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Novel studies for the development of hybrid biosorbent

Asid Majeed[a], Muhammad Idrees Jilani[a], Raziya Nadeem[a], Muhammad Asif Hanif[a] and Tariq Mahmood Ansari[b]

[a]Department of Chemistry, University of Agriculture, Faisalabad-38040-Pakistan.
[b]Department of Chemistry, Baha-u-Din Zakariya University, Multan-60800-Pakistan.

Abstract

The present study evaluates the technical feasibility of immobilized hybrid biomass of *Pleurotus sajar-caju* and sunflower for Pb(II) removal from the wastewater. The many segments of environment adversely affected by presence of Pb(II). At the end of preliminary evaluation, immobilized hybrid biomass of *Pleurotus sajar-caju* and sunflower waste biomass was found as the best biosorbent of Pb(II). The optimized value of contact time, biosorbent dose and metal concentration were, 180 min, 0.05g/100 mL and 800 mg/L, respectively. The uptake of Pb(II) was maximum at 60°C. The sorption of Pb(II) followed the pseudo second order kinetic model. The Langmuir sorption isotherm model fitted to the Pb(II) concentration data.

Key words: Pb(II), immobilization, hybrid, kinetic models, isotherm

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**Corresponding Author*, e-mail: midreesjilani1star@yahoo.com

1. Introduction

Specific gravity of heavy metals is at least 5 times of water. It is estimated that near about 1.5 billion people be deficient in safe and sound drinking water. Waterborne diseases are responsible for 5 million deaths per year [1]. Pb(II) is one of main water contaminant present in industrial wastewater [2]. Industrial wastewater released from storage batteries manufacturing units, tetraethyl lead manufacturing, plating, ammunition, mining and the glass industries of ceramic are major contributor for Pb(II) pollution. Acceptable range of Pb(II) is 0.10 mg/L in drinking water recommended by the Environmental Quality Act. Pb (II) is well known neurotoxin metal at elevated concentrations [3]. The release of large quantities of pollutants in water is a major issue which is acquiring attention of many scientists to overcome this problem [4]. Conventional methods used for removal of heavy metals, are filtration, chemical precipitation, electrochemical treatments, reverse osmosis, ion exchange, redox reactions and adsorption usually lavish and insufficient for treatment of very dilute solutions [5].

Heavy metals accumulation by biological materials through physico-chemical or metabolically mediated pathways from wastewater is known as biosorption [6]. Biosorption has several benefits over conventional methods since no chemical sludge produced, more efficient, cost effective, highly selective and easy to handle for large volume of wastewaters treatment of containing less pollutant concentrations [7-10]. Because the both agro-based materials and microbial biomass have high potential as biosorbents, a new idea of generating a hybrid biosorbent (HB) was the basis for undertaking the present study. An innovative HB matrix was prepared by developing network of *Pleurotus sajar-caju* on *sunflower* waste biomass. The effect of various experimental parameters was evaluated to check the feasibility of HB.

2. Materials and methods

Sunflower waste biomass was collected from Rose Laboratory and *Pleurotus sajar-caju* was collected from Mushroom Laboratory, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan".

2.1. Microorganism and culture medium

Potato dextrose agar (PDA) slants were used to maintain *Pleurotus sajar-caju* slants. The composition of liquid growth medium (gm per liter of distilled water) was as follows: D-glucose (5.0); $MgSO_4.7H_2O$ (0.2); KH_2PO_4 (5.0); NH_4NO_3 (2.0); Peptone (2.0); $(NH_4)_2SO_4$ (4.0); Trisodium citrate (2.5) and Yeast (1.0).

2.2. Preparation of Hybrid matrix

The sieved samples of waste biomass were oven dried at 60 °C to constant weight, autoclaved for 15 min at 121 °C. *Pleurotus sajar-caju* was grown on sunflower waste soaked in growth medium to produce hybrid biosorbent.

2.3. Immobilization of Biomass

Pleurotus-sunflower hybrid biosorbent was mixed with 2% sodium alginate and introduced drop wise into calcium chloride (0.1M) solution to obtain the uniform sized beads of biomass (0.350 mm).

2.4. Pb(II) stock solutions

Stock solutions of Pb(II) was prepared by dissolving $Pb(NO_3)_2$ in 1000ml of deionized distilled water (DDW).

2.5. *Batch biosorption studies*

Lead uptake was studied in each set of experiments by testing 100 mL of 25 – 800 mg/L Pb(II) solution at as pH (1- 4.5), biosorbent dose (0.05 – 0.5g), metal concentration (25 – 800 mg/L), contact time (15 – 1420 min) and temperature (30 – 60°C) on sorption process was studied in batch mode [11] .

