Asian Journal of Chemistry Vol. 21, No. 8 (2009), 6015-6028

Biosorption of Pb(II) From Aqueous Solutions by a Fungal Biomass in a Batch System: Equilibrium and Kinetic Studies

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In this study, the biosorption capacity of the fungus *Sporotricum sp.* biomass in removing of Pb(II) ions from aqueous solution were investigated with different parameters, such as pH, temperature and initial metal ion concentrations in a batch adsorption system. The maximum biosorption of Pb(II) ions onto the *Sporotricum sp.* biomass was 15.48 mg per g of the biomass. The biosorption of Pb(II) ions increased with increased pH up to 6.0 at which the maximum biosorption was obtained. Temperature change between 15 and 40 ºC did not affect the biosorption capacity of the fungal biomass. Desorption of the Pb(II) ions was achieved using 0.1 M HCl solution. Biosorption equilibria were established in about 24 h. Biosorption experimental data could be well interpreted by the Langmuir model with maximum adsorption capacity of 16.42 mg g^{-1} of Pb(II) ion on to the *Sporotricum sp.* biomass. Also the correlation regression coefficients show that the biosorption process can be well-defined by Freundlich model. The change in biosorption capacity with time was found to fit the pseudo-second-order kinetic model.

Key Words: Heavy metals, Biosorption, Optimization, Lead, Fungal biomass, *Sporotricum sp.*

INTRODUCTION

Toxic metals and radionuclides are released into the environment by a large number of processes such as mining and metallugical processing, steel manufacturing, jewelry industries, combustion of fossil fuels, textile printing, application of fertilizer and fungicides, recycling of ferrous scraps and motor oils, disposal and incineration of toxic metal containing products, electroplating, leather tanning, wood

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preservation, pulp processing and tobacco smoking[1-7]. The pollutants from these processes are discharged or transported into aquatic and terrestrial environments mainly as solutes or particulates and may reach high concentrations, especially near the site of entry. The effects of metals on ecosystem vary considerably and are of economic and public-health significance[8-11].

Heavy metals in general are potent inhibitors of enzymatic reactions[12,13]. Their toxic effects mainly by binding to -SH groups present in the active or regulation sites of enzyme and causing their irreversible inactivation. In addition to binding to aromatic amino acid residues in enzyme molecules, they can also cause oxidative stress associated with the production of reactive oxygen species like hydroxyl or superoxide radicals[14]. Toxic metals inhibit active transport mechanism through dissipation of the normal cation gradient and changes in the metabolic activity, including the decrease of ATP concentrations and respiration rate; destroy the mitochondrial apparatus; causes swelling of cells, leading to lysis; decrease DNA content in cells and adversely affects chromosomes leading to mutagenesis[15,16].

The bioremediation of heavy metals has received a great deal of attention in recent years, not only as a scientific novelty but also for its potential application in industry. Recently microbial systems like fungi, bacteria and algae have been successfully used as adsorbing agents for removal of heavy metals[1,17-23]. Conventional physicochemical methods such as electrochemical treatment, liquid-liquid extraction, ion exchange, precipitation, precoagulation, reduction, reverse osmosis, evaporation and biosorption for heavy metal removal from waste streams are not cost effective[24-28].

Metal recovery or removal from solution may involve the following pathways; (i) the binding of metal cations to cell surfaces or within the cell wall when microprecipitation may enhance uptake (ii) translocation of the metal into the cell, possibly by active transport (iii) the formation of metal-containing precipitates, by reaction with extracellular polymers or microbially produced anions such as sulphide or phosphate (iv) the volatilization of the metal biotransformation[29]. In addition, processes have been developed using immobilized extracellular or cellular ligands or more simple chemical models based upon them[30,31].

Fungi and yeast cells take up metal ions by binding to the cell surface and intracellularly. The main structural component of fungal cell walls is either chitin or chitosan, which are polymers of N-acetylated or non-acetylated glucosamine respectively. Other binding sites may be phosphate, carboxyl, amine and hydroxyl, plus groups in melanin and other pigments and also fungal chlamydospores bind higher amounts of heavy metals[23,32-35]. Microorganisms will have various distributions of charge and geometry for these binding groups and so may well selectively bind certain metal cations[36].

