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Utilization of Chicken Tallow for the Production of Cationic Biosurfactant and thereof for decontamination of Cr(III) containing Soil

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Abstract

This work describes the bioremoval of Cr (III) from contaminated soil by cationic biosurfactant produced from Alcaligenesaquatilis sp. using chicken tallow as substrate. Its cationic nature was conformed through the amino acid composition. The optimized conditions for the production of cationic lipopeptide were found to be 96 h, pH 4 and temperature 37^0C.The biochemical characteristics of the cationic lipopeptide show that the protein concentration is 26.06 mg/g and lipid concentration is 60 mg/g respectively. The SDS-PAGE revealed that the molecular weight of the biosurfactant is 100.2 KDa. Chromium removal studies were performed to determine the effect of time,pH and temperature on the removal of Cr by the cationic biosurfactant as well as anionic biosurfactant. Adsorption isotherm studies were performed using Languir and Freundlich isotherms to determine the extent of adsorption of the biosurfactant onto the soil. The characterization of Cationic Biosurfactant was carried out using FTIR, TGA, DSC UV-Visible spectroscopy and Fluorescence spectroscopy. This cationic biosurfactant was used for Insitu Bioremediation of Cr from contaminated soil. The initial concentration of Cr in the soil sample collected was found to be 19.5mg/g using standard Cr estimation method. The removal of Cr from the soil was confirmed after estimating the Cr concentration in the soil treated with cationic biosurfactant. Finally seed germination studies were carried out for Cr sensitive seeds such as Zea mays (Maize), Luffa (Ridge Gourd), Trigonellafoenum-graecum (Fenugreek) using the treated and untreated soil and comparisons were made.Thus conformed the results collected in the present study indicate that the cationic biosurfactant can be considered for exchange of chromium from contaminated soil.

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1. Introduction

The global anxiety for heavy metal pollution has led to the development of newer findings and eco friendly technology for their removal. Leather is produced from skins and hides by tanning with chromium salts, normally $Cr_2(SO_4)_3 \cdot xH_2O$. Annual global leather production is about 6.8 million tonnes; nearly about 80% of the tanneries in India perform chrome tanning process (ParulRana-Madaria et al., 2005; Hannah C. Wells et al., 2014). The two most important species of chromium (III, VI) initiate mainly from tannery, electroplating, and dyeing effluents (N. Rajesh, et al., 2011). About 75000 ton ($1.3x10^{9}$mol) of chromium is put into the atmosphere annually by these sources. Additionally, 54000 ton ($9.4 x10^{8}$mol) of chromium is added to the environment by natural sources (Robert K Kieber et al., 2009). Cr has been concerned in many significant atmospheric redox reactions, all of which depend on the oxidation state of the metal. Cr is a major reactant or catalyst in numerous important redox processes taking place in the atmosphere including transformations of S(IV), hydrogen peroxide, free radicals (OH and HO_2 /O_{2-}), organic acids, and other trace metals.

In the natural environment, Cr exists in two common oxidation states: Cr(III) and Cr(VI). Chromium(III), an vital trace element for mammals, has been shown to be non hazardous to benthic macro invertebrates at concentrations approaching 2% of dry weight and is normally considered as immobile and non bioavailable due to the low solubility of Cr(III) (hydr)oxides at neutral pH. Conversely, Cr(VI) exists as highly soluble oxyanionic species, i.e., CrO_4^{2-} (chromate), $HCrO^{4-}$ (bichromate), and $Cr_2O_7^{2-}$ (dichromate). Chromium levels in soil vary according to area and the degree of contamination from anthropogenic chromium sources. (WHO Regional Office for Europe, Copenhagen, Denmark, 2000).Chromium is harmful because it is capable of causing cancer, entering the gastro-intestinal tract and lungs of humans. The intermediates of Cr (III) attack the DNA and proteins thereby disrupting cell functions.

The conventional physicochemical methodologies such as chemical precipitation, reverse osmosis and evaporative recovery for treating soils contaminated with Cr(VI) require high energy and plenty of chemical reagents when applied to large scale. Other biological and non-biological methodologies such as bio-venting, phytoremediation, land filling, soil flushing, and stabilization/solidification are also not considered to be the best treatment options because either they offer a temporary solution or are costly when applied to larger areas. Consequently, economical and environmentally friendly remediation methods of Cr(VI) contaminated sites is in urgent need. Bioremediation is one of the promising methods to clean up the Cr contaminated site.

Due to the disability of fulfillment and disadvantages of above mentioned methodologies researchers attracted towards bioremediation. Bioremediation is a waste management technique to remove or neutralize the pollutants at a particular site using microorganisms or their product by bacteria or fungi. Some microorganisms are capable of producing biosurfactants as secondary metabolites. Biosurfactants are amphiphilic compounds that reduce the free energy of the system by replacing the bulk molecules of higher energy at an interface. They are used for soil washing or flushing due to their ability to mobilize contaminants. They contain a hydrophobic portion with little affinity for the bulk medium and a hydrophilic group that is attracted to the bulk medium. (Mulligan and Gibbs, 2001 a, 2001 b). They also reduce the surface tension between two liquids which are immiscible. They are active at extreme temperatures, pH and salinity as well, and can be produced from industrial wastes and from by-products. This last feature makes cheap production of biosurfactants possible and allows utilizing waste substrates and reducing their polluting effect at the same time. (Kosaric N. (1992, 2001), (Rahman K.S.M et al,2003), (Das K ,2007),(Das. P,2008,)

In this research work a novel cationic biosurfactant was isolated from *Alcaligenesaquatilis sp.* using chicken tallow as substrate. A new approach of Insitubioremoval of Cr III from the soil was developed using implementation of cationic biosurfactant. The removal efficiency was evaluated and the toxicity study was analyzed by *Zea mays* (Maize), *Luffa* (Ridge Gourd),*Trigonellafoenum-graecum* (Fenugreek).