

4th International Conference on Radiation Sciences and Applications, 13-17/10/2014, Taba, Egypt

4th Int. Con. Rad. Res. Appl. Sci., Taba, Egypt (2014) PP. 139: 150

Biosorption Studies on Yttrium Using Low Cost Pretreated Biomass of *Pleurotus Ostreatus*

Shimaa S. Hussien and Osman A. Desouky

E.mail: o a desouky@hotmail.com

ABSTRACT

The *Pleurotus ostreatus* biomass after the pretreatment with sodium hydroxide was used as a potential biosorbent agent for Y(III) from aqueous solution. The effects of initial metal concentration, pH, biosorbent dosage, contact time and temperature on biosorption were studied. The optimum biosorption conditions were as follows: 200 mg/L of Y(III) ions as initial concentration, pH 7.0, 500 mg/50 ml (dry wt. cell) biomass for biosorption, biosorption time 30 min, temperature 50 °C, and mixing speed 175 rpm. The biosorption kinetics were tested with first-order model and pseudo-second-order model. The biosorption data were conformed to the Langmuir and Freundlich isotherms had been evaluated. The negative value of free energy (ΔG°) and positive value of enthalpy (ΔH°) appeared that the biosorption process of Y(III) ions onto *P. ostreatus* was endothermic and spontaneous in nature. Using SEM and IR techniques revealed that *P. ostreatus* was a good choice as biosorbent agent for Y(III) ions removal from aqueous solution.

INTRODUCTION

n recent years, rare earth elements (REEs) have been in great demand for various functional materials. Yttrium is one of the heavy rare earth elements which used in laser industry, e.g. yttrium vanadate as host for europium in TV red phosphor, high-temperature superconductors, microwave filters and energy-efficient light bulbs (Hammond, 2009). There are many methods such as chemical precipitation, ion exchange, solvent extraction and sorption for removing rare elements from solution (Diniz and Volesky, 2005a).

KEYWORDS

Biosorption, Yttrium, Thermodynamic, Pleurotus Ostreatus.

1. Nuclear Materials Authority, P.O. Box 530 El-Maadi, Cairo, Egypt.

These traditional methods have some disadvantages, such as high consumption of reagent and energy, low selectivity, high operational cost and generation of secondary pollutants (Wu *et al.*, 2004).

Biosorption has been portrayed an emerging and potential technology which involved the sorption of dissolved metals from bearing solution by a biomaterials. Several biomaterials including bacteria, fungi, algae and agriculture wastes were identified as potential candidates for the biosorption of the desired metals (Vijayaraghavan et al., 2009). The metal biosorption process is a two-step process. In the first step, metal ions are adsorbed to the surface of cells by interactions between metals and functional groups displayed on the surfaces of cells. The first step, passive biosorption, is metabolism independent and proceeds rapidly by any one or a combination of the following metal bending mechanisms: coordination, ion exchange, physical biosorption or inorganic microprecipitation. Passive biosorption is adynamic equilibrium of reversible biosorption-desorption. In the second step, due to active metal ions penetrate the cell membrane and enter into the cells. Metal uptake by non-living cells is mainly passive mode (Nilanjana et al., 2008). The desorption process has the purpose of recovering the biosorbed metals while regenerating the biomass that could be used in subsequent sorption and desorption cycles (Diniz and Volesky, 2006). Danis et al. (2012) investigated that mushroom of *P. ostreatus* grows on wood in nature, usually on dead standing trees or fallen logs. It has a relatively large size, whitish gills and exceptionally small stem. It fruits in fall and winter and has a brownish cap. In this study, the use of P. ostreatus as a biosorbent was tested for biosorption yttrium ions from standard aqueous solution. The effects of metal ion concentration, pH, biosorbent dosage, contact time and temperature on the sorption were discussed. In addition to, kinetic and thermodynamic parameters related to the process were performed.

MATERIALS AND METHODS

2.1. Microorganism and biomass preparation

Pleurotus ostreatus on millet grains was ob-

tained from Mushroom Cultivation farm from faculty of agriculture, Mansoura University. A mixture of known amount of rice straw, wheat brain (5%) and CaCO₃ (5%) in bags soaked in hot tap water for 3 hrs for pasteurilization. The *P. ostreatus* on millet grains was inoculated in the sterile substrate in a multilayered form. The spawned bags were placed in dark at 20 ± 3 °C for three weeks. The mature basidiocarps were collected and washed several times with dist. water then cut into small pieces. The air dried basidiocarps were grounded in a mortar and sieved to select particles of less than 0.5 mm (mesh size 125-250 µm) for using as a biosorbent agent.