Biosorption of heavy metal ions by fungi is affected by many experimental factors such as pH, temperature[37,38], ionic strength and presence of different metallic ions in solution, chemical and physical properties of metal ions[37], metal concentrations, metal solution chemistry, cell physiology[39], structural organization of cell wall[40,41].

The objective of this research is to investigate the removal of lead metal ions from solutions by the fungus *Sporotricum sp.* as biosorbent. Biosorption of lead from aqueous solutions was investigated for batch biosorption-equilibrium experiments. The effects of initial metal ion concentration, temperature, biosorption time, initial pH of the solution and time on the Pb(II) uptake capacities of the fungus were evaluated by characterizing the bioaccumulation of this metal. The performance of the preparations was also tested in synthetic waste water samples. In addition, equilibrium studies were performed with isotherm modelling.

EXPERIMENTAL

Cell line and medium: The strain used was *Sporotricum sp.* which was supplied from Faculty of Science, Department of Biology at Anadolu University, Eskisehir, Turkey. Cultures were maintained on potato-dextrose-agar slants and subcultured every month, then transferred to storage at 4 °C. *Sporotricum sp.* was grown in a liquid medium, potato-dextrose-broth (Acumedia) containing (g/l) potato infusion solids, 4; dextrose, 20. The initial pH of the medium was adjusted to 5.1 before sterilization. Media were inoculated with *Sporotricum sp.* and incubation was carried out 100 mL medium in a 250 mL flask at 30 ºC on orbital shaker incubator at 120 rpm for 5 d. After this period, the biomass was harvested from the broth by filtration. The growth media were filtered and preweighed filter paper (Whatmann no. 1) and biomass was washed several times with deionized and distilled water. The wet biomass (500 mg) was used for metal biosorption studies.

Preparation of metal solutions: A stock solution of Pb(II) used in this study was prepared by dissolving an accurate quantity of $Pb(NO_3)_2$ in deionized water. Other concentrations prepared from stock solution by dilution varied between 10 and 500 ppm and the pH of working solutions was adjusted to desired values with 0.1 M HCl or 0.1 M NaOH. Fresh dilutions were used for each experiment. All chemicals used were in analytical grade.

Biosorption procedures: All the batch biosorption-equilibrium experiments were carried out with 500 mg of biosorbent in 250 mL Erlenmayer flasks to find the optimum operating conditions which enhance the Pb(II) uptakes. The effect of the medium pH and the initial concentration of metal ion on the biosorption rate and capacity were studied. The effect of pH on the biosorption rate was investigated in the pH range of 1.0-6.0. The suspensions were brought to the desired pH by adding 0.1 M HCl or 0.1 M NaOH at the beginning of the experiment and not controlled afterwards. Metal ion solutions (10-500 mg L^{-1}) and biosorbents were interacted and agitated magnetically at 120 rpm. The effect of temperature (15-40 °C) on the biosorption capacities of the biosorbent was determined at pH 6.0 and metal ion concentration on the biosorption was studied at pH 6.0 as described above.

The solutions were centrifuged at 10 000 rpm for 20 min and the supernatants were then subjected to quantitative analysis. Each set of experiments was carried out in triplicate and the arithmetical average values were used in calculations.

Analytical procedure: Biosorption of lead ions from aqueous solutions was studied in batch systems. Lead(II) nitrate was used in this experiment. After the desired incubation period (about 24 h) the aqueous phases were seperated from the biosorbents and the concentrations of the Pb(II) ions in these phases were determined by using a flame atomic absorption spectrophotometer (Perkin-Elmer A. Analyst 800 Model) with an air-acetylene flame. Deuterium background correction was applied and the spectral slit width was 1.3 nm. The working current/wavelength values for Pb(II) ions were 7.5 mA/283.3 nm.

The instrument response was periodically checked by using standard Pb(II) solution. For each set of data reported, standart statistical methods were used to determine the mean values and S.D.s. Confidence intervals of 95 % were calculated for each set of samples in order to determine the margin of error.

