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Brown Macroalgae L. hyperborea as Natural Cation Exchanger and Electron Donor for the Treatment of a Zinc and Hexavalent Chromium Containing Galvanization Wastewater

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Abstract : The electroplating industry requires a lot of process water, which generates a large volume of wastewater loaded with heavy metals. Two different wastewaters were collected in a company's wastewater treatment plant, one after the use of zinc in the metal plating process and the other after the use of chromium. The main characteristics of the Zn(II) and Cr(VI) wastewaters are: pH = 6.7/5.9; chemical oxygen demand = 55/<5 mg/L; sodium, potassium, magnesium and calcium ions concentrations of 326/28, 4/28, 11/7 and 46/37 mg/L, respectively; zinc(II) = 11 mg/L and Cr(VI) = 39 mg/L. Batch studies showed that L. hyperborea can be established as a natural cation exchanger for heavy metals uptake mainly due to the presence of negatively charged functional groups in the surface of the biomass. Beyond that, L. hyperborea can be used as a natural electron donor for hexavalent chromium reduction to trivalent chromium at acidic medium through the oxidation of the biomass, and Cr(III) can be further bound to the negatively charged functional groups. The uptake capacity of Cr(III) by the oxidized biomass after Cr(VI) reduction was higher than by the algae in its original form. This can be attributed to the oxidation of the biomass during Cr(VI) reduction, turning other active sites available for Cr(III) binding. The brown macroalgae Laminaria hyperborea was packed in a fixed-bed column in order to evaluate the feasibility of the system for the continuous treatment of the two galvanization wastewaters. The column, with an internal diameter of 4.8 cm, was packed with 59 g of algae up to a bed height of 27 cm. The operation strategy adopted for the treatment of the two wastewaters consisted in: i) treatment of the Zn(II) wastewater in the first sorption cycle; ii) desorption of pre-loaded Zn(II) using an 1.0 M HCl solution; iii) treatment of the Cr(VI) wastewater, taking advantage of the acidic conditions of the column after the desorption cycle, for the reduction of the Cr(VI) to Cr(III), in the presence of the electrons resulting from the biomass oxidation. This cycle ends when all the oxidizing groups are used.

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