2.2. Biosorption experiments

a. Yttrium solution preparation and biosorbent agent pretreatments

Yttrium stock solution (1000 mg/L) was prepared from $Y(NO_3)_3.6H_2O$ which was obtained from Alfa Aesar. The working solutions were prepared by diluting the stock solution to appropriate volume. The pretreatments of the biomass were achieved by alkaline, acidic and heat drying as previously described by (Shuxia *et al.*, 2011).

b. Factors affecting the biosorption process

The biosorption experiments were conducted with 50 mL of 50 mg/L initial concentration of Y(III) ions solution in 250 mL Erlenmeyer flask for 60 minutes contact time at room temperature 26 ± 1 °C. Effect of initial Y (III) ions concentration on biosorption was studied between 50-350 mg/L. The amount of *P. ostreatus* biosorbent was administered between 50-600 mg. Effect of initial pH on biosorption was studied with values ranging from 2-8 using 0.1 mol/L NaOH or HCl. The contact time chosen for the time dependence studies were 10 to 60 minutes. The effect of temperature on biosorption was performed from 20 to 60 °C.

c. Yttrium measurement

The supernatants were filtered through a filter paper (Whatman No. 41) and the concentration of Y(III) in the solution was measured before and after equilibrium by Metertech Ino model Sp-5001, UV- Visible spectrophotometer) using arsenazoI (Marc-zenko, 1976).

The amount of metal adsorbed by *P. ostreatus* was calculated using the following equation:

$$Qe = (Co - Ce) \times \frac{V}{M}$$
(1)

where Qe is the metal uptake (mg/g), Co and Ce are the initial and equilibrium metal concentrations in the solution (mg/L), respectively, V is the solution volume (L), and M is the mass of biosorbent (g).

The percent of biosorption rate = $\frac{(Co - Ce)}{Co} \times 100$ (2)

The distribution coefficient (*Kd*) of metal ions between the aqueous phase and the solid phase can be directly obtained using:

$$Kd = \frac{(Co - Ce)}{Co} \times \frac{V}{M} \quad (mL/g)$$
(3)

Where Co (g/L) and Ce (g/L) are the initial and equilibrium Y(III) concentrations, respectively, V/M is the ratio of the volume of metal solution (mL) to the amount of biosorbent (g) in a batch.

2.3. SEM observation

The texture, pore structure and loaded biomass of *P. ostreatus* were observed under high resolution Environmental Scanning Electron Microscope (ESEM), Philips XL30 vacuum at 30 KV.

2.4. Infrared Analysis

Infrared spectrophotometer was used to determine the functional groups presented on the surface of *P. ostreatus* biomass before and after loading with Y(III). The apparatus used (Model JASCO 4100 FTIR spectrophotometer, Japan) which presented in the Micro Analytical Center, Cairo University, Egypt. The samples were prepared as KBr discs.

2.5. Desorption study

Desorption experiments were performed by mixing *P. ostreatus* loaded biomass (500 mg dry weight) with desorbing agents 50 mL of (0.1, 0.2, 0.3 N HCl and 0.1, 0.2, 0.3 N HNO₃,) for 1 h on a rotary shaker (175 rpm) at 30 °C for three cycles to study the elution rate (Sert *et al.*, 2008).

RESULTS AND DISCUSSION

3.1. Effect of different pretreatment on the biosorption of Y(III) by P. ostreatus

The comparisons of Y(III) ions biosorption rate with native and pretreated P. ostreatus were shown in Table 1. The obtained results appeared that pretreated biomass with NaOH solution has the maximum biosorption rate, and the optimal concentration of NaOH solution is 0.2M. The reason probably that alkali pretreatment could remove the amorphic polysaccharide on the cell wall and change the structure of the dextran and chitin, so the biomass could adsorb much more Y(III) ions on its surface. At the same time. NaOH could dissolve the inclusions in the cell which encumber biosorption, and expose much more active binding sites to improve the biosorption capacity. Furthermore NaOH makes H⁺ to be dissociated from cell wall, resulting in the increase of negative functional groups, then the improvement of the biosorption capacity Bhatti et al. (2008).

