Water Air Soil Pollut (2025) 236:541
https://doi.org/10.1007/s11270-025-08208-3

Bioremediation of Chromium-contaminated Agricultural Soil Using Alginate-Encapsulated Bacterial Beads

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Received: 20 May 2024 / Accepted: 26 May 2025

Abstract In this study, the efficacy of indigenous bacteria present in Cr-contaminated soil was tested for soil decontamination. Potential bacterial strains were screened and selected from soil samples and immobilized on sodium alginate beads. The most effective Cr(VI) reducing strain identified using 16S rRNA genome sequencing was *Enterococcus italicus*. Bacterial beads of *E. italicus* were optimized for Cr(VI) reduction under various exploratory conditions, such as temperature, pH, biomass, contact period, and different nutritional sources. Beads containing 1000 mg/g of *E. italicus* biomass reduced up to 91% of Cr(VI) (from an initial 5.4 mg/g in the soil) at pH 7 and 35 ℃ within 2 h. Glucose was found to be a good source of electron contributors that can reduce up to 94% of Cr(VI). FTIR analysis of the Cr(VI)-treated bacterial beads showed amines, -COO^-, -CH_3, C–O–C, and PO_2 as new functional groups, revealing absorption and reduction of Cr(VI) from contaminated soil. The cell size of *E. italicus* after Cr-contaminated soil treatment was larger than that of untreated bacterial cells. The elemental analyses of treated and untreated bacterial cells revealed the presence of Cr inside the treated cells of *E. italicus*, which were transported from the soil during its treatment. Further, the XPS analysis confirmed the reduction of Cr(VI) to Cr(III) in the treated bacterial beads of *E. italicus*.

Keywords *Enterococcus italicus* · Immobilization · Cr(VI) reduction · Absorption · Soil remediations

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1 Introduction

Industries such as leather, tanning, electroplating, mining, nuclear weapons, stainless steel, and pigment, along with coal combustion, organic fertilizers, and wastewater irrigation, are major sources of chromium (Cr) pollution in ecosystems and agricultural soils (Kannaujiya et al., 2021; Sultana et al., 2014; Vogel et al., 2020). Even at low concentrations, topsoil contamination by heavy metals, such as Cd, Ni, Co, Pb, and Cr, can degrade its quality and persist in the environment, posing long-term ecological risks through biomagnification (Cetin et al., 2022a; Cetin et al., 2022b). The most persistent and stable Cr species exist in Cr(III) and Cr(VI) oxidation

Published online: 03 June 2025