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Removal of Pb(II) ions from synthetic waste water by biocarbon of *Ocimum sanctum* (Lamiaceae)

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ABSTRACT

The biosorption is an effective and versatile method and can be easily adopted in low cost to remove heavy metals from large amount of industrial wastewaters. The biocarbon obtained from medicinal plant called *Ocimum sanctum* (Lamiaceae) is considered as a cheap materials for the removal of lead ions for aqueous solution. From batch biosorption studies, the effect of pH, contact time, different concentration of Pb(II) ions were used to estimate the optimum biosorption conditions. Removal efficiency of the biocarbon for Pb(II) ion in aqueous solution is maximum (87.5%) at pH 5.5. The effective contact time is 150min and the optimum biocarbon dose is 2.5g/100ml. The results indicate that, the percentage removal of metal ion increases progressively with the increase in amount of biocarbon dose. The activated biocarbon *Ocimum sanctum* was investigated as a replacement for the current expensive methods of removing metal ions from aqueous solutions.

Introduction

Water pollution caused by heavy metals has received worldwide attention due to their potentially toxic effects on human beings, flora and fauna. Heavy metal pollution is extremely pernicious because these metals are environmentally persistent and toxic (Ko et al., 2000). The impacts of toxic heavy metals to the environment and to public health are well known. The heavy metals are of special concern because they are non-degradable and their existence in receiving lakes and streams causes bioaccumulation in living organisms. Commonly encountered metals of concern include Pb(II), Cu(II) Zn(II), Co(II), and Ni(II) etc. These metals are toxic in both their chemically combined forms as well as the elemental form and cannot be metabolized by the body and get passed up in the food chain to human beings (Innocent Oboh et al., 2009). Exposure to these contaminants present even in low concentrations in the environment can prove to be harmful to the human health (Arivoli et al., 2010, Bernard et al., 2013, Ayyappan et al., 2005).

A conventional method for removing metals from industrial effluents includes chemical precipitation, coagulation, solvent extraction, electrolysis, membrane separation, ion – exchange and biosorption. Most of these methods suffer with high capital and regeneration costs of the materials. Therefore, there is currently a need for new, innovative and cost effective methods for the removal of toxic substances from wastewaters (Fu and Wang, 2011, Bansal et al., 2009, Jafa and Balasubramanian, 2010, Tangjuank et al., 2009, Alinnor, 2007).

Bio-sorption is an effective and versatile method and can be easily adopted in low cost to remove heavy metals from large amount of industrial wastewaters. Recent studies have shown that heavy metals can be removed using various plant materials (Upatham et al., 2002, Dupont et al., 2003 and Bai et al.,2001). The aim of present work is to study the removal of Lead (Pb) ions by using the biocarbon of *Ocimum sanctum* from synthetic solution, and the maximum biosorption capacity of biocarbon was evaluated.

Materials and Methods

Metal solution

Synthetic wastewater samples were prepared by using analytical grade lead nitrate. For pH adjustment throughout the experiment, 0.1 N Hydrochloric acid and/or sodium hydroxide solutions were used as necessary. The stock solutions contained 100 mg/l of Pb(II).

Biocarbon preparation

Ocimum sanctum plant leaves were collected and air dried for 48 h. The dried leaves were grounded in ball mills and the screened homogeneous powder was used for the preparation of biocarbon. Activated biocarbon of the *Ocimum sanctum* was prepared by treating the leaves powder with the concentrated sulphuric acid (SG 1.84) in a weight ratio of 1:1.8 (biomaterial: acid). The resulting black product was kept in an air-free oven maintained at 160±5 °C for 6 h followed by washing with distilled water until free of excess acid, and then dried at 105±5 °C. The particle size of activated carbon between 85 and 130 µm was used. Batch experiments were performed at 30±2 °C. The samples were mechanically agitated at 200 rpm. The concentrations of Lead are estimated using ICPES. The proportion of heavy metal removed from solution was calculated from $(C_0 - C_e)/C_0$ where C_0 and C_e are, respectively, the initial and final concentrations of heavy metal. The amount of adsorbed metal ions per unit mass of biocarbon was obtained from $q_e = (C_0 - C_e)$ V/m, where V is the volume of the aqueous solution, and m is the mass of biocarbon (Singanan, 2011).

