International Journal of Multidisciplinary Research and Development
Online ISSN: 2349-4182, Print ISSN: 2349-5979, Impact Factor: RJIF 5.72
www.allsubjectjournal.com
Volume 3; Issue 6; June 2016; Page No. 276-278

Removal of lead (Pb) ions from aqueous solution using dried biomass of brown algae, *Sargassum*

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Abstract

Increasing level of heavy metals in water represents a serious risk to human health and ecological system. Lead (Pb) is one of the metals that are extremely toxic to organisms even at low concentration. Biosorption is a biotechnical innovation and reliable method to remove Pb from solution using dried biomass of brown algae as adsorbent. The present work represents the biosorption of Pb from aqueous solution onto the biomass of *Sargassum* as a function of pH, temperature, biosorbent dosage and contact time. Results shows that maximum sorption was found at pH 5.0, contact time of 60 min, temperature 25°C and dosage of 2.0 gm. Thus if above mentioned condition is provided S*argassum* is considered as an ecofriendly, cost effective and potential adsorbent for biosorption of lead from aqueous solution.

Keywords: Heavy metal, Biosorption, Brown algae

1. Introduction

Environmental pollution has become a key focus of concern for all the nations worldwide. Among all the environmental pollution, pollution of water resources is a matter of great concern. Increasing contamination of aquatic sources with large number of pollutants is not only endangering aquatic biota but creating a worldwide shortage of recreational waters [1].The major culprit causing pollution of water resources are different industrial units. Haphazard discharge of toxic chemicals through effluents from a wide range of industries like textile, steel, oil, tanneries, refineries, canneries, mines, fertilizer production units, detergent production units, and electroplating units and sugar mills into aquatic bodies pollutes these resources and causes hazardous effects on flora and fauna [2, 3, 4, 5].

Heavy metal pollution is very hazardous and a serious ecological problem as these are non- biodegradable and persist in environment. So there is an urgent need for these pollutants to be removed from industrial wastes. According to [6] Volesky's ranking of metal Zn, Pb and Cd are three of the most hazardous heavy metals which need to be removed from the environment.

The toxicity of lead is very high even at low concentration. It can damage the nervous system, gastrointestinal track, encephalopathy with pre-treatment damage, kidneys and reproductive system particularly in children [7]. Lead pollution occurs in aquatic bodies from various industries that work with car batteries, sheets of semi-finished metal, and additives in gasoline, ammunition and scrap iron from car batteries [8].

Various conventional technologies like chemical precipitation and filtration, chemical oxidation or reduction, electrochemical treatment, evaporation, reverse osmosis, electro dialysis, solvent extraction, and activated carbon adsorption are commonly used techniques for removal of heavy metals [9, 10, 11, 12, 13]. However these technologies do not remove metals completely, and are quite costly process and requires high reagent and energy requirements [14].

Thus Biosorption is found to be economically feasible and environmental friendly technique to use. It has major advantage in removing heavy metals of extremely low level using inexpensive biosorbent. Biosorption involves using biological material to remove metal or metalloid species, compounds, and particulates from aqueous solution [15].

There are many materials which can be used as biosorbent for removal of heavy metals like cotton, wool, bacteria, fungi, chitosan, algae, etc. The selection of bisorbent for the bisorption depends on factors like number of binding sites, accessibility of sites, chemical state of sites, and affinity between site and metal [16]. Among all, an alga is an interesting biosorbent due to its high sorption capacity and low cost and easy avaibility from all kinds of aquatic bodies [17, 18]. Algae are found to posses all the above advantages for an excellent biosorbent and are thus used.

Of red, green and brown algae, brown algae have been found to have better sorption capacity due to its higher uptake capacity compared to other two. It shows potential for the recovery of heavy metals from liquid effluents due to its physicochemical characteristics, apart from its low cost and high capacity to accumulate heavy metals when compared to ion-exchange resins and other adsorbent materials [19].

The main polysaccharide in *Sargassum* seaweed is alginic acid, a polymer containing β-1,4 manuronic acid (M) associated to α-1,4 guluronic acid (G). The M/G content in different brown seaweeds may vary under different environmental conditions and with different species, with both monomers able to accumulate heavy metals [8].

Brown algae have been selected for present study in order to explore its biosorption capacity of heavy metals especially lead.

