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# Lead biosorption from aqueous solution by filamentous fungus Mucor indicus

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## ABSTRACT

The biomass of Mucor indicus was used for removal of lead ions from aqueous solution. The biomass was used as both untreated and treated form. Both types were successful in removal of lead ions. The treatment was performed using 0.5 M sodium hydroxide added to the fungi in an autoclave. The biomass was dried before biosorption experiments. The effect of drying temperature on biosorption capacity was investigated by drying the untreated biomass at different temperatures of ambient, 0 ºC, and 50 ºC. The best drying temperature in which the biosorption capacity was the highest was 50ºC. The effect of pH in the range of 3.0-5.0 was studied. Biosorption of untreated biomass was independent of pH while for treated biomass, the adsorption capacity increased by increasing the pH. At low pH, biosorption capacity of untreated biomass is higher than that of treated one while at higher pH, the biosorption capacity of treated biomass is higher. The kinetic of biosorption was also investigated. The time to reach the equilibrium for untreated biomass is less than that for treated one. In order to describe kinetic data, pseudo-first order, pseudo-second order, intra-particle diffusion, and Elovich models were used. Ho's pseudo-second order model was the best one for fitting the kinetic data.

**Keywords:** Biomass, Biosorption, Lead, Mucor indicus, Water treatment

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# 1. Introduction

Lead is brought into the environment by metal industries, electroplating, battery manufacturing, pigment and dye industries, lead smelting and internal combustion engine fueled with leaded petroleum. Lead is a toxic pollutant and may damage the nervous system, reproductive system and kidneys. The permitted concentration of lead in effluent before discharge into surface water is 0.1 mg $l^{-1}$ [1]

There are different methods such as chemical precipitation, membrane separation, electrodeposition, lime precipitation, reverse osmosis, and ion exchange for removal of lead from wastewater. They are useful to treat lead concentrated effluents or are very cost effective and may produce large amounts of sludge [2-4]. Biological materials are appropriate adsorbent for removal of heavy metal since they do not have these drawbacks [2].

Fungal biomass is an advantageous biosorbent since it can be obtained as a byproduct of fermentation industries and it is a cost effective biosorbent and has a high capacity for removal of metal ions.

The aim of this work is to investigate the biosorption capacity of lead ion by the filamentous fungus Mucor indicus. The biomass was also pretreated with sodium hydroxide and the change in biosorption capacity was also studied .Effect of parameters like drying temperature, pH and adsorption time on biosorption capacity were also measured. Kinetic data was modeled by pseudo- second order kinetic model.

# 2. Materials and methods

## 2.1. Fungal production

Fungus M. indicus CCUG 22424 (Culture Collection, University of Göteborg, Sweden) was maintained on plates (40 g $l^{-1}$ glucose, 10 g $l^{-1}$ peptone, and 15 g $l^{-1}$ agar) at 32°C for 5 days. The cultivation of fungus was performed in a fermentor containing 90 g $l^{-1}$ date syrup (contained 7.2% fructose, 7.0% glucose, and 1.1% sucrose), 0.5 g $l^{-1}$ ammonium phosphate and 3 g $l^{-1}$ urea at 32°C and 5.0<pH<5.5. It was inoculated with 150 ml suspension containing 9 (±2)× $10^6$ spores $ml^{-1}$. In order to provide aerobic conditions and stir the contents of the fermentor, sterile air flew into the fermentor for about 43 h. The fungal biomass was harvested and washed with distilled water to remove any traces of the medium. A fraction of produced biomass was dried at different temperatures (ambient, 50°C, and 150°C) and another fraction was added to 0.5 M NaOH (30 ml NaOH per gram of dry biomass) and autoclaved for 20 min at 121°C. After centrifugation, the remaining residue (treated biomass) was washed with distilled water to reach neutral pH and was finally dried at 50°C. Both untreated and treated biomass were ground and sieved to obtain particles smaller than 0.5 mm.