3.2. Effect of initial concentration of yttrium on the biosorption rate

The biosorption percentage of Y(III) ions showed a decreasing trend as metal ion concentration increased Fig. 1. The biosorption of Y(III) ions decreased from 83.90 % to 72.74 % with an increase of Y(III) ions concentration from 200 mg/L to 350 mg/L. The maximum biosorption of Y(III) ions was obtained at concentration of 200 mg/L. The increase of Y(III) ions concentration probably lead to the increase in the number of ions competing for the available binding sites in the biomass resulted in the limitation of vacant binding sites, which saturate beyond certain concentrations, thus decreasing Y(III) ions biosorption yields. A similar interpretation can be made for Cr (VI) biosorption by *Pleurotus ostreatus* spent biomass was observed by **Carol et al., (2012).**

Treatments	Concentration (mol/L)	Biosorption rate (%)	Biosorption amount (mg/g)	
1-Control (dried at room temperature 30±2 °C)	-	70.842.55±	31.591.99±	
	0.1	73.753.88±	31.731.33±	
2-Soaking with NaOH for 40 min	0.2	77.601.78±	35.272.77±	
	0.3	70.312.88±	30.453.11±	
	0.1	59.473.65±	29.742.13±	
3-Soaking with HCl for 40 min	0.2	54.591.33±	$27.592.89 \pm$	
	0.3	49.161.30±	25.992.18±	
4- Soaking with 30 % ethyl alcohol for 40 min (Shuxia <i>et al.</i> , 2011)	-	67.774.66±	33.233.90±	
	at 60 °C	56 553 55±	27 621 89±	
5- Heat Drying	at 80 °C	53.34±3.90	24.89±2.12	

 Table (1): Effect of different pretreatment on biosorption of Y(III) ions by P. ostreatus.

* Biosorption conditions: 50 mg/L Y(III), 150 mg/L dry wt. cell, pH 6.5, 30°C, 175 rpm and 2 h biosorption time.



Fig. (1): Effect of initial concentrations of Y(III) ions on the biosorption by *P. ostreatus*.

3.3. Effect different pH on the biosorption rate

The percentage of Y(III) biosorption was strongly dependent on pH Fig. 2. pH is an important factor controlling the process of biosorption. The pH affects not only the surface charge of the biosorbent, but also the degree of ionization of the heavy metal in solution (**Aksu and İşoğlu, 2005**). Maximum biosorption of Y(III) ions was found to be at pH 7.0 with 85.55 %. At low pH, protons compete with Y(III) ions for most of the binding sites on the biosorbent surface. Binding attraction decreases as the surface of the biosorbent becomes more positively charged. This prevents the binding of Y(III) ions due to charge repulsion with the protons on the biosorbent. Under alkaline conditions, deprotonation of the heavy metals binding sites and precipitation of Y(III) ions as insoluble hydroxides or hydrated oxides is believed to be responsible for the decrease in Y(III) biosorption by *P. ostreatus*. **Vijayaraghavan** *et al.* **(2009)** also reported that pH 6.5 was the maximum pH for biosorption of La³⁺ from aqueous solution by crab shell particles.



Fig. (2): Effect of different pH on the biosorption Y(III) ions by *P. ostreatus*.

3.4. Effect of biosorbent concentration on the biosorption rate

Effect of biosorbent concentration on the biosorption of Y(III) ions by *P. ostreatus* is presented in Fig. 3. With an increase in biosorbent concentrations from 50 to 600 mg, the percentage of Y(III) ions biosorption increased from 55.89 % to 86.96 %. The percentage of Y(III) ions biosorption reached equilibrium at 500 mg biosorbent concentration. The increase in biosorbent concentration could be attributing to increase in surface area which leaded to increase the binding sites and combination of metal ion with the corresponding sites (**Pagnanelli** *et al.*, **2000**).



Fig. (3): Effect of biosorbent concentrations of *P. ostreatus* on the biosorption Y(III) ions.

