CHAPTER FOUR

DESORPTION CHARACTERISTICS OF COPPER ON IMMobilised ALGAL BIOMASS
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4.1 General Background

Technical application of the biosorption process for the treatment of industrial effluents includes exploring the potential for recovering the adsorbed metals and the potential for reusing the regenerated biosorbent in multiple adsorption-desorption cycles. The realisation of such a potential would make the use of the biomass similar to that of activated carbon or other synthetic adsorbents. Efficient desorption of adsorbed metals and simultaneous regeneration of the biomass are critical for commercial application of this technology. Efficient desorption involves obtaining a concentrated solution of desorbed metals for possible metal recovery. On the other hand, complete regeneration of the biomass is necessary to enable repeated adsorption-desorption cycles to be performed using the same biomass, thus enhancing the cost-effectiveness of the technology.
Recovery of the adsorbed metal could be achieved by the use of an appropriate desorbent capable of effectively stripping the sequestered metal from the biosorbent and bringing it back into solution. It is desirable that the desorption be complete or any irreversibly held metal be kept to a minimum. In addition, it is desirable that the least possible damage occurs to the adsorption properties of the biomass so as to allow the reuse of the biosorbent in subsequent adsorption-desorption cycles possible.

In this study, hydrochloric acid (HCl) and ethylenediaminetetraacetic acid (EDTA) were employed as desorbents to strip bound copper from the immobilised biomass of a marine macroalga, *Sargassum baccularia*. Different desorbents could exert different mechanisms to release the adsorbed metals into the solution. The mineral acid, HCl, dissolves copper to form copper salt, CuCl₂. Darnall *et al.* (1986) showed that copper bound to free or immobilised algal cells was readily desorbed by using an acidic solution. Once regenerated, the algal biosorbent was reused and the regenerant solution recycled.

Mineral acids are proton exchanging agents. The protons from the acids exchange position with metals bound on the biosorbent surface, concurrently releasing them into the solution. Results obtained in Chapter Three showed that at low pH values copper was weakly adsorbed by the biomass of *Sargassum baccularia*. Based on this observation, it can be expected that desorption of copper would be optimal at lower pH values.
Strong chelating agents such as EDTA form stable complexes with metals and could assist in the desorption of copper adsorbed by the biomass. The cations sequestered to the surface of the biosorbent are easily coupled to EDTA. Thus, this complexing agent may serve as an effective desorbent for regeneration of the biosorbent.

The main objectives of the present investigation are to evaluate the effectiveness of HCl and EDTA solutions in stripping adsorbed copper from the immobilised biomass and to assess the reusability of the immobilised biomass in multiple cycles of copper adsorption-desorption in a batch system.

4.2 Materials and Methods

4.2.1 Materials

The immobilised biomass beads used here were prepared as in Section 3.3.2. Stock copper solution was prepared as before using nitrate salt of copper and dissolved accordingly in distilled deionised water. Copper concentration analysis was carried out by means of Inductively Couple Plasma Atomic Emission Spectrophotometry (ICP-AES) using a Baird instrument. All chemicals and ICP standards used were of analytical grade, obtained from Fluka, Switzerland. Two desorbents were tested, hydrochloric acid and EDTA (ethylenediaminetetraacetic acid). EDTA was used in the form of sodium salt, i.e. ethylenediaminetetraacetic acid disodium salt dihydrate.
4.2.2 Methods

4.2.2.1 Copper Desorption Kinetics

The immobilised biomass of *Sargassum baccularia* was first loaded with copper by conducting batch biosorption studies. The initial concentration of copper solution was fixed at 1.57 mM (100 mg/L). The test flasks were incubated for 24 hours with a shaking speed of 200 rpm and at 25 °C. The experimental procedures were similar to those in Chapter Three (Section 3.3.2).

Upon equilibrium, the gel beads were separated from the solutions. The beads were then washed repeatedly with distilled deionised water to remove any unbound copper. After washing, excess water was removed from the beads.

The beads were again placed in 250 mL Erlenmeyer flasks containing 100 mL of desorbent. The concentration of EDTA solution was fixed at 8 mM. The performance of hydrochloric acid as desorbent was examined with pH values of 1.0 and 2.0. The amount of copper desorbed was evaluated at fixed time intervals. The experiments were carried out in duplicates and the results reported here are based on average values.