## 2.2. Biosorption experiments

$Pb(NO_3)_2$ was dissolved in deionized water to prepare the stock solution (1000 mg $l^{-1}$ $Pb^{+2}$). It was diluted to provide different concentration of $Pb^{+2}$ solutions. The solutions pH was adjusted to the desired value using 0.1 M NaOH or 0.1 M $H_2SO_4$. All experiments were carried out in 250 ml Erlenmeyer flasks containing 50 ml $Pb^{+2}$ solutions at 135 rpm and 32ºC. Control samples were also prepared to investigate just the effect of biomass. After equilibrium, the samples were centrifuged and the supernatant was used to measure the concentration of $Pb^{+2}$.0.03 g biomass was used in all experiments. To find the optimum drying temperature, untreated biomass, which

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was dried at different temperature, was added to 10 mg $l^{-1}$ $Pb^{+2}$ solution at pH 4.5. In order to study the effect of pH, lead solutions with the concentration of 5 mg $l^{-1}$ at pH 3.0, 3.5, 4.0, 4.5, and 5.0 were prepared. For kinetic study, individual flasks were prepared at pH 4.5 and the contents of each were centrifuged at different times to measure the concentration of the supernatant. All experiments were carried out in duplicate and the average values were reported.

### 2.3. Measurement of lead ions

Concentration of lead ions was measured by an atomic absorption spectrometer (210 VGP, Buck Scientific Co., England). Adsorption capacity (mg $g^{-1}$) which is the amount of adsorbed ions to saturate unit mass of biomass was calculated as:

$$q_e = \frac{(C_0 - C_e)V}{m} \quad (1)$$

where V (0.05 l) is the volume of the solution, m (0.03 g) is the mass of biomass, and $C_0$ and $C_e$ (mg $l^{-1}$) are the concentration of lead ions before and after biosorption, respectively.

## 3. Results and discussion

### 3.1. The effect of drying temperature

Untreated biomass was dried at different temperature before adsorption. As Fig. 1 shows, the best temperature is 50ºC since the adsorption capacity is the highest for this temperature. Therefore, untreated and treated biomass was dried at 50ºC to be used in the remaining experiments.

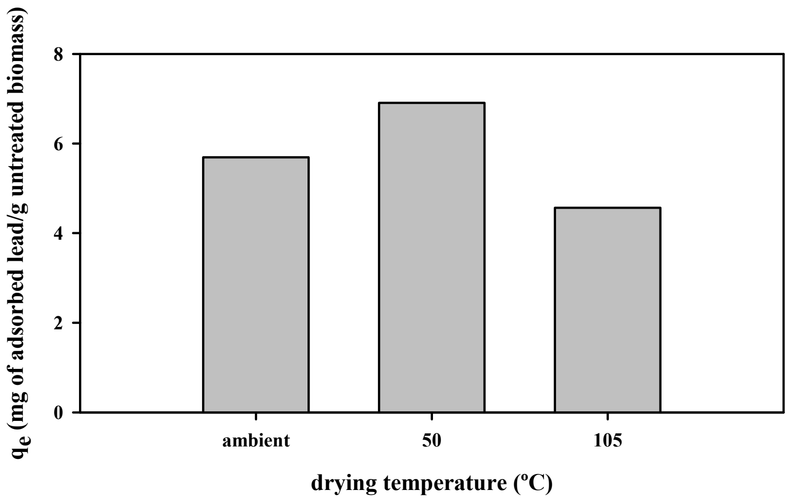


**Fig. 1. The effect of drying temperature on adsorption capacity of lead ion by untreated biomass.**

### 3.2. Kinetics of $Pb^{2+}$ uptake

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The biosorption capacity of lead as a function of time is presented in Fig.2. The results showed that the initial rate of lead ions biosorption was high for both treated and untreated biomass. Afterwards, the rate of biosorption decreased to reach the equilibrium. The lead ions were removed in two steps: the first is rapid and the second is slow [5]. The initial rate is fast since high numbers of free absorbent sites are available on biomass surface and a high lead ions concentration gradient exists at the initial stages of biosorption [6]. Afterwards, the rate of biosorption decreased since the adsorption sites were occupied and the number of accessible free sites decreased. As Fig. 2 shows, the time to reach the equilibrium is faster for untreated biomass in compare with treated one. Besides, the biosorption capacity of treated biomass is higher than untreated one.