Results and Discussion

In batch experiments, the influence of pH, dosage of biocarbon, contact time and initial metal ion concentration on the removal of Pb(II) ions on the surface of biocarbon of *Ocimum sanctum* was studied.

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Effect of pH

pH is an important parameter for the removal of metal ions from aqueous solution on a biocarbon support. In the present study, it is observed that, a quantitative removal of lead ion over the pH range 2 – 6 (Fig. 1). Percent removal of lead increases sharply and almost attains maximum (87.5%) at pH 5.5, there after it shows decreasing trends. The increase is partly attributed to the formation of different hydroxo species in the solution at a higher pH. The other important factor, which might contribute to the higher biosorption of metal ions with increased pH the metal species are more easily attracted by the negatively charged surface of biocarbon, favouring accumulation of metal species on the surface and thus promoting biosorption (Faria et al., 2004, Yupeng Guo et al., 2005). The main biosorption mechanism is an ion exchange type for the biosorption of lead on biocarbon matrix.

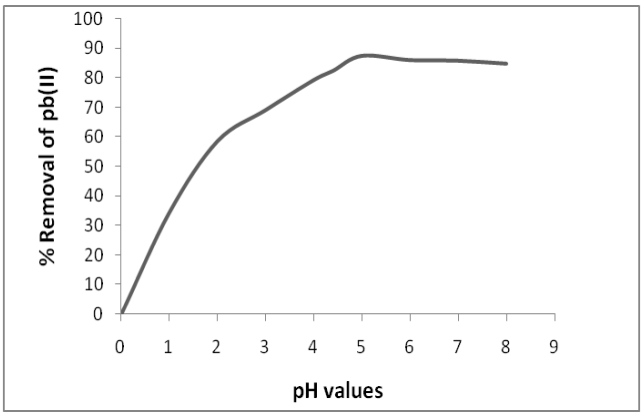

Fig 1. Effect of pH

Effect of amount of biocarbon

To study the effect of amount of biocarbon on percent biosorption 0.5g to 3 g of biocarbon was equilibrated with 100 mg/l of Pb(II) solution. It is well observed that, the percent removal of metal ion increases progressively with the increase in amount of biocarbon dose (Fig. 2). The biosorption rate is significantly higher (87.5%) at the biocarbon dose of 2.5g/100ml. The continuous uptake of metal iuon on the biocarbon matrix might be due to the availability of larger the surface area. This appears to be due to the increase in the available binding sites on the biomass surface for the complexation of the heavy metals. This would probably explain the high percent removal of the heavy metals in aqueous solution (Gong et al., 2005).

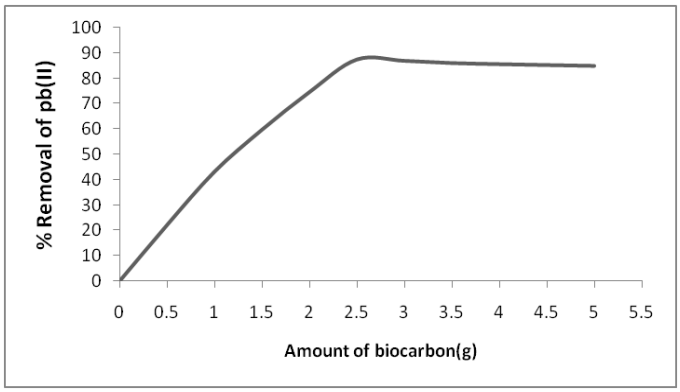

Fig 2. Effect of amount of biocarbon

Effect of Contact time

Kinetic studies play a greater role in the removal of metal ions from the aqueous solution. The percentage of removal of metal ions present in the aqueous solution increases with increase in time. It is observed that the rate of biosorption increased significantly for the metal ions present in the aqueous solution at the contact tome of 150 min (Fig 3). The fast uptake of metal ions Pb(II) in aqueous solution is certainly related to the availability of active sites on biocarbon surfaces (Saeed et al, 2005). The preferential attachment of Pb(II) is related to atomic sizes of the cations and released by the biocarbon. In case of Pb(II) ions removed was nearly 87.5% for optimum contact time to attain equilibrium with biocarbon. Similar results also reported by Singanan, 2011.