3.5. Effect of contact time on the biosorption rate

Fig. 4 shows Y(III) ions biosorption, at different contact time, by *P. ostreatus*. It was observed that there are two stages for the biosorption of Y(III) ions; an initial rapid increase in biosorption percentage during the first 30 minutes, then followed by a plateau phase at 90.90 % for Y(III). This indicated that, as the contact time increased, more and more functional groups participated in biosorption of metal ions until it reaches equilibrium then active sites on the biosorbents were filled. The rate of biosorption became gradually constant and reached a plateau. **Shuxia et al. (2011)** reported similar trend of observation whereby the biosorption of La³⁺ and Ce³⁺ by *Agrobacterium* sp. HN1.



Fig. (4): Effect of contact time on the biosorption of Y(III) ions by *P. ostreatus*.

3.6. Effect of temperature on the biosorption rate

The experiments were carried out at 20, 30, 40, 50 and 60 °C. The other parameters were kept constant. Yttrium solution was shaken with 500 mg P. ostreatus at pH 7 for 30 min. Fig. 5 shows that by increasing temperature, there is a slightly increasing on the biosorption rate of Y(III) ions. It was found that the temperature 50 °C was considered the suitable degree for maximum biosorption rate 95.78%. Similar observation obtained by Meena et al. (2005) they reported that the increase in biosorption with temperature may be attributed to either an increase in the number of active surface sites available for biosorption on the biosorbent or the decrease in the thickness of the boundary layer surrounding the biosorbent with temperature, so that the mass transfer resistance of adsorbate in the boundary layer decreases. Carol et al., (2012) mentioned that increase in biosorption with temperature probably because of the possible denaturation of the intact nature of the bisorbent agent.



Fig. (5): Effect of temperature on the biosorption of Y(III) ions by *P. ostreatus*.

Biosorption enthalpy was evaluated using the method based on the Van't Hoff plot. The values of ΔH° and ΔS° were calculated from the slopes and intercepts of the linear variation of ln Kd with reciprocal temperature, 1/T, Fig. 6, using the relation:

$$\ln Kd = \frac{\Delta S^{\circ}}{R} - \frac{\Delta H^{\circ}}{RT}$$
(4)

where ΔH° and ΔS° are the standard enthalpy and entropy changes of biosorption, respectively. The standard free energy of specific biosorption ΔG° is calculated using the equation:



Fig. (5): Plots of ln Kd vs. 1/T for the yttrium biosorption on *P. ostreatus*.

The values of ΔH° , ΔS° and ΔG° were given in Table. 2 for the Y(III) ions biosorption on *P. ostreatus*. The value of ΔH° =7.18 kJ/mol and ΔG° = -12.75 kJ/ mol for Y(III) ions suggest that the biosorption of Y(III) ions on P. ostreatus is an endothermic and a spontaneous process. In addition, the value of ΔS° was found to be positive due to the exchange of the metal ions with more mobile ions present on the exchanger, which would cause increase in the entropy, during the biosorption process (Ünlü and Ersoz, 2006). The physical structure and chemical components of the material determine the adsorptive behavior, which can be attributed to various mechanisms. These mechanisms may include physical biosorption, ion exchange, chelation or formation of the complex with the functional group of the natural organic matter in the material. It is possible that the adsorptive mechanism may be dominated by one or two mechanisms at certain experimental conditions (Liang et al., 2002).

 Table (2): Thermodynamic parameters for the biosorption of Y (III) ions by P. ostreatus.

Concentration	$\Lambda H^{\circ} (k I/mol)$	ΔS° (J/K.mol)		Δ	G° (kJ/m	ol)	
(µg/mL)) $\left \begin{array}{c} \Delta H \\ \alpha \end{array} \right \left		293K	303K	313K	323K	333K
150	7.18	40.49	-11.94	-12.35	-12.75	-13.07	-13.56

Characterization of the biosorbent agent by scanning electron microscope (SEM) and infrared analysis spectral analysis (IR)

SEM observation

Plate.1A. appeared the global intact fiber like structure of the air dried non-treated *P. ostreatus* biomass. Sodium hydroxide treated biomass examination appeared in Plate.1B. The structure resembles a rigid particle composition. The porosity improved as the volatiles are released. The surface structure morphology may exhibit microstructure porosity. The fact that NaOH treatment removes most of cell wall materials containing –COOH, phosphate groups and amorphous polysaccharides. Thus generate clean surface morphology and more accessible space within β -glucan-chitin skeleton, hence allowing more metals ions chelation at the surface (Amini *et al.*, 2009). In addition Plate. 1C. appeared the loaded biomass where texture of biosorbent more denaturated. All microstructures porosities seemed to be filled with Y(III) ions and surface seemed to be more bright. This result may be due to the biosorption affinity between the biomass and element (Carol *et al.*, 2012).