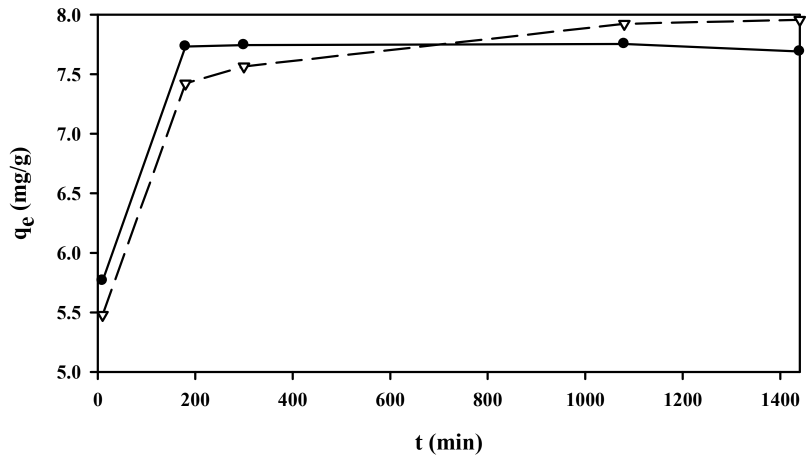


**Fig. 2. Time distribution of lead ions biosorption capacity for untreated (●) and treated (∇) biomass.**

Different models like pseudo-first order [7], Ho's pseudo-second order [7], intra-particle diffusion [8] , and Elovich [7] models were used to describe kinetic data. Ho's model was the best model since it has the highest correlation coefficient for linear regression analysis used to fit kinetic data. Ho's model is:

$$\frac{t}{q_t} = \frac{1}{Kq_e^2} + \frac{t}{q_e} \qquad (2)$$

where $q_t$ (mg $g^{-1}$) is the amount of adsorbed metal ions per unit weight of biomass at time t (min), and K is the pseudo second-order adsorption rate constant (g $mg^{-1}$ $min^{-1}$). The calculated parameters for this model are listed in Table 1. As this table demonstrates, Ho's model can predict the kinetic data well.

**Table.1: Ho's model parameters for the biosorption of lead ions by treated and untreated biomass.**

| biomass type | $R^2$ | K(g $mg^{-1}$ $min^{-1}$) | calculated $q_e$ (mg $g^{-1}$) | experimental $q_e$ (mg $g^{-1}$) |
|---|---|---|---|---|
| untreated | 1.0000 | 0.4586 | 7.71 | 7.69 |

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| | | | | |
|---|---|---|---|---|
| treated | 0.9999 | 0.0106 | 8.01 | 7.95 |

**3.3. Effects of pH**

Initial solution pH was varied in the range of 3.0-5.0. At pH higher than 5.5, lead precipitates as lead hydroxide [1]. The biosorption capacity for both types of biomass at different pH values are shown in Fig. 3. The biosorption capacity of untreated biomass was not dependent on pH but for treated biomass, by increasing the pH, the biosorption capacity ($q_e$) increased. At low pH, the competition between $H_3O^+$ and lead ions decreases the adsorption capacity of treated biomass [9]. By increasing the pH, the negative charge of the treated biomass surface increases and the biosorption of positive lead ions increases [10]. The optimum pH for lead removal was found to be 5.0 for untreated biomass.

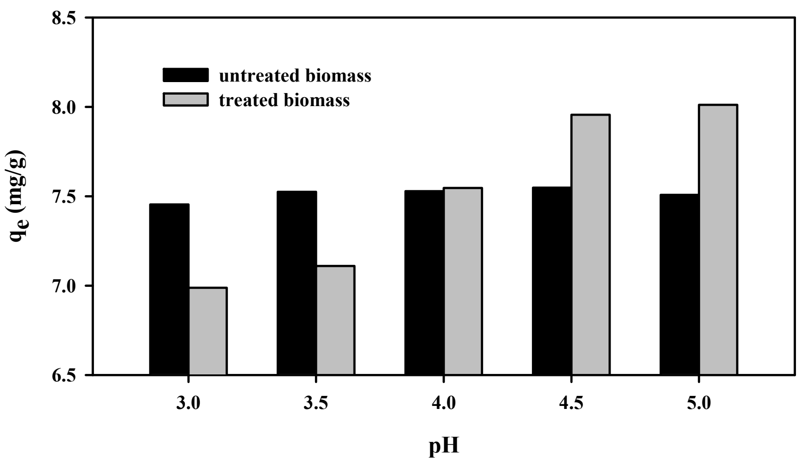


**Fig. 3. Effect of pH on biosorption of lead ion by unrated and treated biomss.**

## 4. Conclusions

Both untreated and treated biomass can remove lead ions from aqueous solutions. The best drying temperature for untreated biomass is 50 ºC. Adsorption process for untreated biomass is faster than treated one. Ho's pseudo- second order model can describe the kinetic data of both types of biomass. Untreated biomass was not considerably dependent on pH, but treated biomass has a better adsorption capacity at high pH values. At Higher pH, treated biomass is more effective than untreated one.

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