2.6. Determination of Pb(II) contents in the solutions

The atomic absorption spectrophotometer was used for the determination of concentration of Pb(II) in aqueous solution and the metal uptake by the simple was calculated with concentration difference method. Pb(II) uptake was calculated by mass balance equation (1):

$$q = V(Ci-Ce)/M \quad (1)$$

Where V is volume solution, Ci is initial concentration, Ce is final concentration of solution and M is mass of sorbent.

3. Results and Discussion

3.1. Influence of pH on metal ion biosorption

To evaluate effect of solution pH, the pH was varied from 1 to 4.5 (Fig. 1). Metal uptake by immobilized hybrid biomass of *Pleurotus sajar-caju* and sunflower waste biomasses increase as the pH increase. The maximum equilibrium uptake for Pb(II) 138.88 mg/g by native biomass of sunflower at pH 4.5. Higher negative charge density results in a greater uptake of Pb(II) at pH 4.5 [12] .

3.2. Influence of biosorbent Dose

The binding sites available for metal adsorption depend upon biosorbent dose. It is necessary to select correct number of binding sites for maximum metal uptake [13]. The maximum equilibrium uptake of Pb(II) ions by dead *Pleurotus sajar-caju* and sunflower head waste biomass hybrid biosorbent was 155.08 mg/g 0.05 g/100ml (Fig. 2) .

At low biosorbent concentration metal uptake was more may be due to an increase in metal to biosorbent ratio [3]. Same type of observation are reported by [3, 14] .

3.3. Influence of Initial Pb(II) Concentration

Effect of initial Pb(II) concentration was studied by varying from 25 to 800 mg/L (Fig. 3). Metal uptake capacity of immobilized hybrid biomass of *Pleurotus sajar-caju* and sunflower was found to increase with Pb(II) initial concentration increased [15,16]. Initial metal concentration data was fitted with Freundlich and Langmuir adsorption isotherms. The equations used to fit the models can be found in previous publication [11]. Results were found to be in well correlation with Langmuir isotherm model for Pb(II) (Table 1).

3.4. Influence of temperature

Temperature effect on metal uptake capacity was evaluated from 30 to 60˚C at constant pH 4.5, initial metal concentration (100 mg/L), dose (0.05g/100mL) and contact time (24 hours). Increase in temperature favored the uptake of metal ions. *Pleurotus sajar-caju* and sunflower hybrid biosorbent was found to have maximum uptake of 205.12 mg/g at 60˚C (Fig. 4). The similar results are reported in literature [17]. The metal uptake capacity of Pb(II) sharply increases with increase in temperature.

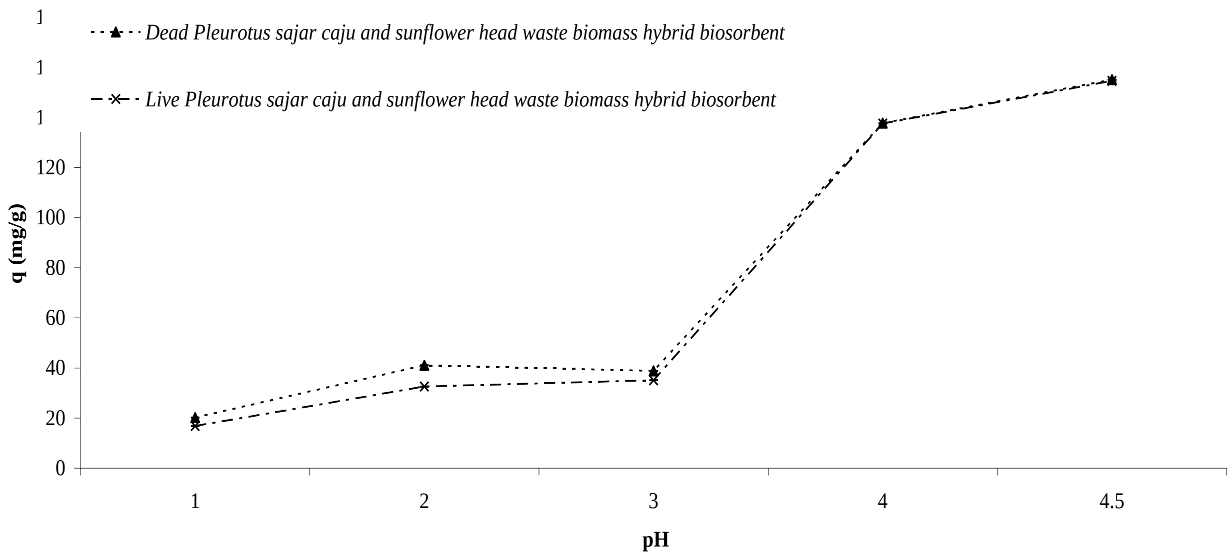

Fig.1. Effect of pH on uptake of Pb(II) by immobilized hybrid biomass of *Pleurotus sajar-caju* and sunflower