Data analysis: The equilibrium sorption capacity of each biomass at the corresponding equilibrium conditions was determined using a mass balance equation expression:

$$q_e = v(C_i - C_f)/m \quad (1)$$

where q_e is the amount of metal ions adsorbed on the biomass (mg g^{-1}), C_i the initial metal ion concentration in solution (mg L^{-1}), C_f the the final metal ion concentration in solution (mg L^{-1}), v the volume of the medium (L) and m is the amount of the biomass used in the reaction mixture (g).

Biosorption/desorption: Desorption of Pb(II) ions was performed by 0.1 M HCl solution. The biomass with Pb(II) ions were placed in the desorption medium and stirred at 120 rpm for 24 h at 30 °C. The final Pb(II) ion concentration in the aqueous phase was determined by using the atomic absorption spectrophotometer. The desorption ratio was calculated from the amount of metal ions adsorbed on the entrapped preparations and the final Pb(II) ion concentration in the biosorption medium. Desorption ratio was calculated from the following equation:

$$\text{Desorption ratio} = \frac{\text{Amount of Pb(II) ions desorbed}}{\text{Amount of Pb(II) ions biosorbed}} \quad (2)$$

Per cent desorption values were obtained by multiplying the above equation by 100.

RESULTS AND DISCUSSION

Effect of contact time on the biosorption: The equilibrium biosorption time of Pb(II) ion on the *Sporotricum sp.* was investigated (Fig. 1). The biosorption conditions are given in the figure legend. The initial concentration of Pb(II) ion within the aqueous phase were constant at 100 ppm. Fig. 1 shows the changes in the amount of Pb(II) ions biosorbed with time. High biosorption rates were observed at the begining and then plateau values are gradually reached within 24 h and then the uptake of Pb(II) ion did not significantly change with contact time. It should be noted that there was no precipitation in these groups of experiments[42]. Data on the

biosorption kinetics of heavy metal ions by various sorbents have shown a wide range of biosorption rates. For example, the biosorption equilibrium time of chromium(VI) on the biomass of *Rhizopus arrhizus* was 2 h[43]. The equilibrium time of biosorption of lead(II) on *Aspergillus niger* biomass was 5 h[34]. The equilibrium time of biosorption of copper(II) on *Sargassum fluitans* biomass was 3 h[44]. The lead and copper biosorption rates of *Bacillus sp.* reached saturation value within 15 and 30 min, respectively[6]. The lead and copper biosorption equilibrium time on *Neurospora crassa* biomass was 15 min[45]. There are several parameters which affect the biosorption rate such as the stirring rate in the aqueous phase, the amount of the biosorbent, the structural properties of both the support and the biosorbent (*e.g.,* porosity, surface change density, protein and carbohydrate compositions of surface) for immobilized biomass, the the properties of the ion under study (*e.g.* ionic radius), the initial concentration of ionic species and the existence of some other metal ions which may compete with the ionic species of interest for the active biosorption sites. So, it is difficult to compare the biosorption results reported. In addition initial uptake of metal ions may be an important parameter for the practical application of biosorption in the industrial wastewater.

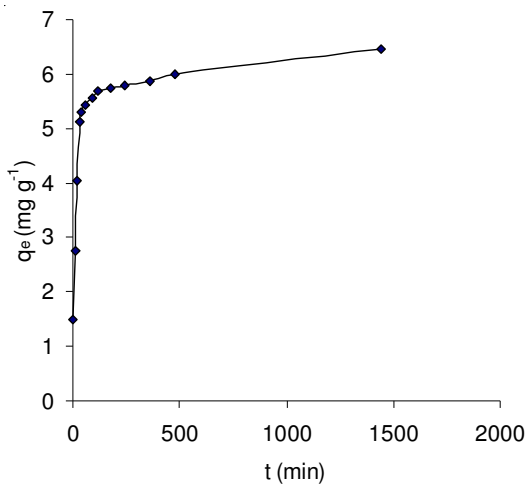

Fig. 1. Effect of contact time on Pb(II) biosorption capacity by *Sporotricum sp.* Biosorption conditions: initial concentration of Pb(II) ion is 100 mg L^{-1}; amount of biosorbent 500 mg; volume of biosorption medium: 50 mL; temperature 30 ºC; pH 6.0; agitation rate 120 rpm