4.2.2.2 Evaluation of Desorbents

The immobilised biomass beads were first exposed to copper solution at 1.57 mM (100 mg/L) as described in Section 4.2.2.1 for copper uptake. The amount
of biomass in the beads was approximately 0.1 g. After adsorption and washing, the beads were added to four Erlenmeyer flasks containing 10, 25, 50 and 100 mL of hydrochloric acid at pH 1.0.

Another set of copper-loaded immobilised biomass was prepared for the evaluation of EDTA as the desorbent. The effectiveness of EDTA in stripping the adsorbed copper from the biomass was tested at various EDTA concentration levels: 0.5, 2, 4 and 8 mM.

All the flasks were incubated for 24 hours to allow the system to reach equilibrium. At the end of the desorption experiments, the immobilised biomass beads were separated from the desorbents. The solutions were then filtered with 0.45 µm cellulose acetate membrane filter. The filtrate was diluted accordingly and subjected to copper analysis using the ICP-AES method.

4.2.2.3 Multiple Cycles of Copper Adsorption-Desorption

In these experiments, the immobilised biomass beads were first loaded with copper by performing batch adsorption experiments. The biomass was then exposed to the desorbents. The procedures were as described in Section 4.2.2.2. At the end of the desorption process, the beads were separated from the desorbent and washed repeatedly with distilled deionised water. The washed biomass was then subjected to another cycle of adsorption and desorption. The
adsorption-desorption procedures were conducted for five consecutive cycles. The desorbents used were HCl at pH 1.0 and 2 mM EDTA solution.

4.3 Results and Discussion

In the present study, all adsorption experiments were carried out by exposing the immobilised Sargassum baccularia beads to 1.57 mM (100 mg/L) solutions of copper. The amount of biomass in the beads was approximately 0.1 g. Upon reaching equilibrium, the absolute amount of copper loaded on the biosorbent was in the range of 0.075-0.080 mmol. These copper-laden biosorbents were then exposed to the two desorbents, HCl and EDTA solutions.

4.3.1 Copper Desorption Kinetics

To determine the amount of time required to achieve desorption equilibrium, the kinetics of the process was studied. HCl at pH 1.0 and pH 2.0 and EDTA at 8 mM were employed as the desorbents. The initial pH of the EDTA solution was 4.6. The pH was not adjusted because previous studies with HCl indicate that the effect of pH on desorption was negligible at pH > 4 (Chu et al., 1997). The time profiles of copper desorption were plotted in Figure 4.1. As seen in Figure 4.1, desorption of copper from the immobilised biomass beads was relatively fast. This is very obvious in the case of HCl at pH 1.0 where desorption equilibrium was achieved within 1 hour.
However, desorption by HCl at pH 2.0 needed a longer time to attain equilibrium; about 3 hours to strip 80 % of the adsorbed copper from the biomass. In the case of EDTA, almost 4 hours were required to reach the final desorption equilibrium. The disadvantage of requiring a longer time is compensated by a higher desorption efficiency. Desorption efficiency is defined as follows:

\[
\text{Desorption efficiency} = \frac{\text{Amount of metal desorbed (mmol)}}{\text{Amount of metal loaded (mmol)}} \times 100 \% \quad (4.1)
\]

Desorption efficiencies calculated according to Equation (4.1) for the three desorbing conditions, 2 mM EDTA solution, HCl at pH 1.0 and HCl at pH 2.0 are 95, 91 and 80 %, respectively.

The desorption of heavy metals from biomass by acidic solution consists of three steps: (1) the desorption reaction of the metal ions from binding sites of the biosorbent; (2) diffusion of the metal ions from the inside to the surface of the biosorbent; (3) diffusion of the ions across a stationary liquid film surrounding the biosorbent particle and into the bulk liquid. Generally, the overall kinetics is mainly controlled by the mass transfer process (Yang and Volesky, 1996).
Figure 4.1: Kinetics of copper desorption from immobilised biomass of *Sargassum baccularia*. Desorbents used were HCl at pH 1.0 and pH 2.0 and 8 mM EDTA solution.
The resistance to mass transfer through the liquid film is proportional to the thickness of the liquid layer for the solution system which is, in turn, controlled by agitation in the bulk solution. Therefore, strong stirring will decrease the thickness of the film and finally eliminate the effect of the film resistance.

