Reusability of Biomaterial: A Cost-Effective Approach

Regeneration of metal-treated biosorbent is an important aspect of cost-effectiveness of wastewater treatment. In general, desorption behavior of metals from biomaterials is usually carried out by using an appropriate stripping agent. Desorption behavior of metal ions from biosorbents is to be observed after eluting with different stripping agents (soft acid, hard acid, base, and distilled water).

The process becomes more lucrative if the active agent can be regenerated through desorption cycle without destroying the integrity of the cell wall. In order to design the proposed process of sorption to be more economical, attempts are to be made to regenerate the metal-treated biomaterial for its effective reuse. The recyclability of biosorbents with desorption reagents in the acid, basic, and neutral media is considered at varying contact times. Tables 1 and 2 represent desorption of metal ions using *soft acid* (0.5 M citric acid) as eluant as well as sorption of regenerated biomaterial cycles taking the example of ZMCP.

This behavior clearly indicates that the present biosorbents can be used after regeneration for the sorption of metals from wastewater system. Some data related with regeneration of biomass used for desorption of various metals are tabulated.

Tables 3 and 4 represent desorption of metal ions using *hard acid* (0.05 M of hydrochloric and nitric acids) as eluant followed by desorption on regenerated biomaterial.

Table 1 Desorption of single metal (25 mg/L: Pb(II), Cd(II), Cr(III), and Ni(II); 50 mg/L: Cr(VI)) ions from *Zea mays* cob powder (ZMCP) using 0.5 M of citric acid

No. of cycles	Desorption (%)				
	Pb(II)	Cd(II)	Cr(III)	Ni(II)	Cr(VI)
1	52.43	51.03	48.18	53.18	53.53
2	52.47	51.07	48.89	53.28	53.84
3	52.52	51.12	49.13	53.34	54.08
4	53.45	52.45	49.41	53.32	54.23
5	53.73	52.70	49.53	53.49	54.46

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Table 2 Sorption of single metal (25 mg/L: Pb(II), Cd(II), Cr(III), and Ni(II); 50 mg/L: Cr(VI)) ions on regenerated biomaterial

No. of cycles	Sorption (%)				
	Pb(II)	Cd(II)	Cr(III)	Ni(II)	Cr(VI)
1	94.72	92.89	81.02	71.53	86.34
2	95.10	93.67	81.76	72.64	87.73
3	96.03	94.67	82.28	73.71	88.01
4	96.02	94.79	82.39	73.87	88.21
5	74.30	72.76	72.15	63.28	73.01

Table 3 Desorption of single metal (25 mg/L: Pb(II), Cd(II), Cr(III), and Ni(II); 50 mg/L: Cr(VI)) ions from *Z. mays* cob powder (ZMCP) using 0.05 M of hydrochloric acid

No. of cycles	Desorption (%)				
	Pb(II)	Cd(II)	Cr(III)	Ni(II)	Cr(VI)
1	92.45	92.18	92.47	91.21	92.49
2	92.58	92.29	92.69	91.42	92.78
3	94.12	93.27	92.97	91.48	93.21
4	95.03	94.08	93.28	91.94	93.27

Table 4 Sorption of single metal (25 mg/L: Cd(II), Cr(III), and Ni(II); 50 mg/L: Cr(VI)) ions on regenerated biomaterial

No. of cycles	Sorption (%)				
	Pb(II)	Cd(II)	Cr(III)	Ni(II)	Cr(VI)
1	94.35	92.79	83.71	73.61	91.42
2	95.78	93.21	84.42	73.69	91.78
3	96.08	94.81	82..42	73..83	88.19
4	75.21	74.38	72.25	63.35	75.11

In general, extent of metal desorption increases with increase in strength of acids ranging from 0.01 to 0.05 M. The maximum desorption was by hydrochloric acid (0.05 M).

Sorption of metals on regenerated *biosorbents* remained constant initially then started decreasing. A better desorption is achieved with the same strength (0.05 M) of nitric acid as eluant (Tables 5 and 6).

The amount of metal ion remaining on the biomaterial as a function of time was calculated using the mass balance equation $q_t = q_e - c_t\ (v/m)$, where q_t and q_e are the biomaterial phase metal ion concentration (mg/L) and c_t solution phase metal ion concentration (mg/L) at time t (min).