Effect of pH on metal biosorption: Biosorption of metal ions on the cell wall surface of organisms has to be affected by various factors such as initial pH, initial metal ion concentration and temperature as well as biomass concentration. It is well known that metal ion biosorption on both non-specific and specific sorbents is pH dependent[2,26,46]. Earlier studies have indicated that solution pH is an important parameter affecting biosorption of heavy metal ions[6,38,47-49]. The medium pH affects

the solubility of metal ions and the ionization state of the functional groups as carboxylic, phosphate and amino groups on the fungal cell wall[42,50,51]. In present study in order to establish the effect of pH on the biosorption of Pb(II) ions onto *Sporotricum sp.* and the batch equilibrium studies were repeated at different pH values in the range of 1-6. Fig. 2 shows the effect of pH on biosorption. The biosorption conditions are given in the figure legend. As seen here biosorption of Pb(II) ions evaluated in this study at pH values above the isoelectric point of the cells, the surface area of the biomass carry negative charges, which cause an increase on the sorption capacity of the fungal cells for the metal ions as a result of attractive forces. At very low pH values with a high proton concentration cell wall ligands, fungal cells is surrounded by the hydronium ions (H_3O^+), which competes with positively charged metal ions for binding. As a result of this repulsive forces, fungal biomass adsorb less metal ions as proposed by several autors[3,38]. The increase in biosorption levels observed with increasing pH can be explained by strong relation of biosorption to the number of surface negative charges, which depends on the dissociation of functional groups[6,13,42,45,51-53]. This means that negative charge attracts positively charged Pb(II) ions and more Pb(II) binding occurs. In present study, at pH 1.0-2.0 metal uptake was negligible and biosorption for Pb(II) ions first increased with pH and maximum Pb(II) ions biosorption occured at pH 6.0. At pH higher than 6.0 could be due to the formation of a $Pb(OH)_2$ complex which would prevent the metal biosorption.

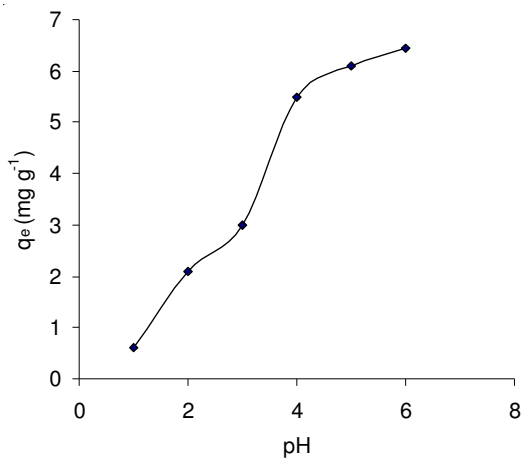

Fig. 2. Effect of pH on Pb(II) biosorption capacity by *Sporotricum sp.* Biosorption conditions: initial concentration of Pb(II) ion is 100 mg L^{-1}; amount of biosorbent 500 mg; volume of biosorption medium: 50 mL; temperature 30 ºC; agitation rate 120 rpm; contact time 24 h

The experimental study included control tests without metal in solution biomass was contacted with acid solutions at pH values between pH 1.0 and 6.0. Similar observations were reported for other biomass types[4,6,13,29,36,38,42,53-56].

Effect of temperature on metal biosorption: The effect of temperature on the biosorption of Pb(II) onto the *Sporotricum sp.* was studied between 15-40 °C at pH 6.0 and with 100 mg L^{-1} Pb(II) concentration. Fig. 3 shows the effect of temperature on Pb(II) ion biosorption and the biosorption conditions are given in the figure legend. It was observed that the temperature changes between 15-40 °C did not affect the biosorption capacity. The temperature of the biosorption medium could be important for energy-dependent mechanisms in metal biosorption by microorganisms. Energy-independent mechanisms are less likely to be affected by temperature since the process responsible for biosorption is largely physicochemical in nature. The biosorption of Pb(II) ions onto the biomass appears to be temperature independent over the temperature range tested. The similar results reported by the other researchers[13,57,58].

