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BIOSORPTION OF CHROMIUM (VI) BY *PENICILLIUM CHR YSOGENUM* IN BATCH REA CTORS

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ABSTRACT

Removal of hexavalent chromium from aqueous solutions using mycelia, *Penicilliumchrysogenum* (a dead fungal biomass) in batch reactor has been investigated. For the five different initial concentrations of synthetic effluent such as 200,400, 600, 800, and 1000 mg/L, the steady state values of chromium removal efficiency were 45.7, 49.0, 72.0, 83.5, and 92%, respectively, using 0.2 grams of mycelia under shaking at the end of 8th hour. The metal removal efficiency increased with increase in contact time between the biosorbent and the effluent. The Langmuir and Freundlich adsorption models fitted well with the equilibrium data of the process studied.

Key words: Hexavalent Chromium, *Penicilliumchrysogenum*, Langmuir and Freundlich isotherms.

INTRODUCTION

Chromium metal exists in environment both in trivalent and hexavalent forms. It is known that Cr(VI) is 500 times more toxic than the Cr (III) form. Hexavalent chromium has got unique properties of corrosion resistance, hardness and colour and therefore finds large number of applications in industries like chrome-plating, automobiles, steel and alloys, paints, leather tanning,petroleum refining, textile manufacturing, and wood preserving and ammunition factories (Raji&Anirudhan, 1998). Consequently, these industries discharge large quantities of chromium containing effluents. Since chromium is a known mutagen and carcinogen (Oguz, 2005),The presence of heavy metals in water supplies and wastewater threatens the environment and the health of humans. Chromium naturally occurs in the environment as chromium (III) or chromium (VI). Natural oxidation of chromium (III) could also, occur to produce chromium (VI). Chromium toxicity and mobility depend on its oxidation state. The trivalent forms are relatively immobile, more stable, and much less toxic than the hexavalent forms'. Chromium (VI) contamination is particularly imperative to remediate because of the severe carcinogenic and toxic effects on humans and fauna.

The prevalent pollution laws in most countries require its complete elimination from waste streams before emancipation. The most commonly used method for chromium removal method is reduction followed by chemical precipitation (Baral et al. 2006). However, this process has many disadvantages like high installation costs, high energy-intensive, consume large quantities of chemicals and difficulty of handling the later produced solid waste and hence are economically unattractive. Therefore, it is necessary to look for a new practical, economic, efficient and sustainable alternative for the management of chromium bearing industrial effluents. Biomanagement practices are gaining immense creditability world over in the recent times (Vinodhini& Das, 2009). Chromium being non-renewable and finite natural resource, the argument is not limited only to their removal from the effluents, but also extends to finding an efficient and economical ways of recovery/recycling

It is, nowadays, known that biosorption, is one of the innovative methods for the removal of toxic metals from the effluent, the more conventional being precipitation, adsorption and ion exchange. The metal sorption capacities of different kinds of microbial biomass have been identified as potential alternatives to the existing metal removal technologies. Various types of non-living biomass, bacteria, filamentous fungi, algae and higher plants can be used in alternative metal removal processes because of their low cost and high metal binding capacity ofcell walls. It has been found that non-living biomass showed greater binding capacity than living ones. Solid wastes from fermentation based industries produced in tones per year, could be used as a suitable biosorbent.

This study focused on the utility of dead fungal biomass of *Penicilliumchrysogenum*a solid waste (mycelia) in the removal of hexavalent chromium from aqueous solutions. The skeleton of *P. chrysogenum* biomass is mostly composed of chitin and (β-glucan chains which are cemented by proteins, lipids, pigments and other polysccharides. Therefore, a large variety of functional groups exist (carboxyl, hydroxyl, phosphoryl, amine and sulfhydryl groups) create a negatively charged surface, that could attract and subsequently sequester metals from the surrounding aqueous medium.

EXPERIMENT

Materials and methods

Biosorbent

Waste biomass of *Penicilliumchrysogenum,* collected from the Department of microbiology, Faculty of Agriculture, Annamalai University, Tamilnadu, India was used as a biosorbent. Since, the biomass was in a colloidal state, it was dried up to harden them for easy handling during further process. The waste biomass was then washed with distilled water followed by acetone wash and again washed with distilled water. Finally, it was dried to 60°C to constant weight. After pulverization to a geometric mean particle size of 52 mesh (B.S.S), it was stored in a dessicator at room temperature.

