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Research Article

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Biosorption of heavy metals using mushroom *Pleurotus eous*

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ABSTRACT

The present study reports the sorption capacity of mushroom Pleurotus eous which is evaluated on the biosorption of heavy metals such as lead, chromium and nickel from aqueous solutions. The optimum sorption conditions were studied for each metal separately. The desired pH of the aqueous solution was found to be 5.0, 3.0 and 7.0 for the removal of lead (Pb), chromium (Cr) and nickel (Ni) respectively. The percentage removal of all the heavy metals was found to be biosorbent dependent and found to increase with the increase in biosorbent dosage and agitation speed. The contact time was optimized to be 9 hours for all the three metals. Comparative studies on biosorption of three heavy metals Pb, Cr, Ni by the mushroom P.eous shows high metal uptake with respect to lead rather than chromium and nickel. Hence the present data demonstrates the suitability of fruiting bodies of P.eous as an efficient biosorbent for the removal of toxic heavy metals and further the studies confirms that the biosorption varies with metals.

Keywords: Mushroom, sorption capacity, heavy metals pollution, Basidiomycetes fungi, water pollution.

INTRODUCTION

Removal and recovery of heavy metals from waste water is important towards the protection of environment and human health [1]. Lead, chromium and nickel are being widely used in wide varieties of commercial processes. The disposal of the effluent containing heavy metals led to the contamination of ground waters. There are various methods proposed and practiced to remove such heavy metals which include the conventional methods chemical precipitation, ion-exchange, lime coagulation, membrane filtration activated carbon adsorption [2]. Due to many disadvantages like incomplete removal, high reagent cost and energy needs, careful disposal of the toxic waste products made effective to find out new cost-effective method such as biosorption which is capable of removing metals from effluents appreciably [3].

Removal of heavy metals from waste waters through biosorption has emerged as an alternative technology in recent years and is considered to be as a promising technology because of its potential application in environmental protections. The major advantage of biosorption over conventional treatment methods include low cost, high efficiency, minimization of chemical and biological sludge, no additional nutrient requirement, regeneration of biosorbent and possibility of metal recovery.

Recent research indicates that microorganisms can accumulate high concentration of metals. Microorganisms including algae, fungi and bacteria are typical examples of biosorbent that exhibit surface specificity towards sorption of heavy metals [4, 5]. Bacteria are less resistant to toxic metals than algae and fungi. Algae being autotrophic organisms require a constant supply of oxygen, carbon source. Moreover, due to small size, algae as well as bacteria are difficult to harvest and require laborious solid liquid separations. Fungi may be better suited as an adsorbent for metal removal than any other microbial mass because of their great tolerance towards toxic metals and other adverse environmental conditions and it grows rapidly under various environmental conditions.

Fruiting bodies of macro fungi (mushroom) are considered ideal for the purpose of evaluation as biosorbent because it has been demonstrated that many fungal species exhibit high biosorptive potentials [2, 6]. Studies have shown that mushrooms can be used to reduce the level of environmental pollution by biosorption of cadmium, copper, nickel and chromium [7- 9].

The mushroom species used for the current study is *Pleurotus eous* mushroom. Our earlier studies on this mushroom *P.eous* shows that which is having analgesic, anti-inflammatory and antipyretic properties [10, 11]. In addition to this, it is also used as potent free radical scavenger, antiplatelet and antibacterial agent [12, 13]. In order to screen our sample for environmental detoxification of heavy metals, we have extended our studies to test the efficacy of *P.eous* in biosorption process on heavy metals. The objective of the present study is to check the metal uptake capability of heavy metals like Lead, Chromium and Nickel by mushroom *P.eous*.

EXPERIMENTAL SECTION

Collection of mushroom fruiting bodies

The fruiting bodies of the mushroom *P. eous* were obtained from Kerala Agricultural University, Trivandrum and authenticated by Dr.Lu Lu Das, Professor, Dept of Plant Biology, College of Agriculture, Vellayani, Kerala Agricultural University, Trivandrum. The authentication No is (Reg:No.T.5365/06:61; 27/08/2009).

Preparation of Biosorbent

The fruiting bodies of *P.eous* was collected and washed thoroughly with deionized water to remove the dirt and impurities. Further it is dried in an oven at 60°C for 16 hrs and powdered using mortar and pestle. The powdered sample was used for the biosorption experiment [2, 3].