Based on the results, the desorption experiments should be carried out under agitated condition and a contact time of more than 4 hours to ensure all the desorption experiments reach equilibrium. A desorption period of 24 hours employed in subsequent experiments was thus more than sufficient to ensure that desorption equilibria was achieved.

4.3.2 Evaluation of Desorbents

4.3.2.1 Hydrochloric Acid as Desorbent

The most convenient way to remove adsorbed metal ions from the biomass is to treat the material with dilute acid. As discussed earlier in Section 4.3.1, hydrochloric acid at low pH values is capable of stripping the sequestered copper from the immobilised *S. baccularia* beads.

In recovering adsorbed species from biosorbents by using a desorbent, it is desirable to use the smallest possible desorbing volume to contain the highest concentration of the metal. At the same time, the volume of the desorbents should be enough to provide maximum solubility for the metal desorbed.
Optimisation of the volume of desorbent is often carried out by optimising a parameter known as the solid-to-liquid (S/L) ratio which is defined as the ratio of the amount of biomass to be processed in mg to the volume of desorbent used in mL. An additional parameter known as the concentration factor (CF), defined as the ratio of metal concentration in the desorbent solution to initial metal concentration, is also often used.

It is desirable to achieve the highest possible S/L ratio which in turn would lead to the biggest possible CF while maintaining a satisfactory level of desorption efficiency. In other words, it is desirable to use the minimum amount of desorbent to process a given amount of biomass loaded with metals.

Since hydrochloric acid at pH 1.0 showed higher desorption efficiency compared to HCl at pH 2.0, HCl at pH 1.0 was selected here as the desorbent to evaluate the S/L ratio and the CF parameter.

Calculated S/L ratios and CF values with HCl at pH 1.0 as the desorbent are summarised in Table 4.1. Table 4.1 shows the volume of desorbent used, the S/L ratio implemented during desorption and the concentration factor (CF) achieved. Figure 4.2 shows the desorption efficiency as a function of the S/L ratio whereas Figure 4.3 depicts copper concentration in the desorbent solution as a function of the volume of desorbent.
Table 4.1: S/L ratio and CF values with HCl at pH 1.0 as desorbent.

<table>
<thead>
<tr>
<th>Volume of desorbent (mL)</th>
<th>S/L</th>
<th>CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>11</td>
<td>3.37</td>
</tr>
<tr>
<td>25</td>
<td>4.5</td>
<td>1.60</td>
</tr>
<tr>
<td>50</td>
<td>2.2</td>
<td>0.76</td>
</tr>
<tr>
<td>100</td>
<td>1.1</td>
<td>0.41</td>
</tr>
</tbody>
</table>

As seen in Figure 4.2, the desorption efficiency remained as high as 90% for S/L ratios < 5. However, the desorption efficiency dropped to 80% at a S/L ratio of 11. The optimum S/L ratio would therefore have to be kept < 5 in order to achieve more than 90% desorption efficiency.

As expected, the experimental results plotted in Figure 4.3 indicate that when the volume of the desorbent solution was reduced, the respective copper concentration in the desorbent increased. The results indicate that over three-fold increase in copper concentration was achieved at a S/L ratio of 11 with HCl at pH 1.0 as the desorbent.
Figure 4.2: Effect of solid-to-liquid ratio on copper desorption efficiency. Desorbent = HCl at pH 1.0.
Figure 4.3: Effect of desorbent volume on copper concentration in the desorbent. Desorbent = HCl at pH 1.0.
A copper concentration of over 5.2 mM (329 mg/L) in the desorbent was observed in the present work. The S/L ratio could, in theory, be increased further, but higher S/L ratios would lead to lower desorption efficiency and are not practical for the experimental contact technique used in the present work. A new contact technique would have to be developed in order to examine higher S/L ratios.

The above results show that HCl is an effective desorbent to strip adsorbed copper from the immobilised biomass beads. Acids have been proven to be efficient desorbents in previous studies (Crist et al., 1990; Khummongkol et al., 1982). A study on desorption of copper from immobilised Pseudomonas putida II-11 showed that HCl successfully removed 94% of the bound copper (Wong et al., 1993). Complete recovery of copper was observed from columns packed with immobilised microalgal biomass using sulphuric acid as desorbent (Greene et al., 1987).