Preparation of synthetic effluent

In order to have waste of uniform characteristics and to avoid interference with other elements the synthetic effluent for the present study was prepared by dissolving known amount of potassium chromate (K_2CrO_4) in distilled water. For 1000 mg/L hexavalent chromium concentration 3.7349 g AR grade K_2Cr0_4 was dissolved in 1.0 litre of distilled water.

Experimental procedure

Batch experiment was carried out in 250 mL Erlenmeyer Flasks containing the *Penicilliumchrysogenum,*biomass. 100 mL of the effluent and the biomass were added to each of the reactor. The residual chromium (VI) concentration was analyzed spectrophotometrically for every one hour as per procedure put lined in APHA Standard Methods. The experiments were carried out to study the effect of operational parameters like initial concentrations, biomass dosages and contact time.

RESULTS AND DISCUSSION

Effect of initial concentration

For the five different initial concentrations of synthetic chromium effluent such as 200,400,600, 800, and 1000 mg/L, the steady state values of chromium removal efficiency were 45.7, 49, 72, 83.5 and 92%, respectively, using 0.2 grams of mycelia under shaking at the end of 8th hour (Fig. 1). With increase in initial concentration of the metal, the equilibrium metal removal efficiency increased. This is because, the initial concentration of the metal provides an important driving force to overcome all mass transfer resistances of the metal between the aqueous and solid phase. Hence a higher initial concentration of the metals will enhance the adsorption process. Similar result was observed by Pakshirajan and Swaminathan in their work on biosorption of lead, copper and cadmium using *Phanerochaetechrysosporium.*

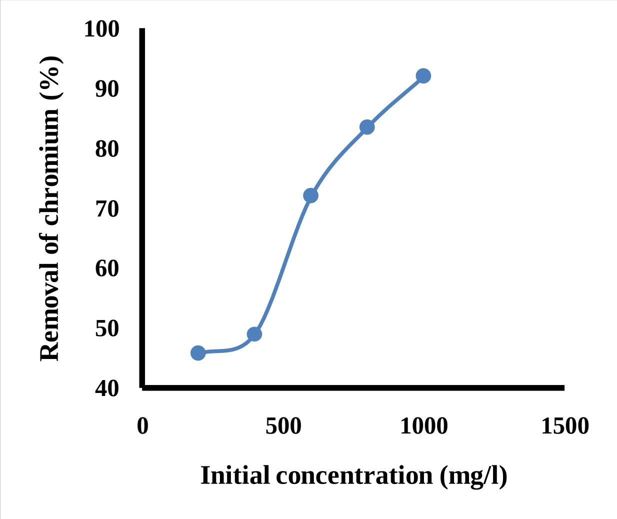

Fig. 1: Effect of initial concentration onchromium removal efficiency

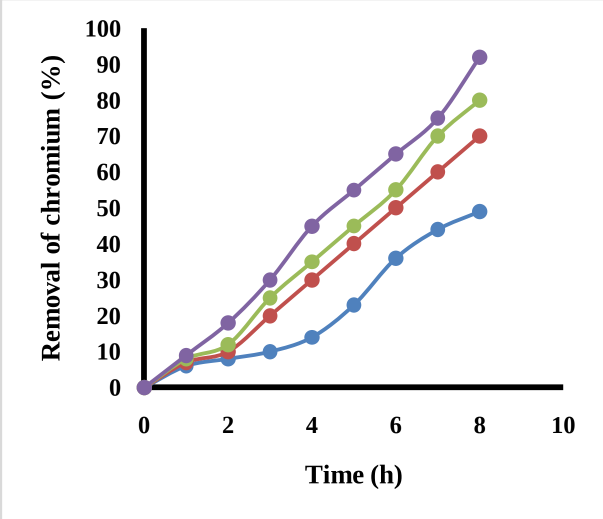

Fig. 2: Effect of contact time on chromium removal efficiency

Effect of biomass

The experiment was carried out for the initial concentration of 1000 mg/L, for the different dosage values of mycelia such as 0.18, 0.2, 0.22 and 0.24 g and the corresponding equilibrium metal removal efficiencies obtained were 83, 92, 81 and 80% respectively at the end of 8th hour. With the increase in biomass loading from 0.18 to 0.2 grams, the metal removal efficiencies increased due to the availability of more active adsorbing sites. Further increase of biomass dosage to 0.22 and 0.24 brought down the metal removal efficiency.

Effect of contact time

Fig. 2 illustrates the effect of contact time on the biosorption of hexavalent chromium using mycelia. From the Fig. 2 it is evident that the biosorption increased gradually with contact time irrespective of the initial concentration of chromium and reached the equilibrium at 8^{th} hour. After the equilibrium level, there was no further increase in the metal removal efficiency and this may be attributed to the limited vacant sites.