Preparation of chromium, lead and nickel solutions

Stock solutions of lead, chromium and nickel is prepared by dissolving 1.5985 g of Lead nitrate, 1.92 g of Chromium trioxide and 4.04 g of Nickel chloride in 1 L de-ionized water. Initial stock solution having concentration 1000 mg/L was subsequently diluted with appropriate amount of deionized water to get desired standard solutions. The resultant concentration of lead, chromium and nickel ions in the biosorption experiment was determined using AAS (Varian AA-240) equipped with deuterium background corrector and air Acetylene burner.

Batch Biosorption experiment

The batch biosorption studies were conducted to investigate the effect of different factors on biosorption of metals onto the biosorbent and also to determine the metal uptake capacity of the biosorbent. Experiment was conducted at room temperature (25°C) on orbital shaker (Remi, RS 24). The samples were collected, filtered and the residual metal concentrations in the filtrates were analyzed by AAS [3]. The efficiency of the biosorption (E) was calculated using the following equation $E = (C_i - C_f) / C_i \times 100$

Where, C_i is the initial and C_f is the final concentration of metal ions (mg / L) in the test samples.

Effect of contact time

The effect of contact time on biosorption of cadmium and lead was studied at initial lead, chromium and nickel concentrations of 5 mg/L, biomass dosage 0.2 gm and the solution was agitated at 250 rpm. The experiment was carried out for 10 hrs in an orbital shaker and for every hour such as 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 hours the samples were collected and separated by filtration and the filtrate is analyzed for residual metal concentrations.

Effect of Biosorbent dosage

The effect of biosorbent dosage was studied with sorbent concentration varying from 0.05 to 0.2 g in 5 mg/L of lead, chromium and nickel solutions. The rest of the experimental procedure was similar to effect of contact time studies.

Effect of Agitation speed
The effect of agitation speed was studied by varying the speed range from 100 to 250 rpm for all the three metals lead, chromium and nickel keeping the other parameters constant such as Biosorbent dosage 0.2 g, initial metal ion concentration 100 mL metal solution (5 mg/L) and contact time for 9 hrs. The rest of the experimental procedure was similar to contact time effect studies.

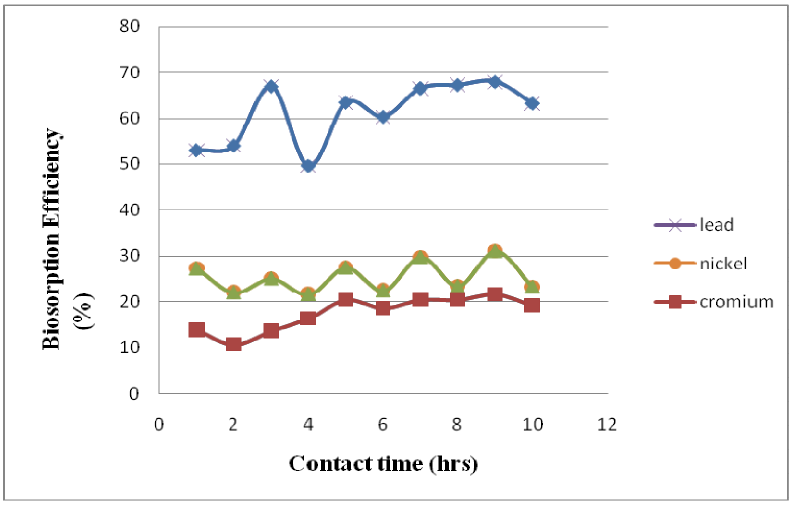
Effect of pH
The effect of solution pH on sorption of heavy metals by the mushroom *P.eous* was studied in batch biosorption experiments over a pH range of 3.0 to 7.0 for lead, chromium and nickel at the concentration of 5 mg/L. The pH adjustment was done with 0.1 M HCl or NaOH as appropriate and the solution pH was measured with digital pH meter [2]. The reaction mixture consists of 100 mL of metal solutions adjusted to various pH and the biosorbent dosage kept constant at 0.2 gm. Six hours contact time was chosen to study the effect of pH which was the enough duration to achieve the equilibrium. The mixture was agitated thoroughly on an orbital shaker at 250 rpm and the sorbents were separated by filtration. Further the solutions were analyzed for residual metal concentration.

RESULTS AND DISCUSSION

Batch Biosorption Studies
Batch biosorption was conducted using the fruiting bodies of fungi *P.eous* as Biosorbent; lead, chromium and nickel as adsorbates. The present work describes the efficiency of *P.eous* as a biosorbent for the removal of lead, chromium and nickel from aqueous solutions. The study involves optimizing contact time, biosorbent dosage, agitation speed and pH.