The high desorption efficiency of mineral acids can be explained in three ways. Firstly, the effectiveness of acids may be attributed to their ion-exchange properties. Protons have been known to play a role in ion-exchange (Crist, 1992). It is possible that the high concentration of protons present was able to displace the metal ions. The copper desorption process resulted in a decrease of H+ ions concentration in the desorbent. This suggests that the copper stripping
process requires some H\(^+\) ions to release copper from the biosorbent, indicating the probable involvement of the ion-exchange mechanism.

Secondly, acids can dissolve metal-ligand complexes. One of the various mechanisms of surface adsorption is the formation of complexes between the metals and functional groups on the biomass surface. These complexes may be acid soluble in nature. Therefore, when the biomass is exposed to acidic solution, the complexes are readily dissolved, concurrently releasing the metals into the solution.

Acid solutions could also have dissolved some types of polysaccharides that may contain ion binding sites and the mineral contents of the biomass (Kuyucak and Volesky, 1989b). Once the binding sites are damaged, the sequestered metal ions initially held by the biosorbent are released back into the solution. Although a macroscopic examination of the acid treated biomass was not done in this study, a similar work by Kuyucak and Volesky (1989b) showed that the granular form of the algal biosorbent changed into a sheet-like soft texture that was difficult to separate by filtration. The deterioration in the macroscopic appearance of the biomass was also observed in desorption of uranium from fungi by acid solutions (Tsezos, 1984).
4.3.2.2 EDTA as Desorbent

EDTA, a strong chelating agent, has been shown to be an effective desorbent for stripping bound copper from the immobilised *S. baccularia* beads (Figure 4.1). The desorption efficiency of the 8 mM EDTA solution is higher in comparison with HCl. However, the concentration of the EDTA solution was not optimised in the preliminary experiment reported earlier. In order to select an effective concentration of EDTA, various concentrations of EDTA solutions were examined. Copper desorption efficiency as a function of EDTA concentration is shown in Figure 4.4. Maximum desorption efficiency (>95 %) was readily achieved at EDTA concentrations greater than 2 mM. However, the desorption efficiency dropped to 54 % at an EDTA concentration of 0.5 mM. The results imply that in order to maintain a relatively high desorption efficiency, the lowest concentration of EDTA to be used as desorbent should be at least 2 mM.

EDTA has been known for its ability to form stable complexes with metal ions. The stability constant (In K') for copper-EDTA pairs is 18.92 (Sillen and Martell, 1964). However, relatively less work has been done by using EDTA as desorbent compared to mineral acids. A study by Wong *et al.* (1993) showed that 0.1 M EDTA was able to recover 89 % of adsorbed copper from the immobilised cells of *Pseudomonas putida II-11*. Results obtained by Chu *et al.* (1997) showed that 3.24 mM of EDTA stripped almost all cadmium adsorbed on the native algal biomass of *Sargassum baccularia*.
Figure 4.4: Copper desorption efficiency as a function of EDTA concentration.
Based on these results, it can be said that EDTA is an effective desorbent with the capability to recover more than 95% of copper bound onto the biomass.

Cations physicochemically sequestered to the biomass surface are easily coupled to EDTA, whereas intracellularly accumulated cations could not be so easily desorbed from the biosorbent material (Norris and Kelly, 1979). Therefore, the ability of EDTA to remove most of the bound copper shows that the biosorption process was probably limited to surface adsorption and that the adsorbed copper did not penetrate the cell wall structure.

4.3.3 Multiple Cycles of Copper Adsorption-Desorption

The reusability of the immobilised algal biomass was tested in five consecutive cycles of copper adsorption and desorption by using two desorbents, hydrochloric acid (HCl) at pH 1.0 and aqueous solution containing 2 mM EDTA. Previous sections showed that HCl at pH 1.0 and 2 mM EDTA solution could easily desorb more than 90% of the adsorbed copper in a single cycle of adsorption-desorption.

