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Research Article

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Biosorption of Zn (II) from aqueous solution onto the Alexandrian laurel oil cake

Ajitha R.[1], Meena Devi V. N.[*1] and Murugan M.[2]

[1]Department of Physics, Noorul Islam Centre for Higher Education, Noorul Islam University, Kumaracoil, Tamilnadu, India
[2]Department of Biomedical Engineering, Noorul Islam Centre for Higher Education, Noorul Islam University, Kumaracoil, Tamilnadu, India

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ABSTRACT

The toxic heavy metals are released in the environment due to rapid industrialization and urbanization processes and are a great threat to environment. Adsorption is an effective technique for the removal of heavy metals from the aqueous solutions. Now a day various natural adsorbent have been used by many researchers as a cheaper method for the treatment of water. In the present study the Alexandrian laurel oil cake is used as the adsorbent for the removal of Zn (II) from the aqueous solution. The parameters studied include contact time, adsorbent dosage, initial concentration, and pH. The Zn(II) removal was attained using 3g adsorbent for 60 minutes with initial concentration of 3g/L and pH6. These findings concluded that Alexandrian laurel oil cake is a suitable for removing Zn(II) in heavy metal polluted water.

Key words: biosorption, heavy metals, Zinc, oil cake

INTRODUCTION

With the advent of the industrial revolution and the advancement of scientific technologies, the incidence of environmental pollution has also increased. Different industrial processes contribute to this environmental degradation. In the last few years, heavy metal pollution has become a matter of serious concern[1]. Heavy metals are one of the major pollutants in the environment, when the tolerance levels are exceeded. Heavy metals in the environment have been a major preoccupation for researchers in the recent years due to their toxicity toward human beings, aquatic life and environment. At present it is very important to protect the environment from such an effect [2].The need to immobilize the heavy metals released into the environment through various anthropogenic activities is an important issue because the dissolved metals in the environment pose a serious threat to human and environment health. Therefore there is a need to remove the heavy metals already immobilized and to recover them for recycling purposes since the heavy metals are not biodegrade and their presence in industrial effluents and drinking water is a public health concern[3]. In general, there are many methods that have been applied for the treatment of these toxic metals. These include chemical precipitation, ion exchangers, chemical oxidation, reverse osmosis, electro dialysis, ultra filtration and biosorption etc [4-6]. Among this, biosorption is found to be an effective method for the removal of heavy metals. Biosorption is a physiochemical process that occurs in certain biomass, which allows it to passively concentrate and bind contaminants on to its cellular structure. The advantages of adopting biosorption are; the availability of the raw material either as wastes or by-products and at almost with no cost, there is no need for costly growth media, the process is very rapid as the material behaves as an anion exchange resin and metal loading is very high, the process is reversible and the metal can be desorbed easily and recycling of the materials is quite possible and the chemical or biological sludge is minimized [7].Various low cost adsorbents have been studied for the removal and recovery of toxic metals like Cr, Ni, Cu, Zn, Pb etc. Metallic Zinc is one of the most important metals which due to its relatively low melting point and is often found in effluents discharged from acid mine drainage. Zinc is toxic to animals, plants and microorganism when it is present at mill molar concentration levels although the metal as a trace element is an essential nutrient. The requirement of Zinc per day to the children is about 3mg, Teen age (boys &girls) about 11mg and 9mg and for adult stage (men &women) about 11mg and 8mg[8].

A number of workers have applied different biosorbent system for the removal of heavy metals. Various waste materials from plant derivatives and fruit-based by- products such as coke[9], olive[10], stones[11], pinewood[12], rice hulls[13], seed husks[14] and Pongamia oil cakes[15] have been reported for the removal of heavy metals from aqueous solution. Recently, the oil wastes have been tested as biosorbents for removal of the heavy metals [16]. In the present study, a new bio adsorbent namely the Alexandrian laurel oil cake is used as the solid biosorbent for the removal of heavy metals form aqueous solution. The oil cake is obtained as the by-product during the extraction of oil from the Alexandrian laurel seeds. The conversion of this waste oil cake into a useful biosorbent contributes not only to the treatment of heavy metals, but also to minimize the solid waste. In the present study, the biosorption effect and removal efficiency of Alexandrian laurel oil cake was studied. The biosorption parameters studied were includes various pH, time, dosage and initial concentration of the metal ion.

EXPERIMENTAL SECTION

Preparation of biomass

Alexandrian laurel oil cake used for the study was obtained from local oil mills, Nagercoil, Tamilnadu. The collected oil cakes were shade dried and impurities were separated manually. The biosorbent material was powdered using a mortar and pestle. The biosorbent was then sieved to get uniform size. The biosorbent oil cake was then stored in airtight containers for further use in the experiments.

Preparation of Zinc solution

A stock solution (1000 mg/L) of Zn (II) was prepared by diluting zinc chloride in deionized water. Zinc ion solution at different concentrations (1 – 5) g/L, were obtained by diluting the stock solution with deionized water. The pH of the solution was adjusted to the desired value using NaOH (0.1 M) and HCl(0.1 M) and monitored using electronic pH meter[17].