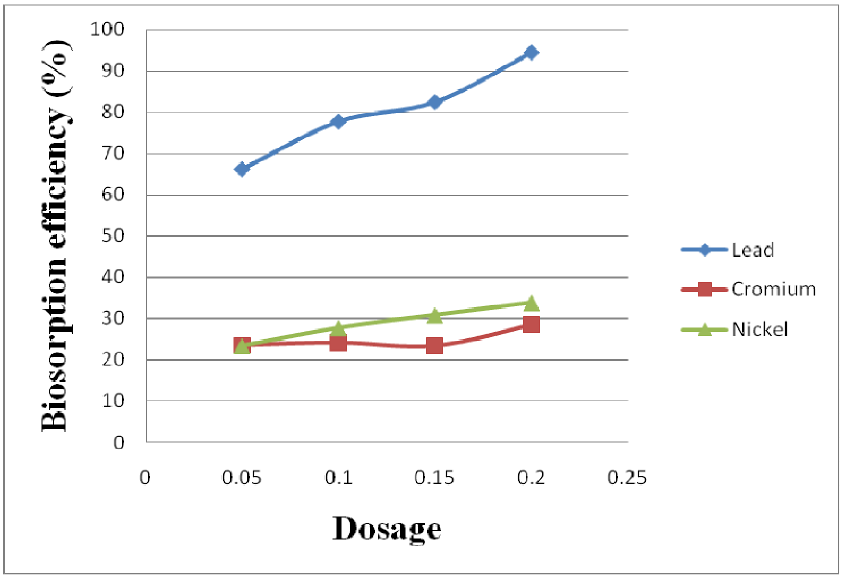
Effect of contact time on biosorption
Biosorption efficiency of all the three metals by *P.eous* is more at 9 hrs and later found to decrease. Maximum percentage of removal of lead, chromium and nickel was found to be 68.0%, 21.6% and 31.0% respectively at 9 hrs by *P.eous*. The lead, chromium and nickel uptake by the biosorbent *P.eous* at various contact time are graphically represented in **Figure 1**.

Figure 1: Effect of Contact time on lead, chromium and nickel sorption of *P.eous*
(Initial concentration=5mg/L; pH= 5.0; Dosage= 0.2 gm/100mL;contact time = 9 hrs; rpm= 250; Temp= 25°C)



Effect of Biosorbent dosage on biosorption
The number of available sites and exchanging ions for adsorption depends upon the amount of adsorbent in the biosorption process. In case of lead, chromium and nickel the biosorption efficiency rapidly increases with increasing concentration of biosorbent upto the biosorbent dosage of 0.2 g of *P.eous*. Maximum percentage of removal of lead, chromium and nickel was found to be 94.4%, 28.6% and 33.8% respectively for *P.eous* at biosorbent dosage of 0.2 g. The lead, chromium and nickel uptake by the biosorbent *P.eous* at various concentrations of biosorbent are shown in **Figure 2.**

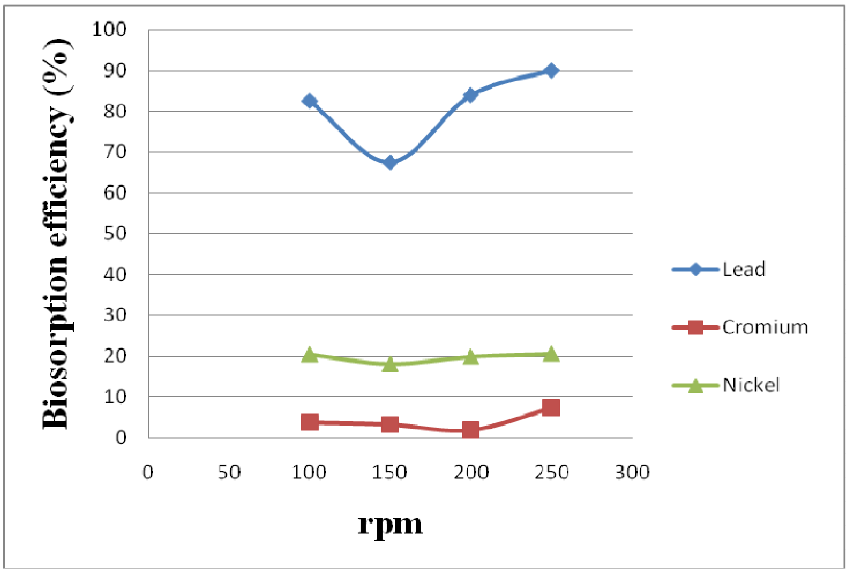
Figure 2: Effect of Dosage on Biosorption of lead, chromium and nickel by mushroom *P.eous*
(Initial concentration= 5mg/L; pH= 5.0; contact time = 9 hrs; rpm= 250; Temp= 25°C)



Specifically *P.eous* is found to respond well towards the biosorption of Pb. In all the biosorbent treated dosage Pb is found to have maximum percentage of removal. 66.2 % at 0.05 g, 77.7 % at 0.1 g, 82.4 % at 0.15g and 94.4 % at 0.2 g dosage of fruiting bodies of *P.eous*.

