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Kinetic studies on adsorptive removal of Ni (II) from aqueous solution using microalgal resins

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Abstract

The removal of Ni from aqueous solution using microalgal resin has been studied. The percentage removal of Ni was carried out by varying experimental conditions *viz*., initial metal ion concentration, contact time, and pH,. It was found that more than 80% removal was achieved within 100 minutes. This process follows first order Lagergren kinetic model. First order rate constant K_{ad} was calculated. Both Langmuir and Freundlich isotherms were found to fit and the experimental uptake, the adsorption capacity and adsorption intensity were calculated. The studies showed that microalgal resin that can be used for efficient removal of Ni(II) from waste water.

Keywords : ion exchange, micro algal resin, removal of Ni (II), Lagergren kinetic model, Langmuir and Freundlich isotherms

INTRODUCTION

Electrochemical industries like metal finishing, electroplating and battery industries, metal fabrication paint and pigment industries contribute considerably to pollution load. Nickel is used in a wide variety of industrial processes such as alloy preparation, metal plating and electronics. Chemical precipitation and filtration, chemical oxidation or reduction, electrochemical treatment, evaporation, ion exchange and reverse osmosis are some of the most commonly used procedures for removing metal ions from aqueous streams (Volesky, 2001). The pollutants include heavy metals, which are toxic. The presence of nickel concentrations at 2-1000pprn has been known to be one of the major toxic pollutants, which necessitates removal of the same as a measure of environmental pollution control. Biosorption of heavy metals from aqueous solutions is a relatively new technology for the treatment of some industrial wastewaters. It is defined as the accumulation and concentration of pollutants from aqueous solutions onto biological materials, thus allowing the recovery and/or environmentally acceptable disposal of pollutants (Do"nmez *et al*., 1999). The major advantages of the biosorption technology are its effectiveness in quickly reducing the concentration of heavy metals ions to very low levels with high efficiency and the use of inexpensive biosorbent materials (Yu *et al*., 1999). These characteristics make biosorption an ideal alternative for treating high volumes of low concentration complex wastewaters (Tsezos, 2001). Pretreatment of tannery wastewater by ion exchange process for the removal of Cr (III) was studied by Tiravanti *et al*. (1997). Rengaraj *et al*. (2001) and Periyasamy and Namasivayam, (1995) studied the removal of chromium from water and wastewater by ion exchange resins. In the present study micro algal resin was used for the removal of Ni (II) from aqueous solution. The objective of this work was to investigate equilibrium and kinetic parameters of the ion exchange resin for the removal of Ni (II) from aqueous solution. The parameters, which influence adsorption such as initial metal concentration contact time, and pH, were investigated.

EXPERIMENTAL METHODS

The removal of Ni from aqueous solution by microalgal resin has been studied using nickelsulphate solution. A stock solution of 1000 mg/l of nickel was prepared. This solution was diluted as required to obtain initial concentrations of 100, 150, and 200 mg/L of nickel. Different pH levels were adjusted using dilute acid or dilute sodium hydroxide. 5 gms of resin were added to each bottle and the pH was adjusted. The solutions were agitated for a predetermined period in shaking incubator and for each time, the samples were taken and filtered. The solution was analyzed by AAS. All experiments were conducted at room temperature i.e 30°C. Adsorption isotherm and kinetic studies were carried out with different initial concentrations of nickel *viz*., 100, 150, and 200 mg/L and different pH *viz*., 2,4,6, and 8.