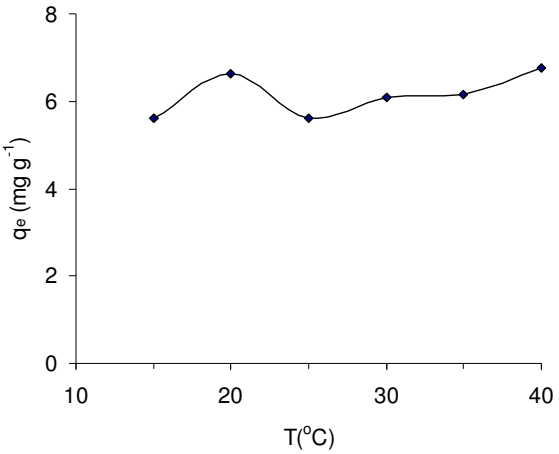

Fig. 3. Effect of temperature of biosorption medium on Pb(II) biosorption capacity by *Sporotricum sp.* Biosorption conditions: initial concentration of Pb(II) ion is 100 mg L^{-1}; amount of biosorbent 500 mg; volume of biosorption medium: 50 mL; temperature 15-40 ºC; pH 6.0; agitation rate 120 rpm; contact time 24 h

Effect of initial metal ion concentration: The effect of initial metal ion concentration on the biosorption capacity of *Sporotricum sp.* was studied at optimum pH and contact time. These experiments were carried out using Pb(II) ion solutions (10-500 ppm). Fig. 4 shows the effect of initial Pb(II) ions concentration on biosorption and the biosorption conditions are given in the figure legend. The amount of Pb(II) ion adsorbed per unit mass of the biosorbent (*i.e.*, biosorption capacity) significantly increased with the initial Pb(II) ion concentration as expected. In order to reach the plateau values which represent saturation of the active sites which are available for specific interaction with metal ion on the biosorbent. The maximum biosorption capacities of the *Sporotricum sp.* biomass are 15.48 mg g^{-1} for Pb(II) ion at pH 6.0 and 400 ppm initial Pb(II) ion concentration. Biosorption results of Pb(II) reported by the other researchers in the literature by various biosorbents and

operating conditions are summarized in Table-1. The uptake values obtained in present study are comparable with them and were found to be similar with some corresponding fungal biosorbents[4,13,29,36,42].

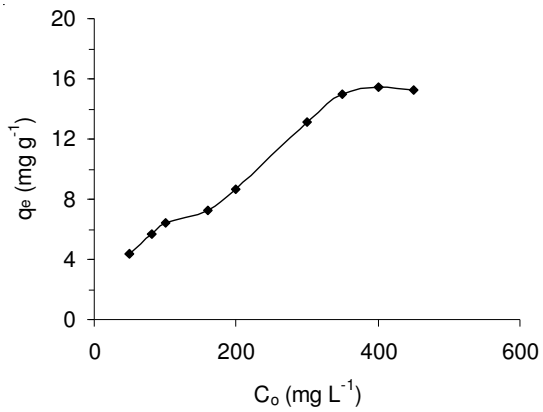

Fig. 4. Effect of initial metal ion concentration on Pb(II) biosorption capacity by *Sporotricum sp.* Biosorption conditions: initial concentration of Pb(II) ion is 10-500 mg L^{-1}; amount of biosorbent 500 mg; volume of biosorption medium: 50 mL; temperature 30 ºC; pH 6.0; agitation rate 120 rpm; contact time 24 h