Fig. (6): SEM photographs at 100X magnifications were shown in the plate: parts A (dried *P. ostreatus* biomass, B (treated *P. ostreatus* biomass by NaOH and C (Y(III) ions loaded *P. ostreatus* biomass).

IR spectral analysis

The FTIR spectral analysis is important to identify some characteristic functional groups which are responsible of adsorbing metal ion. Fig.7. shows typical FTIR spectra for *P. ostreatus* biomass before and after the biosorption of Y (III) ions. FTIR spectra of the biosorbents are recorded in the range of 400- 4000 cm⁻¹ to obtain the information regarding stretching and bending vibrations of the functional groups which are involved in the biosorption of metal ions.



Fig. (7): Infrared spectra of *P. ostreatus* biomass non-loaded (control) (A) and loaded (B) with Y (III) ions.

The spectrum of dried unloaded *P. ostreatu* appears a sharp stretching vibration band at 3430.74 cm⁻¹ due to the presence of hydroxyl groups on the biomass surface. The peaks at 2924.52 cm⁻¹ is due to stretching vibration of C-H. The biosorption peak at 2135.78, 1650.77, 1415.49, 1314.25 and 602.64 cm⁻¹ were due to C=C bending, C=O stretching vibration, C-H, C-N and C-X, respectively.

Comparing Y(III) ions unloaded P. ostreatus biomss with Y(III) ions loaded P. ostreatus biomass. 2135.78 cm⁻¹ peak is reduced greatly in Y(III) ions loaded P. ostreatus biomass. The peaks at 2340.19 and 1565.92 1066.44 cm⁻¹ were appeared in loaded biomass due to presence of C-H alkyl methelyene, C=C aromatic rings and C-O of alcohols, ester, ether, carboxylic acid. The peak at 1314.25 cm⁻¹ is disappeared in Y(III) ions loaded P. ostreatus biomass. The peak at 1415.49 cm⁻¹ is shifted to 1426.10 cm⁻¹ in Y(III) ions loaded P. ostreatus. The relevance explanation of a shift in the spectra, reduction and disappearance of the peaks are that there is an effect of chemical pretreatment and metal biosorption on the functional groups. These obtained results were inagreement with that obtained by (Qing, 2010).

3.8. Biosorption kinetics

The effect of contact time on the uptake of Y(III) on *P. ostreatus* at 50 °C and pH= 6.8 is shown in Fig (8). The equilibrium was attained within 30 min for metal ions. About 39 mg/g of the total uptake was obtained. The biosorption data were treated according to pseudo-first order kinetic model (Qing, 2010). Several kinetic models are needed to examine the mechanism of biosorption process from a liquid phase on *P. ostreatus* and to interpret the experimental data. Pseudo-first-order and pseudo-second-order are used to explain the kinetics of biosorption to investigate the mechanism of adsorption. The pseudo-first-order model for solid/liquid systems of biosorption is expressed as

$$Log (Qe - Qt) = Log Q1 - \frac{K1}{2.303}t$$
 (6)

where Qe and Qt is the amounts of Y(III) ions biosorbed on *P. ostreatus* at equilibrium and at any time *t* (mg/g) respectively, k1 is the rate constant of pseudo-first-order adsorption (g/(mg·min)), Q1 is the calculated biosorption capacity of the pseudofirst-order model (mg/g). The intercepts and slopes of the straight line plots of Log(Qe-Qt) versus t were used to calculate Qe and k1 and are given in Table(3) and shown in Fig (9).



Fig. (8): Biosorption of yttrium ions on *P. ostreatus* as a function of time at 50°C and initial concentration 200 ppm.



Fig. (9): Pseudo-first order kinetics of yttrium ions biosorbed on *P. ostreatus*.

Obviously, a satisfactory agreement was obtained between calculated and experimental values of Qe. This implies that the biosorption process proceeds according to first order kinetics depends upon metal ions or active site concentrations



Fig. (10): Pseudo-second order kinetics of yttrium ions biosorbed on *P. ostreatus*.