2. Materials and methods

2.1 Algal collection and biomass preparation

Fresh *Sargassum sps*.were collected from Veraval coastal area in Junagadh district of Gujarat. Algal material was brought to the laboratory in polythene bags. They were cleaned washed and dried in sun for a day. After that it was dried in oven at 60°C. The dried algal biomass was shredded ground in a mortar and sieved. An average size of 500-600µm was used for biosorption. This powered biomass was stored in plastic air tight container at room temperature. This powder was later used in Biosorption.

2.2 Preparation of metal solution
Metal solutions stocks of 100 ppm were prepared using salts like Pb $(NO_3)_2$ .These solutions were kept at 25°C. Concentration of 10 ppm from these salts was used as adsorbent for algal biomass. The pH of solution was adjusted to required value (2.0 to 6.0) using 0.1M NaOH and acetic acid.

2.3 Batch Sorption
Batch experiment was carried out in 250 ml flasks containing required amount of algal biomass and 50 ml each of metal solution. Different initial pH (2.0 to 6.0) and different temperature range (25° C to 50° C) was used for each solution. The flask were placed in a shaker with constant shaking at 150 rpm for different time interval for 20', 40', 60', 80' and 100'. After desired time interval the biomass was separated by filtering the content using Whatman No.1 filter paper. The amount of metal adsorbed on the biosorbent was calculated from the difference between the metal ion concentration in the solution before and after the biosorption process. The initial and final concentration of the solution was measured using AAS.

2.4 Effect of temperature
Biosorption experiment was set up with different temperature range from 20 to 50 °C. Using 50 ml of 10ppm Pb solution and studied.

2.5 Effect of Biomass concentration
Biosorption experiment was set up with different concentration of biomass from 0.5 to 3.5 gm. Different concentration of biomass was added in 50 ml flask containing 10 ppm of Pb solution. Then the flasks were kept on shaker and maximum sorption rate was determined from the study and were analyzed for metal concentration through AAS.

2.6 Effect of pH
Biosorption experiments were carried out at different pH ranging from 2.0 to 6.0. Effect of pH was carried out with *Sargassum* biomass as biosorbent. The experiment was set up using desired biomass of *Sargassum* in 50 ml of metal solution having 10ppm concentration. Optimum pH giving maximum metal removal was determined from this study.

2.7 Effect of contact time
In order to study the effect of time on the Biosorption process, the agitation period was varied from 0 to 100 min using desired biomass in 50 ml of metal solution (10 ppm) adjusted to appropriate pH. The samples were removed after every 10 min interval and filtered and analyzed for metal concentration on AAS.
Once one parameter was optimized it was kept stable and next parameter was optimized.

3. Determination of Lead Ions in the Solution
Biosorption experiment were carried out and used in analysis. The % Biosorption of metal ion was calculated as follows,

$$\text{Biosorption (\%)} = \frac{Ci - Cf}{Ci} * 100$$

Where,
Ci = initial metal ion concentration,
Cf = final metal ion concentration.
An atomic absorption spectrophotometer was used to determine the amount of lead present in the aqueous solution before and after equilibrium was established.

4. Results and Discussion
4.1 Effect of temperature
From figure: 1 it is clear that maximum uptake of 48% lead was obtained at 25°C.

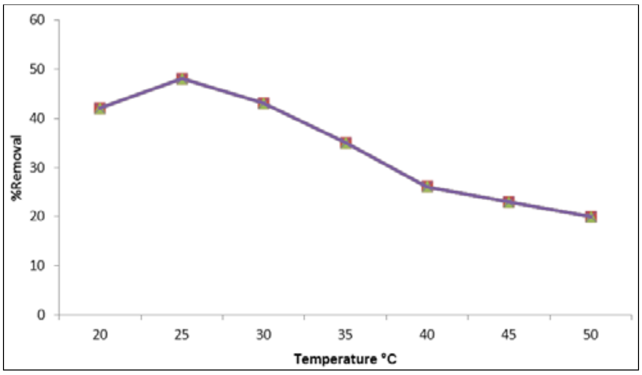

Fig 1: Effect of temperature on biosorption of lead using *Sargassum sps.*

The temperature profile indicates that as the temperature increases the sorption capacity increases to a maximum value and then decreases. Maximum sorption was found at 25°C. This is because biosorbent loses its properties at very high temperature due to denaturation.

4.2 Effect of biomass
From the figure: 2 it is clear that maximum biosorption of 53% lead occurs at 2.0 gm of biomass concentration at 25°C.