TABLE-1
BIOSORPTION RESULTS OF Pb(II) ION FROM THE LITERATURE BY VARIOUS BIOSORBENT AND OPERATING CONDITIONS

Biosorbents material	Biosorption capacity (mg/g)	Operating conditions				Reference
		pH	T (ºC)	C (mg/L)	Biomass (g/L)	
Streptomyces longwoodensis	100	3	28	50-200	0.3	69
Arthrobacter sp.	130	5-5.5	30	250	1.4	70
Penicillium digitatum	5.50	5.5	25	10-50	6.5	71
Rhizopus arrhizus	75	3.5	26	10-300	–	72
Rhizopus arrhizus	55.60	5-7	25	10-600	3	38
Saccharomyces cerevisiae	2.70	5	25	10.4	2	73
Bacillus sp. (ATS-1)	92.27	3.0	25	250	2	6
Mucor rouxii	17.13	5.0	25	10	–	74
Pinus sylvestris	11.38	4.0	25	10-100	4	75
Streptomyces noursei	36.50	6.1	30	2.207	3.5	76
Sporotrichum sp.	15.80	6.0	30	10-500	5	This study

Equilibrium equations: The equilibrium biosorption isotherms are one of the most important data to understand the mechanism of the biosorption and the biosorptive metal uptake can be quantitatively evaluated by experimental equilibrium isotherms. The relationship between the amount of a substance adsorbed at constant temperature and its concentration in the equilibrium solution is called the biosorption

isotherm. The graphical expression of isotherm is a plot of the metal uptake by the per unit weight of biosorbent against the residual metal ion concentration in the biosorption medium. In order to optimize the design of a biosorption system to remove the metal ions, it is important to establish the most appropriate correlations of the equilibrium data of each system. Two isotherm equations have been tested in the present study *i.e.*, Langmuir and Freundlich models[24,59,60]. The applicability of the isotherm equations is compared by judging the correlation coeffcients, R^2.

The Langmuir isotherm is valid for monolayer biosorption on a surface containing a finite number of identical sites. The model assumes uniform energies of biosorption on the surface and no transmigration of adsorbate in the plane of the surface. The Langmuir equation is commonly expressed as:

$$\frac{C_e}{q_e} = \frac{1}{q_{max} x K_L} + \frac{C_e}{q_{max}} \quad (3)$$

where, C_e (mg L^{-1}) and q_e (mg g^{-1}) are the equilibrium concentration and the amount of adsorbed metal ions at time t (mg/g), K_L (L mg^{-1}) is a direct measure for the intensity of the biosorption process and q_{max} (mg g^{-1}) is a constant related to the area occupied by a monolayer of adsorbate, reflecting the biosorption capacity[61-63]. From a plot of C_e/q_e *vs.* C_e, q_{max} and K_L can be determined from its slope and intercept (Fig. 5). Table-2 presents the correlation coeffcient results for Langmuir isotherm.

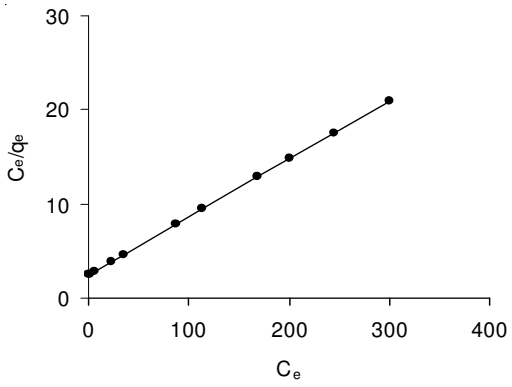

Fig. 5. Langmuir biosorption isotherm plot for Pb(II) biosorption by *Sporotricum sp.* biomass. Biosorption conditions: pH 6.0; temperature 30 ºC; agitation rate 120 rpm

TABLE-2
LANGMUIR AND FREUNDLICH PARAMETERS FOR THE BIOSORPTION ISOTHERMS OF Pb(II) ION FROM AN AQUEOUS SOLUTION ONTO *Sporotricum sp.* AT 30 ºC

q_{exp} (mg g^{-1})	Langmuir equation	Freundlich equation
	q_{max} (mg g^{-1}) / $K_L \times 10^2$ (L mg^{-1})/R^2	K_F (mg g^{-1}) / 1/n / R^2
15.48	16.61 / 2.38 / 0.945	2.07 / 0.34 / 0.980