Effect of Agitation Speed on biosorption
In case of agitation speed (rpm) of all the three metals Pd, Cr and Ni the biosorption efficiency increases rapidly on increasing the rpm upto the range of 250 rpm. Maximum percentage of removal of lead, chromium and nickel was found to be 90.06%, 7.29% and 20.5% for *P.eous* at 250 rpm. The lead, chromium and nickel uptake by the biosorbent *P.eous* at various rpm are discussed in **Figure 3**.

Figure 3: Effect of Agitation speed on Biosorption of lead, chromium and nickel by *P.eous*
(Initial concentration = 5mg/L; Biosorbent dosage= 0.2 g/100mL; pH=5.0; Temp=25°C)



Effect of pH on biosorption

The pH of an aqueous medium is an important factor which influences the uptake of metal ions by biosorbent in many ways. In case of lead, as the pH increases the biosorption also increases and reaches equilibrium at pH 5.0 and then gradually decreases. Maximum percentage of removal of lead was found to be 82.2% for *P.eous* at pH 5.0. In case of nickel as the pH increases the biosorption efficiency increases and reaches the equilibrium at pH 7.0. Maximum percentage of removal of nickel was found to be 38.3% for *P.eous* at pH 7.0. According to the results chromium has the more biosorption efficiency which is seen at pH 3.0 and then decreases gradually. Percentage removal of chromium was found to be 21.5% for *P.eous* at pH 3.0. The lead, chromium and nickel uptake by the biosorbent *P.eous* at various pH values are graphically represented in **Figure 4**.

Figure 4: Effect of pH on lead, chromium and nickel Biosorption by mushroom *P.eous*

(Initial concentration=5mg/L; Biosorbent dosage = 0.2 gm/100mL; contact time = 9 hrs; rpm= 250; Temp= 25°C)

