they are relatively expensive materials. Alternative biomaterials, such as fern, fruit derived biomass and leaves of castor

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