For a desorbent to be considered efficient it must fulfil two major criteria: (1) complete desorption in each cycle and (2) metal uptake capacity of the adsorbent remains unchanged in successive cycles.
Desorption efficiency as defined in Equation (4.1) can be used as a parameter to assess whether a desorbent is able to meet the first criterion and the equation is reproduced here and labelled as Equation (4.2):

\[
\text{Desorption efficiency} = \frac{\text{Amount of metal desorbed in one cycle (mmol)}}{\text{Amount of metal loaded in the same cycle (mmol)}} \times 100\% \quad (4.2)
\]

The ability of a desorbent to meet the second criterion in multiple cycles of adsorption-desorption can be assessed by defining a parameter called 'reloading efficiency' which is defined in Equation (4.3):

\[
\text{Reloading efficiency} = \frac{\text{Amount of metal loaded in higher cycle (mmol)}}{\text{Amount of metal loaded in first cycle (mmol)}} \times 100\% \quad (4.3)
\]

Equation (4.3) allows one to assess the reusability of an adsorbent by comparing metal uptake in subsequent cycles to metal uptake by the virgin adsorbent in the first cycle.

Figures 4.5 and 4.6 show the experimental results obtained from five consecutive cycles of copper adsorption-desorption using HCl at pH 1.0 and 2 mM EDTA solution as the desorbent. The open bars depict the amount of copper adsorbed while the solid bars represent the amount of copper desorbed
Figure 4.5: Five consecutive cycles of copper adsorption-desorption using HCl at pH 1.0 as desorbent.
Figure 4.6: Five consecutive cycles of copper adsorption-desorption using 2 mM EDTA solution as desorbent.
in each cycle. Figures 4.5 and 4.6 clearly show a noticeable decrease in copper uptake after the first cycle of adsorption-desorption. The highest uptake was about 0.08 mmol copper which occurred at the first cycle.

Calculated values of the desorption and reloading efficiencies of the five cycles according to Equations (4.2) and (4.3) are tabulated in Tables 4.2 and 4.3.

Tables 4.2 and 4.3 show that the desorption efficiency ranged from 89 to 104 % with HCl at pH 1.0 as the desorvent and from 89 to 100 % with EDTA as the desorvent, indicating that both desorbents were effective in stripping adsorbed copper from the immobilised biomass over five consecutive cycles of adsorption-desorption. A desorption efficiency greater than 100 % indicates that the excess copper must have come from the copper that was not desorbed in the preceding cycles.

Table 4.2: Desorption efficiency and reloading efficiency in five consecutive cycles of copper adsorption and desorption using HCl at pH 1.0 as desorvent.

<table>
<thead>
<tr>
<th>Cycle number</th>
<th>Desorption efficiency (%)</th>
<th>Reloading efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>91</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>91</td>
<td>56</td>
</tr>
<tr>
<td>3</td>
<td>96</td>
<td>55</td>
</tr>
<tr>
<td>4</td>
<td>104</td>
<td>52</td>
</tr>
<tr>
<td>5</td>
<td>89</td>
<td>59</td>
</tr>
</tbody>
</table>
Table 4.3: Desorption efficiency and reloading efficiency in five consecutive cycles of copper adsorption and desorption using 2 mM EDTA solution as desorbent.

<table>
<thead>
<tr>
<th>Cycle number</th>
<th>Desorption efficiency (%)</th>
<th>Reloading efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>94</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>71</td>
</tr>
<tr>
<td>3</td>
<td>97</td>
<td>69</td>
</tr>
<tr>
<td>4</td>
<td>94</td>
<td>68</td>
</tr>
<tr>
<td>5</td>
<td>89</td>
<td>66</td>
</tr>
</tbody>
</table>

Table 4.4 shows the cumulative amounts of copper adsorbed and desorbed and the recovery percentage over the entire five cycles. In both cases the quantity of copper desorbed was very close to the quantity loaded, indicating that almost complete desorption was eventually achieved. The recovery percentage of copper was 92 and 97 % by using HCl at pH 1.0 and 2 mM EDTA solution as the desorbent, respectively. It is clear that copper uptake by the immobilised biomass is reversible with very little accumulation of irreversibly bound copper on the biomass. This observation indicates that the two desorbents had successfully fulfilled the first criterion stated earlier, i.e., complete desorption of the adsorbed metal.
Table 4.4: Total amount of copper adsorbed and desorbed and the recovery percentage over five cycles of adsorption-desorption.