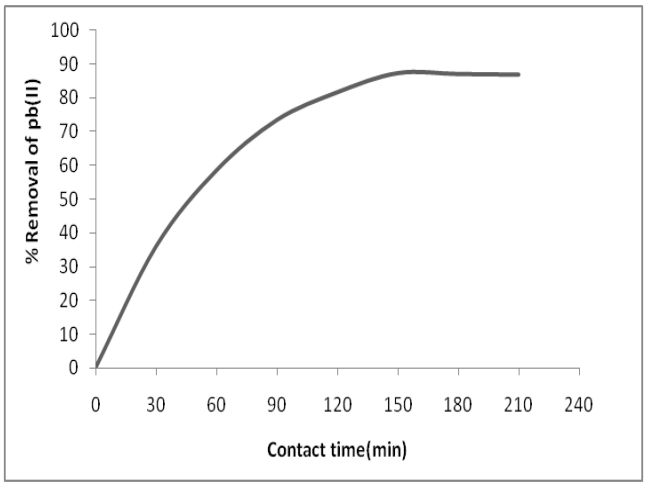

Fig 3. Effect of contact time

Effect of initial concentration

To evaluate the effect of initial metal ion concentration on biosorption behavior of Pb(II), studies were conducted with initial concentration of 50, 75 and 100 mg/l with biocarbon dose of 2.5 g/100ml. From (Fig 4) it is clear that when the initial concentration of metal ions is increased from 50 to 100 mg/l, the amount of metal uptake per unit weight of the biocarbon (mg/g) increases whereas the percentage biosorption decreases. This can be explained in terms of relatively lesser number of active sites at higher concentration of metal ions (Krishnan and Anirudhan, 2002; Ahmed et al., 2003) that, percent biosorption decreased with increase in initial lead ion concentration, but the actual amount of lead ion adsorbed per unit mass of carbon increased with increase in metal ion concentration. It means that the biosorption is highly dependent on initial concentration. It is because of that at lower concentration, the ratio of the initial number of lead ion to the available surface area is low subsequently the fractional biosorption becomes independent of initial concentration.

However, at high concentration the available sites of biosorption becomes fewer and hence the percentage removal of lead ion is dependent upon initial concentration of lead ion. At contact time biocarbon dose (2.5g/100ml) the aqueous solution by bio carbon removal was 87.5%. At higher concentration the heavy metal ions are relating higher compound to availability of biosorption sites.

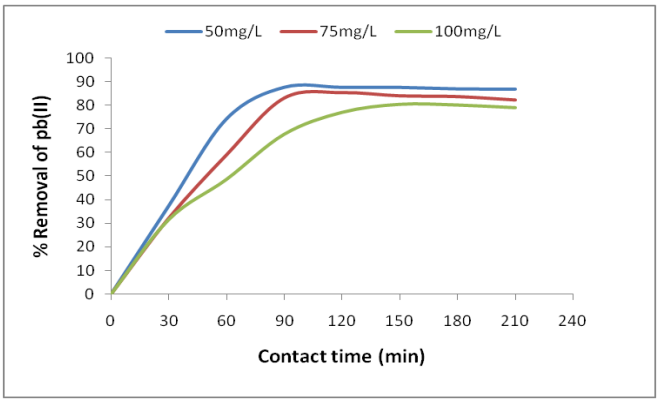

Fig 4. Effect of initial metal ion concentration

Conclusions

From the biosorption results, it is observed that, the maximum percent removal of lead ion was achieved at the contact time of 150min. It is also noted that, the fractional biosorption becomes independent of initial concentration. However, at high concentration the available sites of biosorption becomes fewer and hence the percentage removal of lead ion is dependent upon initial concentration. The best biosorption were obtained under the condition of 2.5g/100ml lead ion concentration and original pH solution was 5.5. *Ocimum sanctum* plant material has the potential for use as biocarbon for the removal lead ion from aqueous solution.

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