The Freundlich isotherm is an empirical equation employed to describe heterogenous systems and constants, being indicative of the extent of the biosorption and the degree of non-linearity between solution concentration and biosorption, respectively. In addition, it is shown to be satisfactory for low concentrations[48,64,65]. The equation is commonly given by

$$\log q_e = \log K_F + \frac{1}{n}\log C_e \quad (4)$$

where K_F (g^{-1}) is a constant for the system, related to the bonding energy. K_F can be defined as the biosorption or distribution coefficient and represents the quantity of metal ion adsorbed onto adsorbent for an unit equilibrium concentration. The slope 1/n, ranging between 0 and 1 becoming more heterogeneous as its value gets closer to zero. A value for 1/n below one indicates a normal Langmuir isotherm while 1/n above one is indicative of cooperative biosorption. The plot of log q_e *versus* log C_e for the biosorption of Pb(II) ion onto *Sporotrichum sp.* (Fig. 6). The Langmuir model was able to describe the experimental equilibrium data for biosorption of Pb(II) ions on *Sporotrichum* sp under given experimental conditions (Table-2). The magnitudes of n and K_F (Freundlich constants) show easy separation of metal ions from aqueous medium and indicate favourable adsorption. The values of 1/n are in the range of 0.340 (Table-2), which indicates favourable biosorption. The correlation regression coefficients also show that the adsorption process can be well defined by both Langmuir and Freundlich equations.

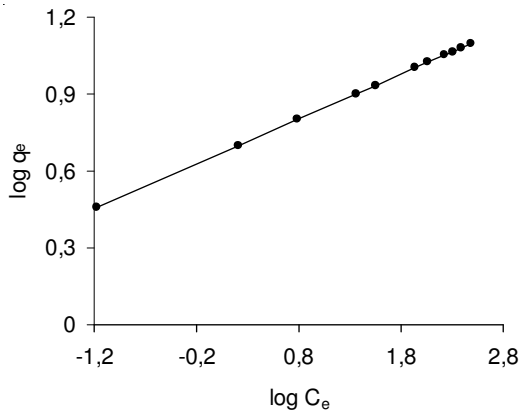

Fig. 6. Freundlich biosorption isotherm plot for Pb(II) biosorption by *Sporotricum sp.* biomass. Biosorption conditions: pH 6.0; temperature 30 ºC; agitation rate 120 rpm

Pseudo-first and second-order equations: In order to examine the controlling mechanism of the biosorption process such as mass transfer and chemical groups on the cell wall of the fungal mycelia (*e.g.*, -COOH, -NH_2, =NH, -SH, -OH) imply that there are many types of fungal mycelia-metal ion interactions. The kinetic

studies have carried out to determine the efficiency of Pb(II) ion biosorption onto *Sporotrichum sp.* and indicated that the biosorption capacity increases with the initial metal ion concentrations in all cases. Various kinetic models including the pseudo first-order and pseudo-second-order were tested for the experimental data to elucidate the biosorption mechanism[66-68]. Among them the pseudo-first-order rate equation can be written as follow:

$$\log (q_{eq} - q_t) = \log q_{eq} - (k_1.t)/2.303 \quad (5)$$

where q_1 and q_m are the amounts of Pb(II) biosorbed at equilibrium and at time t in (mg g^{-1}) and k_1 is the first-order rate constant (min^{-1}) for biosorption. Values of k_1 and q_m calculated from the slope of the plots of $1/q_t$ *versus* 1/t are given in Table-3 and Fig. 7. It was showed that the correlation coefficients for the pseudo-first-order model are lower than that of the pseudo-second-order model.

TABLE-3
KINETIC PARAMETERS FOR THE REMOVAL OF Pb(II) IONS BY *Sporotricum sp.*

q_{exp} (mg g^{-1})	Pseudo-first order	Second-order
	q_{max}(mg g^{-1}) / $k_1 \times 10^3$(min^{-1}) / R^2	q_{max} (mg g^{-1}) / $k_2 \times 10^3$(min^{-1}) / R^2
15.48	8.86 / 4.45 / 0.941	15.79 / 9.51 / 0.999