<table>
<thead>
<tr>
<th>Desorbent</th>
<th>Copper loaded (mmol)</th>
<th>Copper desorbed (mmol)</th>
<th>Percent recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCl</td>
<td>0.26</td>
<td>0.24</td>
<td>92</td>
</tr>
<tr>
<td>EDTA</td>
<td>0.31</td>
<td>0.30</td>
<td>97</td>
</tr>
</tbody>
</table>

Tables 4.2 and 4.3 show that while the two desorbent were efficient in releasing the adsorbed copper into solution in each cycle, their application negatively affected subsequent copper uptake (reloading). After the first cycle, copper uptake by the immobilised biomass in Cycles 2-5 with HCl as the desorbent was reduced to 52-59% of the original copper uptake observed in the first cycle. A similar reduction was observed with EDTA as the desorbent, yielding adsorption efficiencies ranging from 66 to 71% in Cycles 2-5.

The results presented above therefore suggest that the two desorbent had failed to meet the second criterion which requires a desorbent to cause little reduction in the metal uptake capacity of an adsorbent in multiple cycles of adsorption-desorption.

The reduction in the copper reloading capacity of the immobilised biomass may be attributed to the release of residual desorbent during the copper uptake step in Cycles 2-5. Following the stripping of the adsorbed copper in each cycle, the
polymeric beads were repeatedly washed with distilled deionised water to remove any residual desorbent adhered to the structure of the beads. The beads were then reloaded with copper. If the desorbent was not completely removed, the release of the residual desorbent during the copper reloading step would hinder copper uptake by the immobilised biomass.

Another possible cause of the observed reduction in the copper reloading capacity of the immobilised biomass may be attributed to the adverse effect of the desorbent on the binding sites of the biomass. The reduction in copper uptake after five cycles by using HCl at pH 1.0 as the desorbent was due to the possibility that the binding sites on the biomass were either destroyed or morphologically altered. As mentioned in the previous section, acid solution can dissolve certain cell wall components of algae. Consequently, repeated exposure to acidic conditions destroyed the metal binding sites. This may have prevented the copper ions from binding onto the biomass surface in the subsequent cycles. Studies by Kuyucak and Volesky (1989b) and Percival and McDowell (1967) showed that hydrochloric acid can rupture the structure of alginate chains and the hydrogen bonding capacity of the alginates by hydrolysis. Alginate has been shown to be the principal component in the algal cell wall responsible for metal binding. As a result, a majority of the metal binding sites on the biomass was destroyed.
Similarly, the reduction in the reloading capacity of the immobilised biomass for copper from the second cycle onward with 2 mM EDTA solution as the desorbent was probably due to the adverse effect of EDTA on the cell wall upon repeated exposure to the EDTA solution. As EDTA is a strong chelating agent, it might have altered the configuration of the binding sites on the biomass surface following extraction of the adsorbed copper by EDTA in the first cycle to form highly stable complexes in solution (Chu et al., 1997). The change in the conformation of the active sites could have prevented copper from binding onto the immobilised biomass and thus causing a gradual decrease in its reloading capacity in subsequent cycles.

4.4 Conclusions

Results obtained in the present study indicate that hydrochloric acid and EDTA are potential desorbents to release bound copper from the immobilised biomass of *S. baccularia*. Desorption of copper was a relatively rapid process. Less than 1 hour was required to attain equilibrium when HCl at pH 1.0 was used as the desorbent while approximately 4 hours were needed to reach equilibrium with 8 mM EDTA solution as the desorbent. In copper desorption, EDTA solutions with a concentration of 2 mM or greater was capable of desorbing almost 95% of the bound copper and a desorption efficiency of 91% was obtained with HCl at pH 1.0 as the desorbent.
The present study also shows that a very high solid-to-liquid ratio of 11 could be achieved with more than 80% desorption efficiency when HCl at pH 1.0 was used as the desorbent. A concentration factor of more than 3 was easily obtainable.

Recycling experiments involving adsorption-desorption processes indicate that regeneration of the immobilised *S. baccularia* beads was possible. Both HCl at pH 1.0 and 2 mM EDTA solution, were found to be effective in stripping adsorbed copper from the biomass of *Sargassum baccularia* immobilised in polyvinyl alcohol beads over five consecutive cycles of adsorption-desorption. In both cases, the total quantity of copper desorbed over the five cycles corresponded well to the quantity loaded, indicating that almost complete recovery of the adsorbed copper was readily achieved. Unfortunately, following the completion of the first cycle the copper uptake capacity of the immobilised biomass deteriorated in subsequent cycles. It can therefore be concluded that neither HCl nor EDTA appears to be attractive as a desorbent although both possess excellent desorption efficiency.