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RESEARCH ARTICLE

REMOVAL OF CHROMIUM FROM EFFLUENT BY BIOSORPTION USING *SPIRULINA PLATENSIS*

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ABSTRACT

Industrial effluents is a threat to the biological species in the aquatic environment. Removal of these heavy metals would make the aquatic world free of pollution and will be a boon. This paper presents the studies carried out on the applicability of microalga namely Spirulina sp. for heavy metal removal from the electroplating industrial effluent. The effects of pH, adsorbent dose, temperature and contact time on the adsorption of chromium by the dry biomass were studied. Concentrations of the metal before and after the experiments were measured by manual method of estimation of chromium. The present study describes the metal absorption by dry biomass of *S. platensis* that has been used to remove heavy metal pollutants from effluents.

INTRODUCTION

Biosorption is a process of rapid and reversible binding of ions from aqueous solutions onto functional groups that are present on the surface of biomass. It is independent on cellular metabolism and does not require capital investment was proposed by Michlak *et al.* (2013). The fascinating features of biosorption over conventional treatment methods include: high efficiency, minimization of chemical and or biological sludge, no additional nutrient requirement, regeneration of biosorbent, and possibility of metal recovery was reported by Al Homaidan *et al*. (2014). It has been proved that they are capable of adsorbing heavy metals from aqueous solutions, especially for the metal concentration below 50 mg/L. The metal-binding capacities have been identified to be very high, including marine algae, fungi and yeasts. Chromium can make fish more susceptible to infection; high concentrations can damage and/or accumulate in various fish tissues and in invertebrates (Velma and Tchounwou 2013). *S. platensis* has been proven to treat wastewater by degrading the organic matter and heavy metals. It is a tiny blue-green algae in the shape of a perfect spiral coil. Its scientific name is *Arthrospira platensis*. Biosorption is cheap and eco-friendly method that utilizes microbes to concentrate and to decontaminate water. Biomaterials like algae, fungi, bacteria and activated sludge have been tested as biosorbents for heavy metal removal as reported by Hassouni *et al.* (2014). Biosorption is the method of sorption by either dead biomass or living biomass and it has various significant advantages as (i) high efficiency in eliminating heavy metals even from very low concentrations (ii) low cost, (iii) high adsorbingcapacity and (iv) the ability of recovering the important metals adsorbed as discussed by Dixit *et al.* (2014).

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MATERIALS AND METHODS

Culture Maintenance: Fresh culture of *S. platensis*, the blue green algae was collected from a local commercial production unit. Effluent sample got from an electroplating industry located in Coimbatore. The effluent was raw in nature to which no treatment was carried out in the electroplating industry.

Biosorbent preparation: Biosorbent using the micro algae *S.platensis* was acquired from the commercial production unit. Collected sample was cultivated using Zarrouk medium (Zarrouk, 1966). The sun-dried biomass was rinsed with deionized water to remove the residual alkalinity and dried at room temperature for 24 hours and subsequently at 80^0C for 12 hr. The dried biomass was obtained in a powder form was used for further study.

Effects of pH: To determine the effect of pH on adsorption of zinc by algal biomass test solutions containing 0.1 g of algal dry biomass with different pH levels (6, 7 and 8) were prepared by adjusting the pH to desired initialpH value using 1 N HCl or 1 N NaOH before mixing the adsorbent. pH measurements were done using pH meter. The time, temperature and concentration of biomass was maintained as constant throughout the study.

Effects of contact time: Impact of contact time on adsorption of Cr by biomass was determined at varying periods of incubation time (40, 60 and 80 minutes), with effluent. After incubation for specific contact time, the supernatant was then analyzed for residual metal concentrationin the solution.

Effects of temperature: Effect of incubation temperature on biosorption of zinc was carried out at different incubation temperatures (35, 45, 55°C) with effluent which contained heavy metals. The pH, concentration of adsorbent biomass, and contact time were kept constant throughout the study unless otherwise mentioned.