RESULTS AND DISCUSSION

Effect of initial concentration

Fig. 1 shows the effect of reaction time on the removal of Ni (II). Ni (II) removal increased with time for all the initial metal iron concentration. The metal removals versus time curves were smooth and continuous

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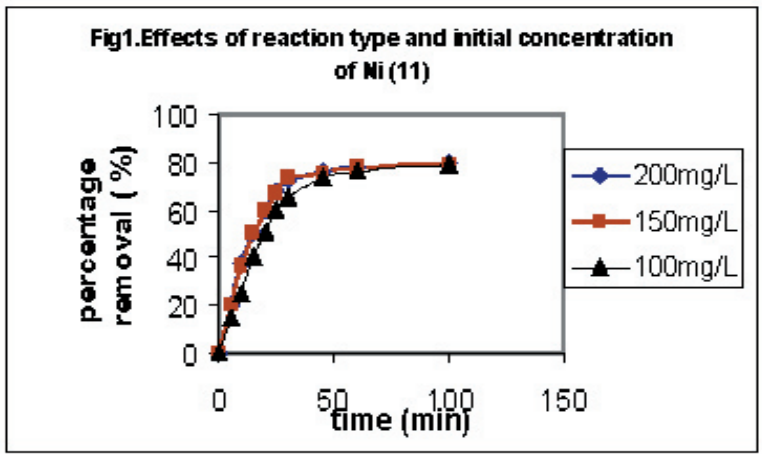


Fig1.Effects of reaction type and initial concentration of Ni (11)
percentage removal (%)
100
80
60
40
20
0
0
50
100
150
time (min)
200mg/L
150mg/L
100mg/L

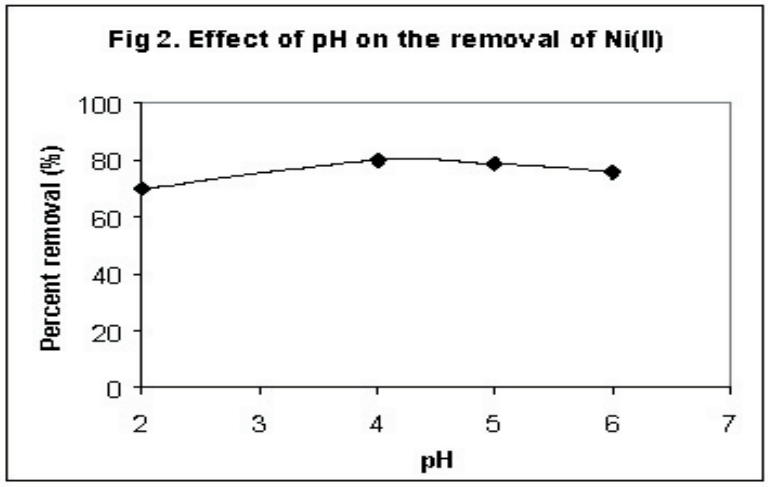
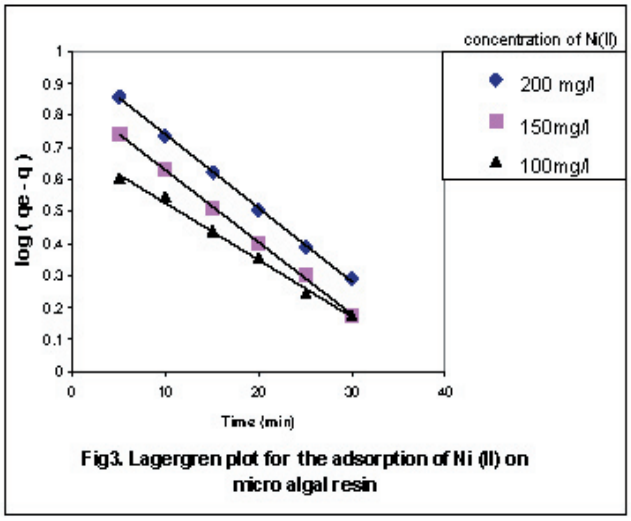
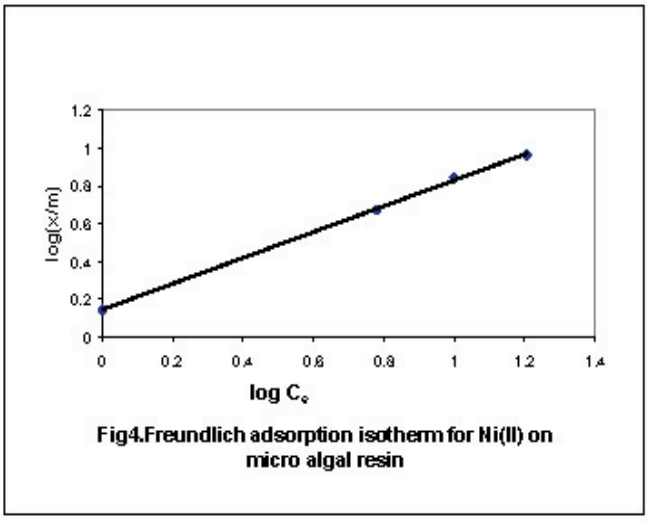