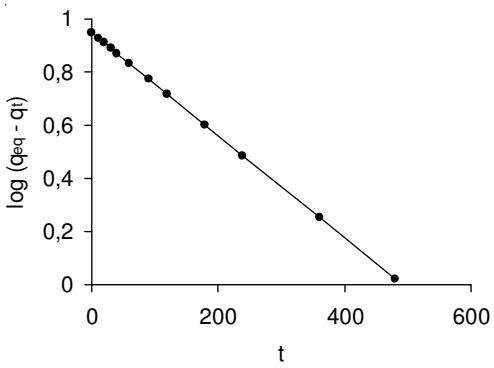

Fig. 7. Pseudo-first-order kinetic plot for the biosorption of Pb(II) ion onto *Sporotricum sp.* biomass

The pseudo-second-order kinetic model[67] is expressed as:

$$\frac{t}{q_t} = \frac{1}{k_2 q_m^2} + \frac{1}{q_m} t \quad (6)$$

where q_m is the maximum biosorption capacity (mg g^{-1}) for the pseudo-second-order biosorption, q_t the amount of Pb(II) biosorbed at equilibrium at time t (mg g^{-1}) and k_2 is the equilibrium rate constant of pseudo-second-order biosorption (gm g^{-1} min^{-1}). Values of k_2 and q_m were calculated from the plot of t/q_t against t (Fig. 8). These parameters are give in Table-3. The calculated q_m values agree with experimental q values and the correlation coefficients for the pseudo-second order kinetic

plots were very high. Comparing the equilibrium capacities (q_{eq}) of the kinetic models 'namely first and second order' with the experimental equilibrium capacities of the biosorbents, the calculated maximum capacities from second-order equation seems to describe best the experimental data. These results suggested that the biosorption system studied follows the pseudo-second-order kinetic model.

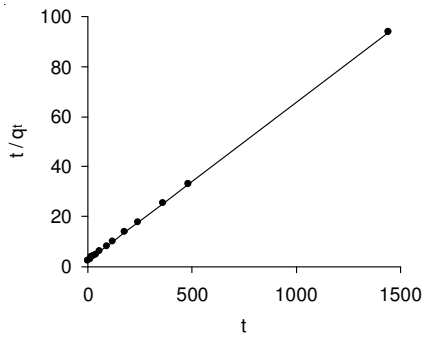

Fig. 8. Pseudo-second-order kinetic plot for the biosorption of Pb(II) ion onto *Sporotricum sp.* biomass

Desorption: To be useful in seperation and uptake processes, the heavy metal ions adsorbed by different sorbents or biosorbents could be easily desorbed under suitable conditions and than these sorbents or biosorbents could be used many times and so, reduced the cost. In present study the desorption of the adsorbed Pb(II) ions from the biomass of *Sporotricum sp.* was studied in a batch system. The Pb(II) ions adsorbed onto biosorbents were eluted with 0.1 M HCl. More than 70 % of the adsorbed Pb(II) ions was desorbed from the biosorbent. It must be pointed out that biosorption onto fungal biomass is completely reversible and this means HCl breaks down the interaction forces between Pb(II) and binding sites onto the surface of the fungal biomass.

Conclusion

Biosorption of heavy metal ions is one of the promising technologies involved in the removal of the heavy metal ions from synthetic waste water. In present study, Pb(II) uptake by *Sporotricum sp.* from synthetic waste water was investigated in the batch system. The performance of the biosorbent was examined as a function of the operating conditions, in particular medium pH, temperature, initial Pb(II) concentration in the solution, biosorption time and regeneration of biomass. The biosorption of Pb(II) had no effect important on the biosorption capacity between 15-40 °C and maximum Pb(II) biosorption observed at pH 6.0 about 100 ppm in the solution. The characteristic biosorption parameters for Freundlich and Langmuir biosorption isotherms were determined. The equilibrium was well described by the each isotherm isotherm model. The biosorbent regenerated by HCl treatment (up to 71 %) in biosorption capacities. It was observed that *Sporotricum sp.* is an effective and inexpensive biomaterial for the removal of Pb(II) ion from the aqueous solution.

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(*Received*: 10 September 2008; *Accepted*: 22 May 2009) AJC-7575