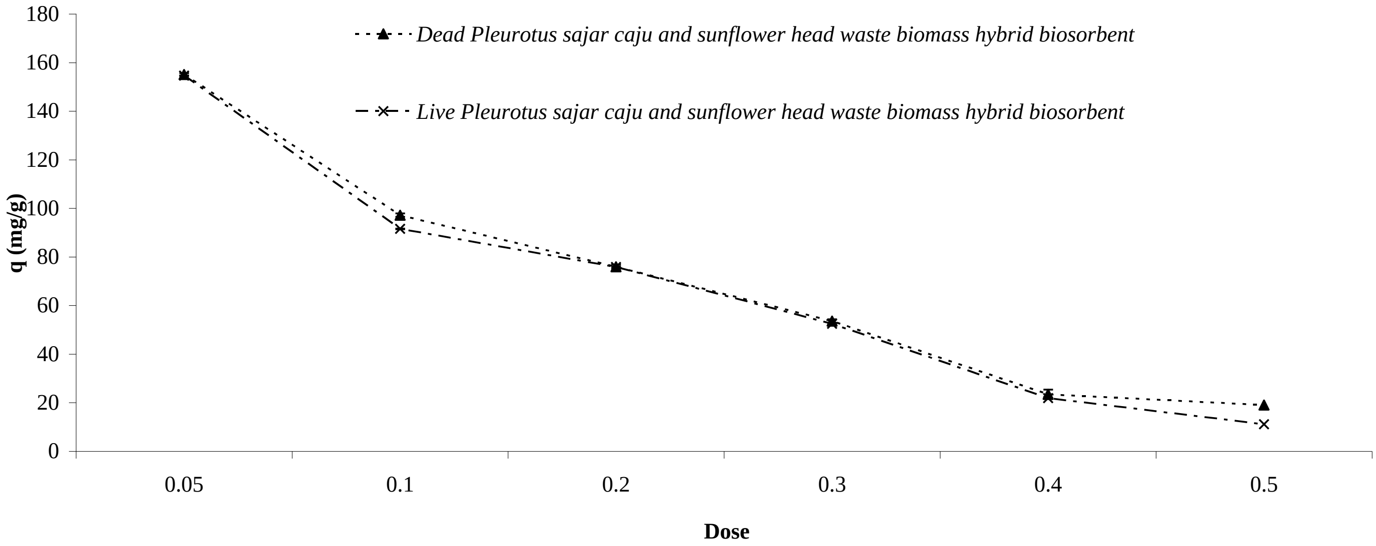

Fig.2. Effect of dose on uptake of Pb(II) by immobilized hybrid biomass of *Pleurotus sajar-caju* and sunflower