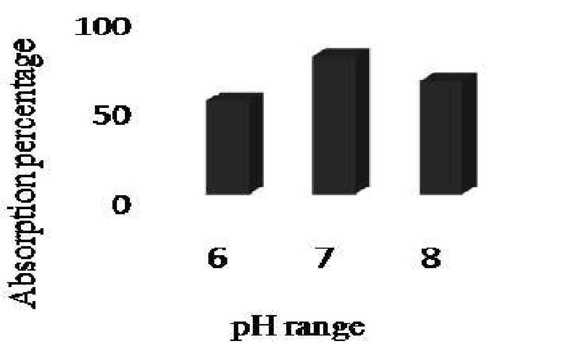
Effects of biomass dose: The effect of dose (concentration) of adsorbent biomass on adsorption of zinc was studied using different biomass concentrations [0.1, 0.2, 0.3 g (dry weight)/L] present in the effluent. The equilibrium time and the pH of the test solution were kept constant to note the amount of biosorption of metal.

Heavy metal analysis: After adsorption, the adsorbates – loaded adsorbent were separated by centrifugation at 6000 rpm, 30 min, filtered through the whatmann filter paper no.3 and used for further analysis. After the incubation chromium estimation was carried out manually under laboratory condition. Control runs without the biosorbent were also performed in order to evaluate the effect of biosorbent on metal removal as shown in www.law.resource.org/pub/in/bis.

RESULTS AND DISCUSSION

Effect of pH: The effect of pH on sorption of Cr is presented in Fig. 1. The pH of the solution has a great effect on the adsorption capacity of metals; adsorption capacity was a maximum when pH was 7 and decreased by either the raising or lowering of pH values. An increase in the biosorption of Cr(III) with the increase of pH can be explained on the basis of decrease in competition between protons and metal cations for the same functional groups and by decrease in the positive surface charge resulting in a lower electrostatic repulsion between the surface and metal ions.

Fig.1 EFFECT OF pH ON ABSORPTION OF CHROMIUM BY *S. platensis*



The dry biomass of *S. platensis* for the biosorption of copper ions from aqueous solutions was noted (Rezaei, 2016). Water soluble *S. platensis* extract was used to remove hexavalent chromium ions from industrial waste water was shown by later scientists too, Kwak *et al.* (2015). From the results presented in Figure 1, it was inferred that, at pH 6, where there was low level of metal adsorption in all other pH levels 7 and 8 there was more than 50% of metal adsorption.

Fig.2 EFFECT OF CONTACT TIME ON ABSORPTION OF CHROMIUM BY *S. platensis*

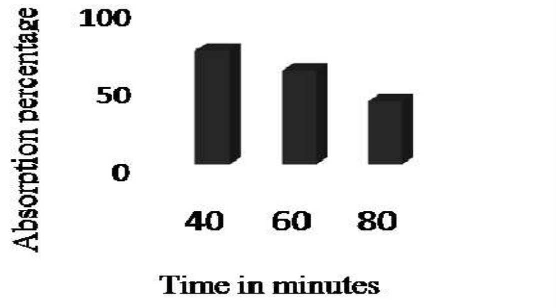
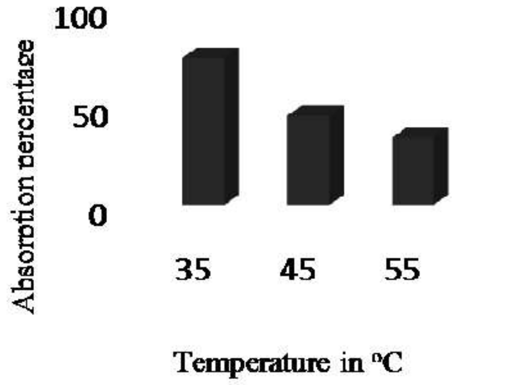
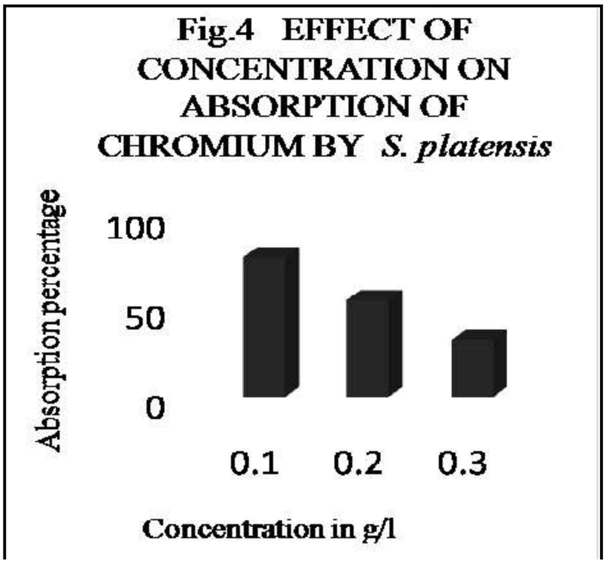