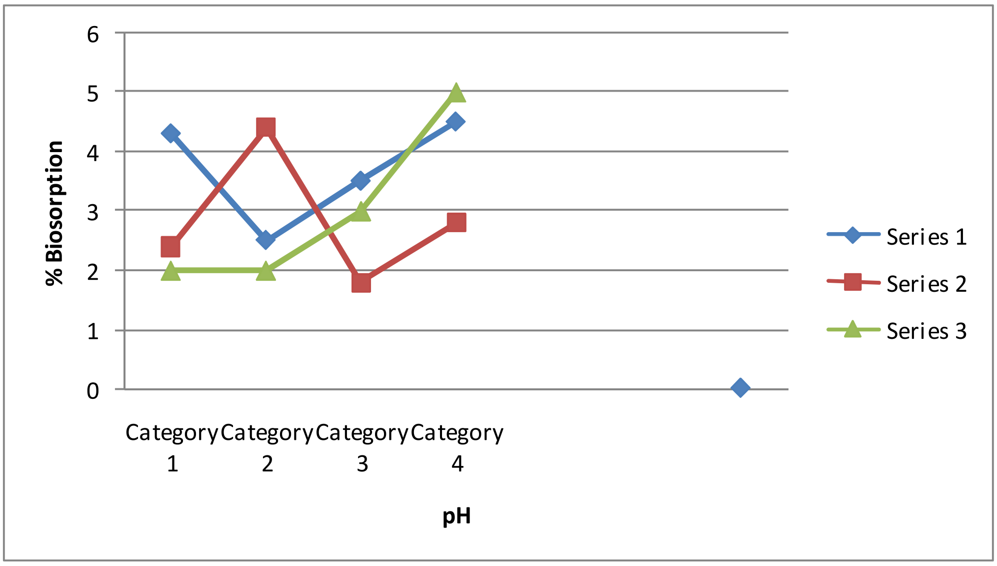
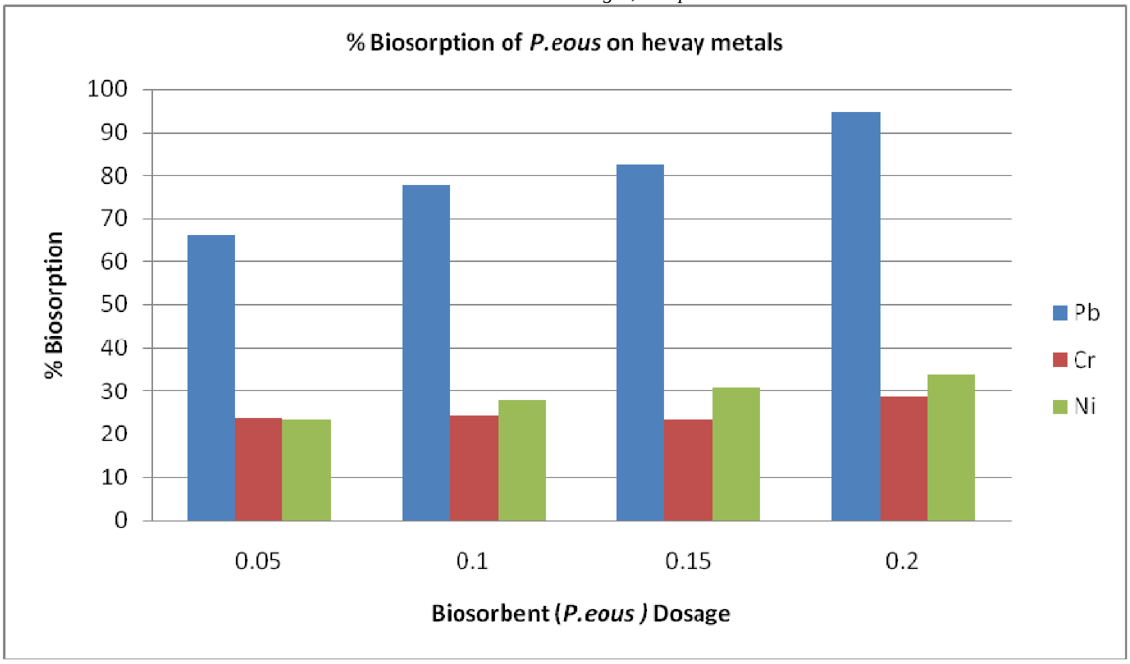


Figure 5: Comparison of Biosorption Efficiency of Lead, Chromium and Nickel on mushroom *P.eous* at optimized time (9 hrs), agitation speed (250 rpm) and at pH (3, 5, 7 for Pb, Cr & Ni respectively)

Initial Concentration = 5mg/L; Temp= 25°C



Comparative studies of Biosorption efficiency of P.eous on heavy metals

Comparative studies on biosorption efficiency of *P.eous* on heavy metals Pb, Cr and Ni was carried out using the optimized conditions with respective pH of 5.0, 3.0 and 7.0, agitation speed 250 rpm, biomass from 0.05-0.2 g and contact time 9 hrs. The maximum biosorption efficiency was found to be 93.2%, 27.6% and 39.8% of Pb, Cr and Ni respectively. Among the three metals mushroom *P.eous* shown higher removal of lead rather than chromium and nickel. Comparison of biosorption efficiency of *P.eous* on heavy metals Pb, Cr and Ni is shown in **Figure 5**.

CONCLUSION

Mushrooms are potential source of raw material for the development of biosorbent. The present study confirms the efficiency of the mushroom *P.eous* as biosorbent of heavy metals such as lead, chromium and nickel. The effect of parameters like pH, agitation speed, biomass dosage and contact time for the biosorption process was optimized. The desired pH value for biosorption was found to be 5.0 (82.2%), 3.0 (21.5%) and 7.0 (38.3%) for lead, chromium and nickel respectively. The optimized agitation speed was 250 rpm at 25°C for all the three metals. The efficiency of dosage was shown at 0.2 gm for all the three metals. The optimized time for biosorption was 9 hrs for all the three metals.

Comparison of biosorption efficiency of *P.eous* on heavy metals Pb, Cr and Ni reveals that the biosorption efficiency on Pb (93.2%) metal is more than Cr (27.6%) and Ni (39.8%). *P.eous* is Tarragon oyster mushroom which exhibits a maximum uptake of lead (93.2%) among the other metals chromium and nickel. Thus the study proves that the cultivation of mushroom *P.eous* is eco friendly and decreases environmental pollution as it has the capacity of adsorption of heavy metals. Further the study also reveals that biosorption capacity is specific to metal ions.

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