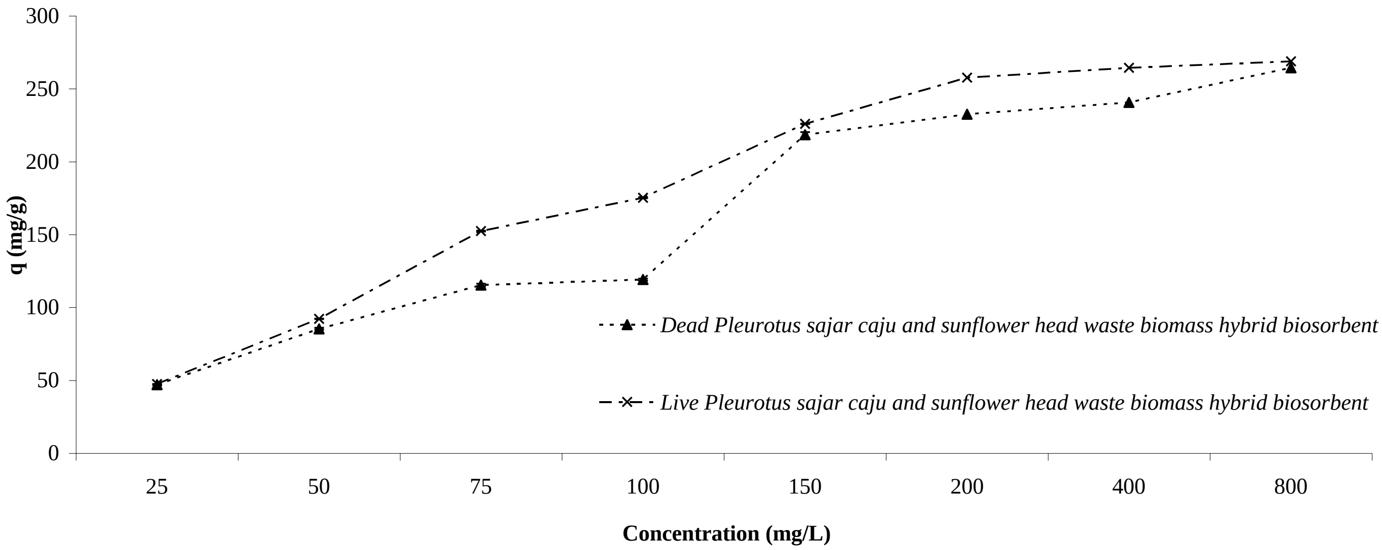

Fig.3. Effect of initial metal concentration on uptake of Pb(II) by immobilized hybrid biomass of *Pleurotus sajar-caju* and sunflower

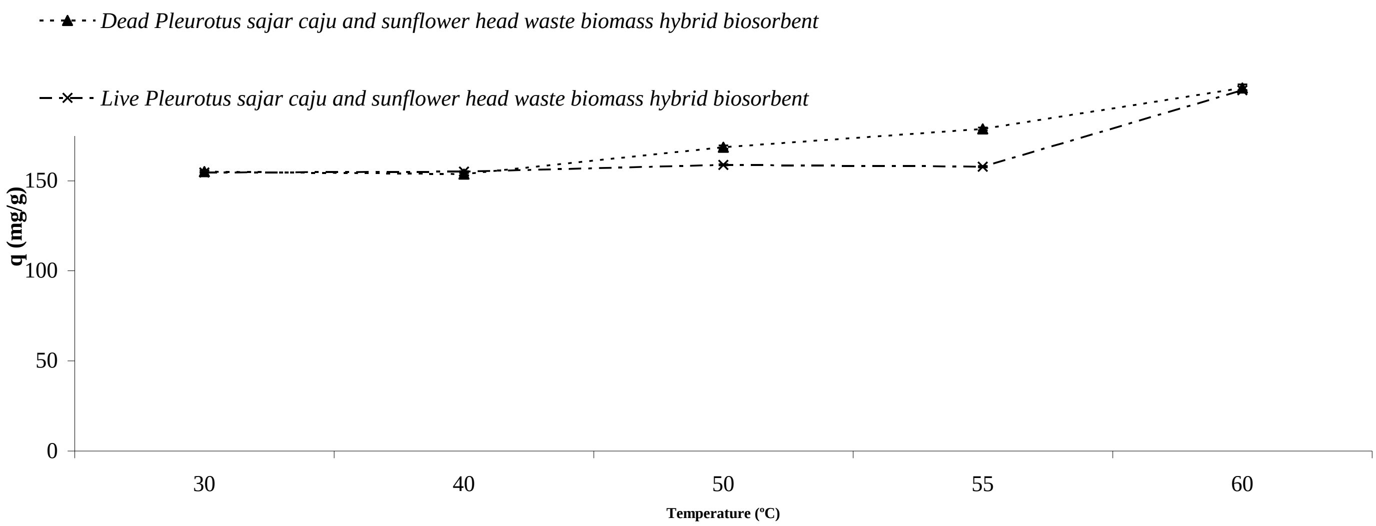

Fig.4. Effect of temperature on uptake of Pb(II) by immobilized hybrid biomass of *Pleurotus sajar-caju* and sunflower