Fig. 3 EFFECT OF TEMPERATURE ON ABSORPTION OF CHROMIUM BY *S.platensis*



It was found that maximal adsorption of chromium reaching equilibrium occurred at pH 7. Based on statistical analysis on algae potentiality in biosorption, it has been reported that algae absorb about 15.3% - 84.6% which is higher as compared to other microbial biosorbents. In all the type of algae brown algae was known to have high absorption capacity. Biosorption of metal ions occurs on the cell surface by means of ion exchange method was stated (Mohammed and Normala, 2015).

Effect of Contact Time: Data presented in Fig. 2 indicated that the rate of adsorption of Cr increased along with increase in contact time from 30 minutes to 60 minutes and declined rapidly on further increase in contact time. Thus the maximum adsorption of chromium was recorded at 40 minutes of contact time, although significant levels of chromium adsorption could be observed even after 30 minutes of contact time. Many researchers studied the effect of contact time on adsorption process. The sorption was studied for high concentration 100mg/l at different time (5, 10, 20, 30, 60, 80, 90 and 120 minutes). The maximum removal of heavy metals was attained at 40 minutes for Cr was shown (Elhaddad and Mahmoud, 2015).



Effect of Temperature: Temperature was observed to have vital effect on adsorption process as it influenced the rate of metal ion adsorption by the cyanobacterial biomass. Interestingly, more than 72% of metal adsorption was recorded at 35°C as shown in Fig.3. Further it was also noted that at higher temperatures such as 45 and 55°C the rate of chromium adsorption declined rapidly. The increase in the equilibrium adsorption of Cr with temperature indicated that removal of chromium ions by *S. platensis* biomass is enhanced at ambient temperatures. Therefore, 35°C was selected as the optimum temperature for further experiments. According to the location where the metal removed from solution is found which is called Non -metabolism dependent/ metabolism independent like extra cellular accumulation/ precipitation, cell surface sorption/ precipitation and intracellular accumulation was proposed by Neethu *et al* (2015).

Effect of Initial Concentration: Studies on the effect of initial concentration of chromium on the rate of adsorption by the cyanobacterial biomass indicated that the initial metal concentration plays an important role in the process of adsorption. It was observed that with increase in initial chromium concentration there was an increase in adsorption of chromium until it reached the saturation point in time when no more chromium was further removed from solution (Fig 4). Thus maximum adsorption of chromium was recorded with 100 mg/l concentration of chromium. Further increase in chromium concentration above 100 mg/l concentration resulted in decrease in rate of adsorption of metal. The adsorption rate declined with the increased concentrations such as 0.2 and 0.3g/l. Therefore, 100 mg/l of chromium was established as the optimum concentration and was used for final experimentation.

Conclusion

In this study, it is reported that *S.platensis* could remove chromium from the effluent. It is economical since the effluent applied was not enriched with nutrients and the biomass was fully renewable. The adsorption process was found to be rapid, since maximum metal removal could be achieved within one hour of contact time and the adsorption capacity depended on pH, biosorbent dose, contact time, temperature and initial lead concentration. Hence, *S. platesis* native biomass is an efficient biosorbent for the removal of Cr from effluent effectively when its concentration is less than 100 mg/L. Thus *Spirulina* biomass can be considered for use to decontaminate water from heavy metals.

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