In order to show the effect of biosorbent concentration on the rate of the biosorption process, the plot between the amount of Y(III) biosorbed at different time intervals (Qt) and the square root of time ($t^{0.5}$) were carried out according to the intraparticle diffusion which is defined with Equation (7).

$$Qt = X + Ki t^{0.5} \tag{7}$$

The plots are shown in Fig (10) and the parameters are listed in table (3). The correlation coefficient for the pseudo-second order equation is higher than the correlation coefficient of pseudo-first-order equation. This indicate that the system under study is more appropriately estimated by the pseudo-second order reaction. The results show that the biosorption process is controlled by concentration of both adsorbate Y(III) ions and biosorbent (*P. ostreatus*). Also, the negative value of X indicated the limit effect of the boundary layer on the rate of biosorption, which may be a chemical sorption or chemisorption **Rao** *et al.* (2008).

 Table (3): Equilibrium model parameters for biosorption of Y(III) ions by P. ostreatus.

Adsorbent	Qe _(exp) (mg/g)	Pseudo-first order Pseudo-second orde			der		
Y(III)	45.45	$Q_{max}(mg/g)$	$K_1(\min^{-1})$	R ²	Ki (mg/g)	Xi (min ^{0.05})	R ²
		39	1.07×10-3	0.9791	6.56	-0.0143	0.9864

3.9. Biosorption isotherms

a. Langmiur isotherm

In order to understand the biosorption rate of the biosorbents, the equilibrium data were evaluated according to the Freundlich and Langmuir isotherms. The Langmuir equation, which has been successfully applied to many biosorptions, is given by:

$$\frac{Ce}{Qe} = \frac{1}{bnm} + \frac{Ce}{nm}$$
(7)

where, Ce is the equilibrium concentration (mg/L), Qe is the amount absorbed at equilibrium (mg/g), nm and b are the Langmuir constants related to monolayer capacity and energy of biosorption. A linearised plot of Ce/Qe versus Ce is obtained for biosorbent as shown in Fig. 11.

Langmuir isotherm models the monolayer coverage of the biosorption surface. This model assumes that biosorption occurs at specific homogeneous bio-



Fig. (11): Langmuir plots for the biosorption of yttrium ions on *P. ostreatus*.

sorption sites within the biosorbent and intermolecular forces decrease rapidly with the distance from the biosorption surface. The Langmuir biosorption model further based on the assumption that all biosorption sites are energetically identical and biosorption occurs on a structurally homogeneous biosorbent (Ünlü and Ersoz, 2006).

Table (4): Langmuir and Freundlich constants for the biosorption of Y(III) ions on P. ostreatus.

	Langmuir constants			Freundlich constants		
	R^2	<i>nm</i> (mg/g)	b (L/mg)	R ²	N	K
Yttrium	0.9988	45.45	0.93	0.8926	3.18	4.86

Freundlich isotherm

Freundlich equation, which was applied for the biosorption of yttrium is given as:

$$Log q = \log K + \frac{1}{\pi} \log Ce$$
(8)

where q is the amount of solute adsorbed per mass unit biosorbent, Ce is the equilibrium concentration, K and n are the Freundlich constants characteristic of a particular biosorption isotherm and can be evaluated from the intercept and slope of the linear plot of log q versus log Ce Fig. 12.



Fig. (12): Freundlich plots for the biosorption of yttrium on *P. ostreatus*.

The corresponding Freundlich and Langmuir parameters along with correlation coefficients are reported in Table.3. Based on the value of the correlation coefficient (R^{2} > 0.99) it can be seen that the behavior of yttrium (III) biosorption on *P. ostreatus* is a Langmuir type isotherm.

Diniz and Volesky (2005b) studied the "Effect of counter ions on lanthanum biosorption by S. polycystum". In this study, the Langmuir model was used to describe the sorption isotherms. The biosorption capacity, n_m which is a measure of the maximum sorption capacity corresponding to complete monolayer coverage showed a mass capacity of 0.95±0.06 (mmol/g) and the biosorption coefficient b, that is related to the apparent energy of biosorption was calculated to be 51.3±12.1 (L/ mmol) at pH 4. In another study; the Freundlich model constants; k and n were obtained to be 100 and 1.8, respectively. Additionally, the Langmuir parameter, b (0.0027 L/g) and the monolayer biosorption capacity, nm (1.926 mg/g) were obtained by Kazy et al. (2006).

