ABSTRACT

Our Earth seems to be unique with three fourths of its surface covered by water of which only 1% is usable to us. The conservation of water is really a global issue that we should all be a part of. Due to various industrial processes huge amount of metallic species are released into the environment. The increased circulation of the toxic metals through the soils, water and air remain an important environmental issue because the metallic species released tend to persist indefinitely, accumulating in living tissues throughout the food chain. The heavy metals are to be appropriately removed from the waste stream before being discharged into the environment.

The purpose of the present study is to develop a good biosorbent from microbial biomasses to remove the heavy metals from industrial effluents which may replace the existing expensive adsorbents. The present study has examined the biosorption of heavy metals, chromium, zinc and nickel from industrial wastewaters by using algal biomass of *Chlorella, Volvox* and *Zygema* as well as with fungal biomass *Trichoderma*.

Chromium, zinc and nickel wastewater samples were collected from Electroplating Industries located in Coimbatore. Biomass samples collected from various fresh water sources were subjected to microbiological procedures to identify the genus of the microbe present in the collected sample. The genus of the algal
samples were identified as *Chlorella, Volvox* and *Zygnema*. The fungal sample was identified as *Trichoderma*. Biosorbents were prepared from the collected biomass samples subjected to characterization.

Batch sorption experiments were conducted to remove chromium(VI), zinc(II) and nickel(II) using the four biosorbents prepared from algal and fungal biomass. The experiments were carried out to study the effect of contact time, dose of biosorbent, pH, temperature, agitation speed, particle size of the biosorbent and initial metal ion concentration of the samples. Desorption studies were carried out using 0.1N HCl as the desorbing agent. The regenerated sorbent was used in two consecutive adsorption-desorption cycles to study the regenerative capacity of the biosorbents.

The analysis of equilibrium adsorption data by fitting them to different isotherm models is an important step to find the suitable model that can be used for design purposes. Langmuir, Freundlich, Tempkin and Dubinin-Radushkevich isotherms models were selected for isotherm study. The kinetics of sorption reveals the solute uptake rate of the reaction. The kinetics of sorption process was investigated using different kinetic models namely the pseudo first order, pseudo second order, intra particle diffusion and Elovich models.

Infrared spectroscopy is a widely used spectral technique in academic and industrial laboratories, as an instrumental method for structural and functional group analysis of compounds. It provides excellent information on the nature of the bonds
present in the adsorbent and allows identification of the different functional groups on the cell surface. The most important of these groups include carbonyl, carboxyl, amine, secondary amine, amide and imine. The FTIR spectrums of the algal and fungal biosorbents before and after metal biosorption are obtained. It can be seen that IR spectra indicated the presence of ionisable functional groups. This gives an indication that these materials can be used as adsorbents for heavy metal removal.

In the fields of material science and surface chemistry, detailed knowledge of the physical nature of the surfaces of solids is of great importance. Characterization of surface morphology is of vital importance in understanding the physical and chemical behaviour of the material. The comparison of SEM pictures between the raw and metal loaded biosorbents shows that the particles have undergone remarkable physical change after adsorption in all the four biosorbents.

Essentially the main requirement of an industrial sorption system is that the sorbent can be utilized as a continuous system. In column biosorption studies, the efficiency of biosorbents were investigated for the bed depths 2.5 cm, 5 cm, 8cm and 10 cm and flow rates of 2 mL/min, 4mL and 6mL/min for heavy metal removal from industrial wastewater. Sorbent bed height and flow rate strongly affects the volume of the solution treated or throughput volume.

Breakthrough curves were plotted with the observed column sorption data and analyzed. The results indicated that the throughput volume of the aqueous solution increased with increase in bed height, due to the availability of more
number of sorption sites. The equilibrium biosorption capacity decreased with increase in bed height. This shows that at smaller bed height the effluent adsorbate concentration ratio increased more rapidly than for a higher bed height. The breakthrough time also increased with increasing bed depth, suggesting that it is the determining parameter of the process. At low flow rate, relatively high volume was observed while at higher flow rates much sharper breakthrough was obtained. The time required to reach the breakthrough decreased with an increased flow rate. It was noticed that the best performance of sorbents in the removal process of metal ions in column studies occurs under the process parameters of 10 cm bed depth and 2 mL/min flow rate, highest bed height and lowest flow rate for all the three metals.

The column data were fitted to the Yoon-Nelson model to determine the Yoon-Nelson rate constant ($K_{YN}$) and the time required for 50% adsorbate breakthrough ($\tau$). Similarly the column data were fitted to the Thomas model to determine the Thomas rate constant ($K_{TH}$) and maximum solid-phase concentration ($q_e$). The model coefficients and relative constants were obtained using linear regression analysis. The column adsorption data were fitted well with Thomas and Yoon Nelson models.

The neural network model for biosorption process was developed by correlating the parameters volume treated, bed depth and flow rate and the output from the trained network by multiple regression analysis.