Equilibrium study

Analysis of equilibrium data is important for design purpose in developing an e describing the process. For equilibrium modeling of the biosorption systems, the equilibrium data obtained was fitted with the two well known adsorption models, Langmuir and Freundlich models, using their linearized forms.

The Langmuir isotherm model is expressed as,

$$q_e = \frac{Q^o bC_e}{1 + bC_e}$$

Where

q_{eq} (mg/g) and C_{eq} (mg/L) are the amount of metal ion per unit weight of biosorbent and unadsorbed metal ion in solution at equilibrium, respectively.

$Q°$ (mg/g) is the maximum amount of the metal ion per unit weight of biomass to form a complete monolayer on the surface and b (L/mg) is a constant related to the affinity of the binding sites.

The Freundlich isotherm is based on the heterogeneous surface is expressed as

$$q_e = K_F C_e^{1/n}$$

where K_F and n are the Freundlich constants. K_F and n are indicators of adsorption capacity and adsorption intensity, respectively.

The experimental data were found to fit with the Langmuir and Freundlich isotherms (Figs. 3 and 4). The isotherm constants values of Q°, b, K_F and n were 111.11, 0.00458, 0.5001 and 1.002, respectively. The essential characteristics of Langmuir isotherm can be describedby a separation factor (Hall *et al*. 1996) which is defined by $R_L = \frac{1}{1+bC_i}$. Since R_L value lies between 0 and 1 the reported isotherm represents the favourable adsorption. According to Treybal (1988), the values n>1 represent favourableFreundlich isotherm adsorption condition and the same was obtained in the present investigation.

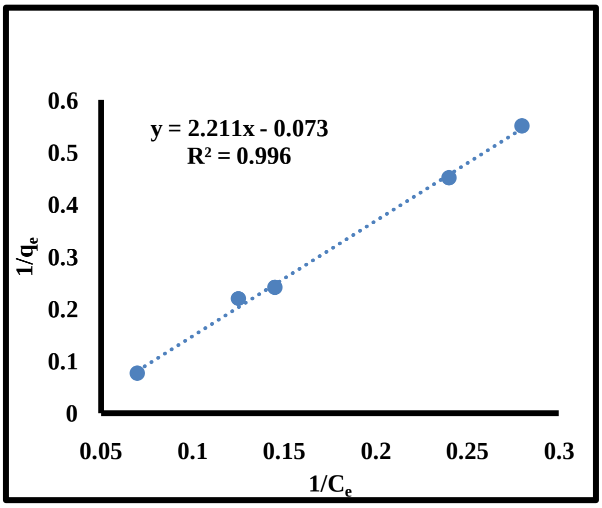

Fig. 3: Langmuir isotherm for different concentrations

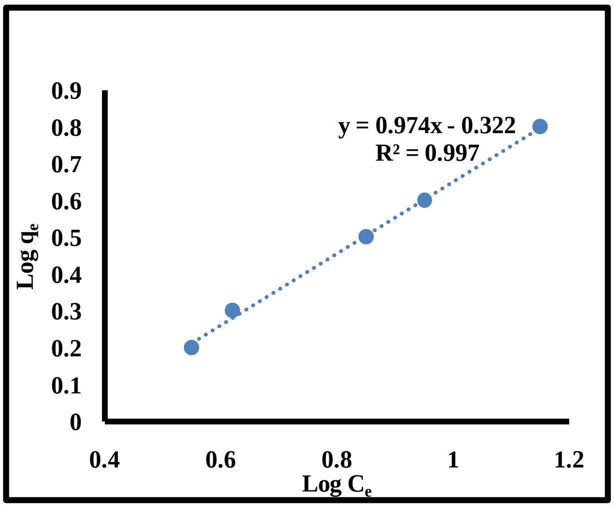

Fig. 4: Freundlich isotherm for different concentrations

Furthermore, the higher correlation coefficients showed that both the Freundlich and Langmuir models are very suitable in describing the biosorption equilibrium of the metal by *Penicilliumchrysogenum* in the studied concentration range.

CONCLUSIONS

In the present investigation for the five different initial concentrations of synthetic chromium effluent such as 200,400, 600, 800, and 1000 mg/L, the steady-state values of chromium removal efficiency were 45.7, 49, 72, 83.5 and 92%, respectively, using 0.2 grams of mycelia under shaking at the end of 8th hour and concluded that Penicilliumchrysogenumis the best and cheap biosorbent. The Langmuir and Freundlich adsorption models fitted well with the equilibrium data of the process studied.

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