3.10. Desorption study

The purpose of desorption was verify the possible of desorbing the immobilized metal ions from the biomass. Fig.13. appeared the percentage of desorbed Y(III) ions from the biomass using hydrochloric, nitric and sulfuric acids at different concentrations for three washing cycles. These desorbent agents were chosen because mineral acids appear to be the most feasibly applicable eluting agents. It was found that 0.1 N HCl desorbent agent eluted about 94.89% of the biosorbed Y(III) ions by *P. ostreatus* biomass after three cycles. Higher acid concentrations could be produced higher concentration of protons which swept the metal ions away from the biosorbent. As expected, a slightly lower in weight loss could be achieved by 0.1 N HCl compared to other acid concentrations so, it safe to be used for desorption purpose without increasing the biomass weight loss (Diniz and Volesky, 2006). Diniz and Volesky (2005a) mentioned that the most common acid concentration of 0.1 mol/L desobed from 80 to 90% of Eu³⁺, La³⁺, and Yb³⁺ biosorbed by sargassum biomass.



Fig. (13): Desorption of Y(III) ions with different desorbent agents.

3.11. Yttrium biosorption from rare earths concentrate solution

The chemical composition of pure rare earths concentrate solution obtained from Egyptian monazite was presented as 20.75% La₂O₃, 34.71% Ce₂O₃, 6.78% Pr₂O₃, 14.98% Nd₂O₃, 2.42% Sm₂O₃, 2.69 % Gd₂O₃, 1.11% Tb₂O₃ and 2.34% Y₂O₃. In addition to, P₂O₅, Fe₂O₃ and loss of ignition (LOI) which presented in percentages 4.20%, 3.13% and 6.89%, respectively. Under the previously obtained optimum conditions for biosorption of Y(III) ions, it was found that the percentage of removal Y(III) ions from concentrate of REEs solution was to be 78 %. Furthermore, 87 % of biosorbed Y(III) ions were desorbed by 0.1 N HCl. Less removal of Y(III) ions occurred in REEs solution as compared to synthetic Y(III) ions solution might be attributed to the presence of interference of other rare earths in the solution that compete with Y(III) ions for binding sites on the biosorbent. Similar observation was also reported by (Katsumata *et al.*, 2003).

CONCLUSION

The biosorption properties of P. ostreatus biomass were studied for Y(III) ions recovery. The results obtained show that pH and initial Y(III) ions concentrations, biosorbent dosage, contact time and temperature highly affect the uptake of the biosorbent. The Langmuir adsorption model and Freundlich equation were used for mathematical descriptions of the biosorption of Y(III) ions onto P. ostreatus biomass. Two models were used to study the adsorption kinetics. It was found that pseudo-second-order equation provided the best correlation to the data. It was found that the adsorption equilibrium data fitted well to the Langmuir model. Thermodynamic parameters ΔH° , ΔS° and ΔG° were estimated and these parameters show that adsorption is endothermic, favorable and spontaneous, respectively. The yttrium removals from rare earths concentrate by P. ostreatus biomass was found 78 %. In conclusion, P. ostreatus was considered promising biosorbent agent used for the removal of Y(III) ions from rare earths concentrate.

REFERENCES

- Aksu, Z. and İsoğlu, I.A. (2005): Biosorption of copper(II) ions from aqueous slution by biosorption onto agricultural waste sugar beet pulp. *Process Biochemistry*. 40, 3031–3044.
- Amini, M.; Younesi, H. and Bahramifar, N. (2009): Statistical modeling and optimization of the cadmium biosorption processin an aqueous solution using *As*-

pergillus niger. Coll. & Sur. A: Physicochem. Eng., 337: 67-73.