Desorption in the acidic media for metal ions appeared to be rapid and higher than in basic and neutral media. In the basic media, less than 20% of the metal ions were recovered from the metal-laden biomaterial. Insignificant level (<4%) of

Table 5 Desorption of single metal (25 mg/L: Cd(II), Cr(III), and Ni(II); 50 mg/L: Cr(VI)) ions from *Z. mays* cod powder (ZMCP) using 0.05 M of nitric acid

No. of cycles	Desorption (%)				
	Pb(II)	Cd(II)	Cr(III)	Ni(II)	Cr(VI)
1	98.56	98.23	99.12	98.31	98.56
2	98.89	98.72	99.43	98.76	98.89
3	99.25	99.19	99.61	99.23	99.12
4	99.28	99.22	99.82	99.57	99.35

Table 6 Sorption of single metal (25 mg/L: Cd(II), Cr(III), and Ni(II); 50 mg/L: Cr(VI)) ions on regenerated biomaterial

No. of cycles	Sorption (%)				
	Pb(II)	Cd(II)	Cr(III)	Ni(II)	Cr(VI)
1	94.87	92.85	83.78	73.68	91.48
2	95.12	93.28	84.49	73.73	91.82
3	96.05	94.76	82.42	73.81	88.13
4	76.43	74.43	72.31	63.48	75.23

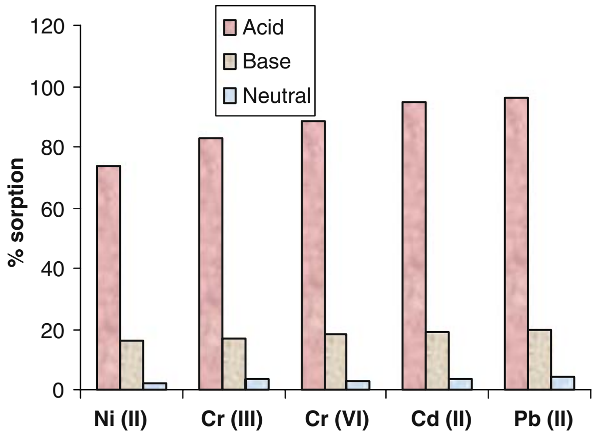

Fig. 1 Effect of desorption media on the recovery of Cd(II), Cr(III), and Ni(II) from metal-loaded SILP

desorption was recorded for distilled water. It is inferred from Fig. 1 that desorption in the acidic media for metal ions using *Saraca indica* leaf powder (SILP) was rapid and higher than in basic and neutral media.

The kinetics of desorption assesses the overall performance of desorbing reagent. The pseudo-first-order kinetics of desorption K_{des} was used to evaluate the release constant. The larger the value of K_{des}, the greater the desorption. The release constant, K_{des}, and value of desorbable fraction (θ) for all metal ions as obtained

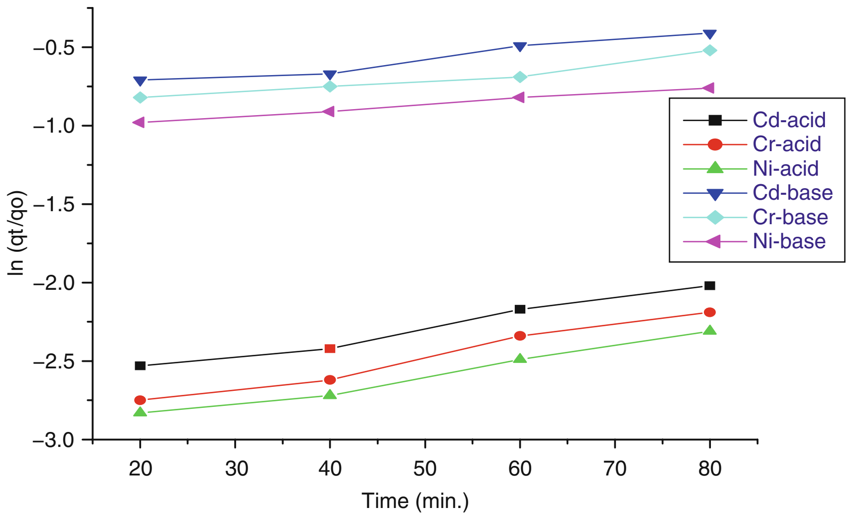

Fig. 2 Pseudo-first-order desorption kinetics on the recovery of metal ions from metal-loaded LLSP

Table 7 Value of release constant (K_{des}) and desorbable fraction (θ) of Cd(II), Ni(II), and Cr(III)

Desorption reagent	Cd(II)		Ni(II)		Cr(III)	
	K_{des}/min	θ	K_{des}/min	θ	K_{des}/min	θ
0.05 M HCl	7.86×10^{-2}	0.89	8.56×10^{-2}	0.78	8.17×10^{-2}	0.83
0.05 M NaOH	3.27×10^{-2}	0.23	2.56×10^{-2}	0.01	3.02×10^{-2}	0.13

from the regression lines (Fig. 2) are presented in Table 7. The release constant of the acid reagent was double than the basic reagent. Among the acid eluants, hard acid [(0.05 M) hydrochloric acid and nitric acid] showed higher desorption, while comparatively low desorption rate was achieved with soft acid (0.5 M citric acid). Sorption of metals on regenerated LLSP biomaterial with hydrochloric acid and nitric acid (0.05 M) remains constant up to three cycles and then started decreasing. Citric acid (0.5 M) elution of the metals resulted in the reusability of the biomaterial for four cycles. It is to think that we should have better desorption by non-eco-friendly hard acid or less with soft green acid but with less desorption rate.