Detoxification of chromium (VI) in coastal water using lignocellulosic agricultural waste

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Abstract

Development of new economically feasible eco-friendly products from natural plants/agricultural wastes for removal of pollutants from coastal aquaculture systems is the objective of our continued research. In the present study, attempts have been made to harness lignocellulosic agricultural waste material (bagasse) for the removal of chromium (VI) from highly saline coastal water used for aquacultural practices using brackish water. Five different products prepared from bagasse were evaluated for the detoxification of Cr(VI) from high saline coastal water. The maximum removal capacity for Cr (VI) was found for the material charred with sulphuric acid. Dried bagasse powder was the second most effective product. These substrates are efficient for Cr removal from coastal water owing to their very low cost.

Keywords: phytoremediation, reduction, chromium, bagasse, coastal waters

Introduction

The successful growth, propagation and harvest of aquatic animals, whether freshwater or marine, are heavily dependent upon the quality of the surrounding water. Coastal water receive a heavy influx of sewage, industrial effluents, domestic and agricultural waste which consists of varying hazardous chemical and causing deleterious effects on fish and other aquatic organism. Heavy metals are among the conservative pollutants that are not subject to bacterial attack or other breakdown and are permanent additions to the marine environment (El-Nady and Atta, 1996). The primary sources of heavy metals pollution in coastal lagoons are input from rivers, sediments and atmosphere, which can affect aquaculture profitability in certain areas. In recent years, chromium concentrations have been increasing in coastal waters through the electroplating industry, metal finishing, leather tanning and chrome preparation. In the United States, it is the second most common inorganic contaminant in waters, after lead (Wielinga et al., 2001). However, Cr is necessary for normal life processes; it can be toxic to organisms at elevated concentrations. Free metal ionic activity in seawater is a function of metal toxicity, rather than the total concentration of the metal (Viarengo, 1989). Chromium usually exists in both trivalent and hexavalent oxidation states in soils and aqueous systems. The hexavalent form is of particular concern because of its great toxicity resulting from its powerful oxidation properties. The Cr (VI) is a U.S.EPA classified group A carcinogen based on its chronic effects (Nkhalambayausi-Chirwa and Wang, 2001). This has adverse impact on aquatic species as it accumulates in fish tissues and causes reduction in fish production at high concentrations (Cutter, 1991; Krishnani et al., 2003). The trivalent form of chromium, namely Cr (III), on the other hand, is about 1 000 times less toxic than Cr(VI). Furthermore, it has a limited hydroxide solubility making it relatively immobile and less available for biological uptake. As a result, Cr (VI) toxicity could be reduced and then become less bio-available when reduced to Cr(III).

Among available conventional processes used to remove hexavalent Cr, the most commonly used are precipitation as chromium hydroxide or ion exchange using macroporous resins (Jianlong et al. 2000). However, these methods suffer from some disadvantages due to their relatively high operational costs and cannot be recommended for Cr removal from coastal waters. Conversely, in recent years, a promising alternative method for removal of Cr(VI) uses the sorption by lignocellulosic solid wastes such as sugar- beet pulp (Reddad et al. 2003), wheat bran (Dupond and Guillon, 2003) and saw-dust (Raji and Anirudhan, 1998). Sugarcane bagasse is a highly fibrous lignocellulosic material, which is the residue remaining after sugar cane has been pressed to remove sucrose. Sugar-cane mills produce more bagasse than can be utilised as a fuel source for sugar processing; few commercial uses for the excess bagasse have been developed and its accumulation presents a waste problem for the sugar industry. One potential use of bagasse is as a feedstuff for shrimps (Freeman et al. 1992). However, reports on its use for the detoxification of Cr (VI) from high saline coastal water are not available. This study reports the use of five different products prepared from bagasse for detoxification of Cr (VI) in high saline coastal waters under laboratory conditions.

Materials and methods

Preparation of bagasse products

Five different kinds of materials were prepared from bagasse:

- Raw bagasse filaments (BRF)
- Dried bagasse filaments (BDF): Raw material was thoroughly washed with water and then dried in sun light
- Dried bagasse powder (BOP): Material dried in sunlight was dried in an oven at 75°C for 6 h and then powdered.
- Charred bagasse powder (BCP): Dried material was charred at 250°C in a muffle furnace and then powdered.

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