- Bhatti, H.N.; Samina, G. and Hanif, M. A. (2008): Enhanced Removal of Cu(II) and Pb(II) from Aqueous Solution by Pretreated Biomass of *Fusarium solani J. of the Chinese Chemical Society*, *55*, 1235-1242.
- Carol, D.; Kingsley, S.J. and Vincent, S. (2012): Hexavalent chromium biosorption from aqueous solutions by *Pleurotus ostreatus* spent biomass. *International Journal of Engineering Science and Technology* (*IJEST*), 4:7-22.
- Danis, U., Kaya,Y. and Barlık, N. (2012): Biosorption of Cu (II) on the *Pleurotus Ostreatus*. The Fifth International Scientific Conference BALWOIS-Ohrid, Republic of Macedonia from 28th May to 2nd June 2012.
- Diniz, V. and Volesky, B.(2005a): Biosorption of La, Eu and Yb using *Sargassum* biomass. *Water Research*, 39: 239-247.
- Diniz, V. and Volesky, B. (2005b): Effect of counterions on lanthanum biosorption by Sargassum polycystum. Water Research, 39, 2229–2236.
- Diniz, V. and Volesky, B. (2006): Desorption of lanthanum, erupium and ytterbium from Sargassum. Separ. & Purific. Technol., 50: 71-76.
- Hammond, C. R. (2009): "Section 4; The Elements", in CRC Handbook of Chemistry and Physics, 89th Edition (Internet Version 2009), David R. Lide, ed., CRC Press/Taylor and Francis, Boca Raton, FL.
- Katsumata, H.; Kaneco, S.; Inomata,K.; Itoh, K.; Funasaka, K.; Masuyama, K.; Suzuki, T. and Ohta, K. (2003): Removal of heavy metals in rinsing wastewater from plating factory by adsorption with economical viable materials *J. Environ. Manage.*, 69,187-191.
- Kazy, S.K., Das, S.K. and Sar, P. (2006): Lanthanum biosorption by a *Pseudomonas* sp.: equilibrium studies and chemical characterization. *Journal of Industrial Microbiology Biotechnology*, 33, 773–783.
- Liang, H., Adeyiga, A.A., Greer, T. and Miamee, E. (2002): Biosorption of metal ions from waste water roadside tree leaves. *Chemical Engineering Communication,s* 189, 1587–1597.
- Marczenko, Z. (1976): Spectrophotometric Determi-

nation of Elements, John Wiley and Sons, New York.

- Meena, K.A, Mishra, G.K., Rai, P.K., Rajagopal, C. and Nagar, P.N. (2005): Biosorption of heavy metal ions from aqueous solutions using carbon aerogel as an biosorbent. *Journal of Hazardous Materials*, 122: 161–170.
- Nilanjana, D.; Vimala, R. and Karthika, P. (2008): Biosorption of heavy metals- An overview. Ind. J. of Biotechno., 7: 159-169.
- Pagnanelli, F., Petrangeli, M., Trifoni M., Toro, L. and Vegliò, F. (2000): Biosorption of metal ions on *Arthrobacter* sp.: biomass characterization and biosorption modeling. *Environmental Science & Technology*, 34: 2773-2778.
- Qing, C.H.E.N. (2010): Study on the biosorption of lanthanum (III) from aqueous solution by bamboo charcoal. *J. of Rare Earths*, 28: 125-131.
- Rao, M. M.; Rao, G.P.; Seshaiah. K.; Choudary, N. V. and Wang, M. C. (2008): Activated carbon from Ceibapentandra hulls, an agricultural waste, as an adsorbent in the removal of lead and zinc from aqueous solutions. *J. Waste Management*, 28: 849-858.

- Sert, S., Kütahyali, C., İnan, S., Talip, Z. Çetinkaya, B. and Eral, M. (2008): Biosorption of lanthanum and cerium from aqueous solutions by *Platanus orientalis* leaf powder. *Hydrometallurgy*, 90: 13–18.
- Shuxia, X.U.; Shimin, Z.H.A.N.G.; Ke, C.H.E.N; Jinfeng, H.A.N.; Huashan, L.I.U. and Kun, W.U. (2011): Biosorption of La³⁺and Ce³⁺ by *Agrobacterium* sp. HN1. *J. OF RARE EARTHS.*, 29, 265-270.
- Ünlü, N. and Ersoz, M. (2006): Biosorption characteristics of heavy metal ions onto a low cost biopolymeric sorbent from aqueous solutions. *Journal of Hazardous Materials*, 136, 272–280.
- Vijayaraghavana, A., Mahadevanb, U.M. Joshi and Balasubramanianb, R. (2009): An examination of the uptake of lanthanum from aqueous solution by crab shell particles. *Chem. Eng. J.*, 152, 116-121.
- Wu, D. B., Niu, C. J., Li, D.Q. and Bai, Y.(2004): Solvent extraction of scandium (III), yttrium (III), lanthanum (III) and gadolinium (III) using Cyanex 302 in heptane from hydrochloric acid solutions. *J. Alloys Compd*, 374: 442-446.