Fig 2. Effect of pH on the removal of Ni(II)
Percent removal (%)
100
80
60
40
20
0
2
3
4
5
6
7
pH


concentration of Ni(II)
200 mg/l
150mg/l
100mg/l
log (qe - q)
Time (min)
Fig3. Lagergren plot for the adsorption of Ni (II) on micro algal resin


log(x/m)
log Ce
Fig4.Freundlich adsorption isotherm for Ni(II) on micro algal resin

indicating monolayer adsorption of metals on the surfaces of the resin.

Effect of pH

In order to investigate the effect of pH, the batch experiments were conducted in the pH range 2-7 and the results are shown in Fig 2. As the pH increases the removal of metal ion increases. The maximum capacity of Ni adsorption is found in the pH range 4- 5.

Adsorption kinetics

The first order rate expression given by Lagergren (7)

$$\log(qe-q) = \log qe \; K_{ad} (t/ 2.303) \quad \ldots(1)$$

where q and qe are the amounts of Ni(II) adsorbed (mg/g) of time t (min) and at equilibrium time respectively and K_{ad} is the rate constant of adsorption.

Metal uptake q(mg of metal / gm of resin) was calculated as follows

$$q = V (C \text{ initial } C \text{ final}) /1000m \quad \ldots(2)$$

V - the volume of metal solution (ml), C initial - the initial concentration of metal ion solution (mg/l), C final - the final concentration of metal ion in the solution (mg/l), m - the mass of the resin (g).

Fig 3 is a linear plot of log (q_e - q) versus t, which shows that the removal of Ni (II) by this cation resin is following first order expression. The kinetics of Ni(II) adsorption on micro algal resin followed first order expression given by Lagergren. K_{ad} values were calculated from the slopes of the linear plots and are presented in Table 1.

Table 1. Adsorption rate constants of Lagergren plots for Ni(II) on micro algal resin

Initial concentration of Ni(II) (mg/l)	K_{ad} (1/ min)
200	0.0525
150	0.0516
100	0.0410

Adsorption isotherm

The experimental results were fit into Freundlich adsorption isotherm.

$$x/m = kc_e^{1/n}$$

The logarithmic form of the equation becomes

$$\log(x/m) = \log k + 1/n \log c_e$$

x/m = The amount of metal adsorbed per unit mass of the resin

c_e Concentration of the metal in solution at equilibrium

The experimental results obtained for the adsorption of nickel on micro algal resin is found to obey Freundlich adsorption isotherm. Fig 4 shows the plot of log(x/m) versus log c_e for various initial concentrations which was found to be linear indicating the adsorption capacity (k) and adsorption intensity (n). The adsorption capacity (k) and adsorption intensity (n) were calculated from Fig 4 and the values are 7.3957 and 1.457, respectively.

Value of n shows the favorable adsorption of metal on micro algal resin

CONCLUSION

The present study showed that micro algal resin could be used as an adsorbent for the effective removal of nickel from aqueous solution. The removal efficiency increases with increase in contact time, decrease in initial metal ion concentration, and increase in pH. Longmuir isotherm was found to fit the experimental metal uptake rates. Application of this micro algal resin to waste water treatment could be economical and efficient.

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