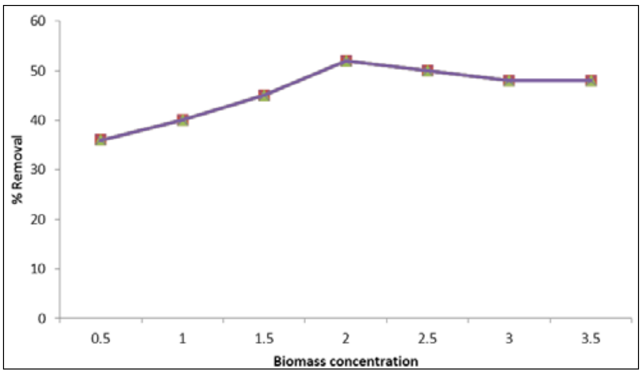

Fig. 2: Effect of biomass concentration on biosorption of lead by *Sargassum sps.*

For biosorption of lead the biomass concentration selected was 0.5 to 3.5 gm per 50 ml of 10ppm of lead solution. The maximum sorption biomass concentration was at 2.0 gm. The percentage uptake of lead by biomass was found to be decreased gradually with increased concentration greater than 2.0 gm. It has been suggested that electrostatic interaction between cells can be a significant factor between biomass concentration and metal sorption. Thus, lower the biomass concentration in suspension, the higher will be the metal/

biosorbent ratio and metal retained by sorbent unit, unless the biomass reaches saturation.

4.3 Effect of pH

For Biosorption of lead the pH selected was 2.0 to 6.0,the reason behind taking such pH range is as most of industrial effluents containing heavy metals are acidic [20].

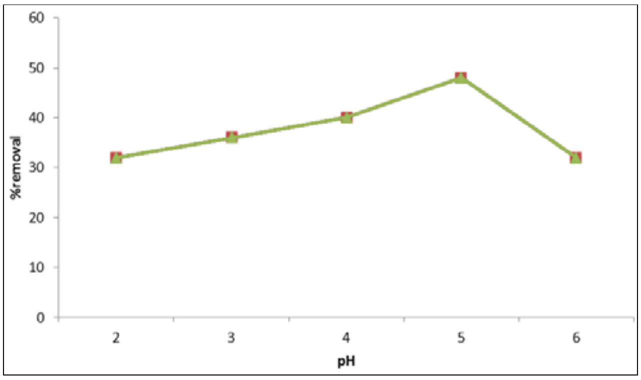

Fig. 3: Effect of pH on biosorption of lead by *Sargasum sps*

In the present study maximum sorption of lead occurred at pH 5.0.using 2.0g of biomass at 25°C. As the pH increases (2 to 6) adsorption capacity increases and maximum removal of 48% is observed at the pH 5.0. At the pH higher than 5.0 the adsorption capacity decreases.

4.4 Effect of contact time

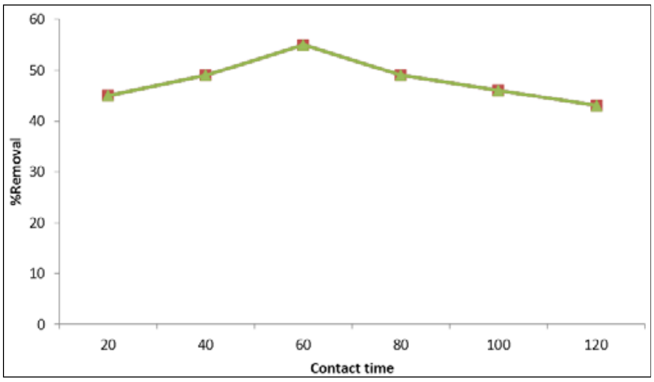

Fig. 4: Effect of contact time on biosorption of lead by *Sargassum sps*.

Contact time of 1 hour i.e 60 min was found to be optimum for the biosorption of lead metal using *Sargassum* as a biosorbent biomass of 2.0 gm and at 5.0 pH with 25°C temperature.

5. Conclusion

Based on the results obtained the biomass of brown algae *Sargassum* was found to be a potential low cost adsorbent for the removal of lead from aqueous solution. It can be concluded that the dried biomass of *Sargassum* has affinity towards heavy metal lead when provided with optimum pH, temperature, biomass and contact time.

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