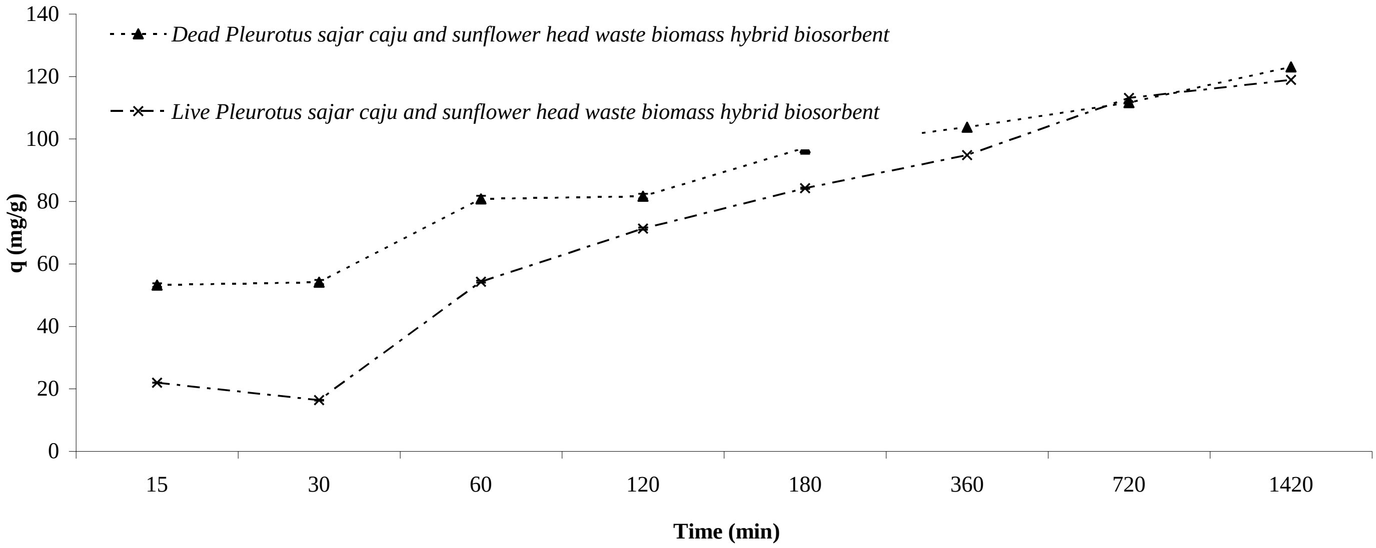

Fig.5. Effect of contact time on uptake of Pb(II) by immobilized hybrid biomass of *Pleurotus sajar-caju* and sunflower waste biomass.

Table 1. Langmuir and Freundlich isotherm parameters for Pb(II) biosorption

Biomass	Langmuir isotherm parameters			Experimental	Freundlich isotherm parameters			
	Xm (q max) mg/ g	**K_L** (L/mg)	**R^2**	**Q** (mg/g)	**q** (mg/g)	**K** (mg/)	**R^2**	**1/n**
DPSHW biomass	270.27	$3.91x10^{-2}$	0.99	264.48	342.34	41.65	0.85	0.32
LPSHW biomass	270.27	$1.242x10^{-1}$	0.99	268.92	296.75	92.96	0.49	0.17

Table 2: Comparison between Lagergren pseudo-first-order and pseudo-second-order kinetic models for Pb(II) biosorption

Biomass	Pseudo first order kinetic model			Experimental	Pseudo second order kinetic model		
	q_e (mg/g)	**$K_{1,ads}$** (min^{-1})	**R^2**	**Q** (mg/g)	**q_e** (mg/g)	**$K_{2,ads}$** (g/mg.min)	**R^2**
DPSHW biomass	56.72	2.53×10-3	0.87	123.06	125	1.63×10-4	0.99
LPSHW biomass	89.59	3.91x10-3	0.96	118.94	128.2	6.96x10-5	0.99

DPSHW biomass Dead *Pleurotus sajar caju* and sunflower head waste biomass hybrid biosorbent
LPSHW biomass Live *Pleurotus sajar caju* and sunflower head waste biomass hybrid biosorbent

3.5. Influence of Time

The effect of the contact time was studied from 15-1440 min (Fig. 5). The maximum sorption capacity of Pb(II) ion by *Pleurotus sajar-caju* and sunflower seed waste biomass hybrid biosorbent was 169.56 mg/g at 24 hours. The rapid initial uptake was occurs because of extra cellular binding and the following sorption phase was slow due to intracellular binding [18]. Selection of proper equilibrium times determines the cost of treatment process [19-21] have reported similar results type of results. Contact time data was fitted to Lagergren first order expression given by Lagergren and pseudo second order approach (Table 2). The equations used to fit the models can be found in previous publication [11].

4. Conclusion

The present study first time proposed the use of hybrid biosorbents for cost effective removal of hazardous heavy metals from toxic aqueous streams.

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