Batch Biosorption studies

Batch Biosorption experiments were carried out in 250ml of conical flask with 100ml volume of Zinc concentration of 1000mg/L. About 3g of biosorbent were added to the solution. The conical flasks were agitated at a constant speed 1600 rpm for 2min. The influence of pH(1, 3, 5, 7, 8), initial concentration(1, 2, 3, 4, 5(g/L)), biosorbent dosage (1, 2, 3, 4, 5 (g)), contact time (10, 20, 30, 40, 50 min) was evaluated during the present study. Samples were collected from the conical flask at predetermined time intervals for analyzing the Zn concentration in the solution. The amount of Zn absorbed in each flask was investigated using the colorimeter. Under the experimental conditions, the adsorption capacities of all the adsorbents for each concentration of metal ions at equilibrium were calculated using

$$Q_e = \frac{Co - Ce}{M} * V$$

where C_o and Ce are the initial and equilibrium concentrations of metal ions (in milligrams per litre) in the test solution, respectively, V is the volume of solution (in liter) and Mis the mass of adsorbent (in gram) used in the experiment. The biosorption capacity (q_e) of a biosorbent, which is obtained from the mass balance on the adsorbate in a system with solution volume V.

The percentage of Zinc removal efficiency was calculated using,

$$\text{Percentage of removal} = ((C_i \text{-} C_F)*100)/C_i$$

Where C_i-Initial concentration; C_f-Final concentration.

RESULTS AND DISCUSSION

Effect of pH

The most important single parameter influencing the sorption capacity is the pH of adsorption medium. This parameter is directly related to the competitive ability of the hydrogen ions over metal ions to win active sites on the biosorbent surface[18].

In the present work, the effect of pH on Zn(II) biosorption onto oil cake was carried out by varying the pH from 1, 3, 5, 7, 8. The result was presented in figure 1. At pH 1 (highly acidic) the biosorption was found to be negligible. This shows that at lower pH (pH 1), protons dominate to occupy only at surface of the oil cake. It has been generally reported that in highly acidic medium (pH = 1) the removal of metal ions is almost negligible and this increases by increasing the pH of the solution up to a certain limit [19]. The minimum biosorption at low pH is due to the fact that high concentration and high mobility of H^+ ions, the hydrogen ions are preferentially adsorbed rather than the metal ions [20].

In the present study, progressive increase in biosorption was observed from pH 2 to 8. The increase in pH causes a decrease in protons lowering the electrostatic repulsion between the oil cake surface and Zn(II) ions resulting a decrease in competition for Zn (II) to occupy the oil cake surface. The optimum biosorption was observed at pH 8 which remained constant. At this condition, an H^+ion prevail at high concentrations and competes with Zn^{2+} for binding onto the adsorbent's surface. In addition, positive charged surface due to either, protonation by H^+ ions or natural charge, will result in repulsion of Zn^{2+} ions from binding onto the adsorbent [22]. In precise, at higher pH values, the lower number of H^+ ions and greater number of ligands with negatives charges results in greater metal ions biosorption[20]. The pH of solution showed considerable influence on biosorption process. Alteration in metal speciation, biomass degradation and protonation/deprotonation of reactive surface groups might be some of the possible influences caused by solution pH on biosorption[21].

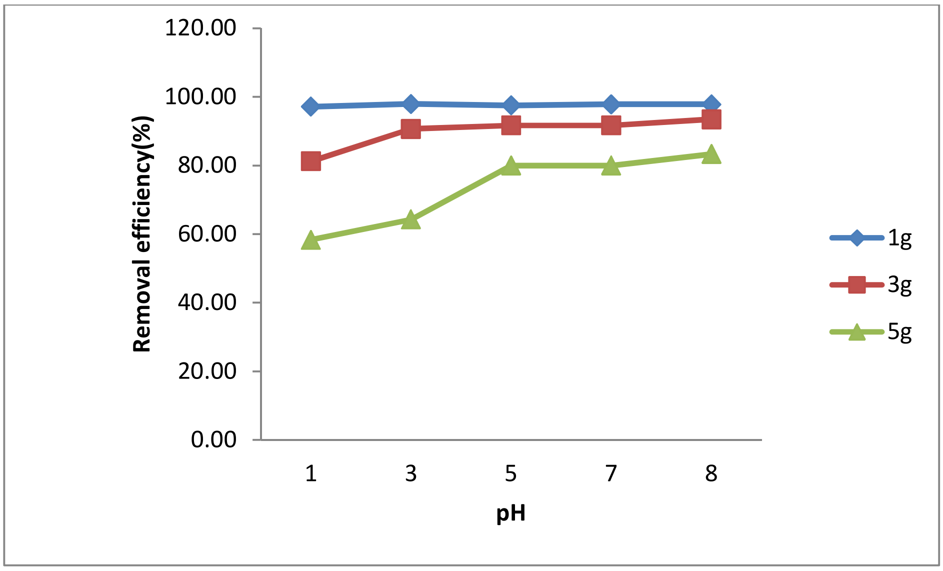

Fig 1: Effect of pH on Zn(II) adsorption onto Alexandrian laurel oil cake
(experimental conditions: Dosage=3g, Time=10 Sec, Initial conc. =1g/L, 3g/L, 5g/L)

Effect of Initial Zn(II) concentration

The initial concentration of zinc provides an important force to overcome all mass transfer resistance of metal ions between the aqueous and solid phases[23]. In the present work, the concentration of zinc (II) was varied from (1,2,3,4,5(g/L)) and for that the removal efficiency was found to be 98% (1g) to 85% (5g).The experimental result was given in figure 2. The result shows that the removal efficiency decreases as the concentration of the Zinc ion increases. The initial concentration gradient provides an important driving force which helps to overcome all mass transfer resistance of Zn(II) ions between the aqueous and solid phases, resulting in an increased biosorption capacity. At lower concentration, all Zn(II) ions present in the solution interact with the binding sites of sites of the biosorbent, facilitating about 98% biosorption. However all biosorbent have a limited number of binding sites, which become saturated at a certain concentration[24].

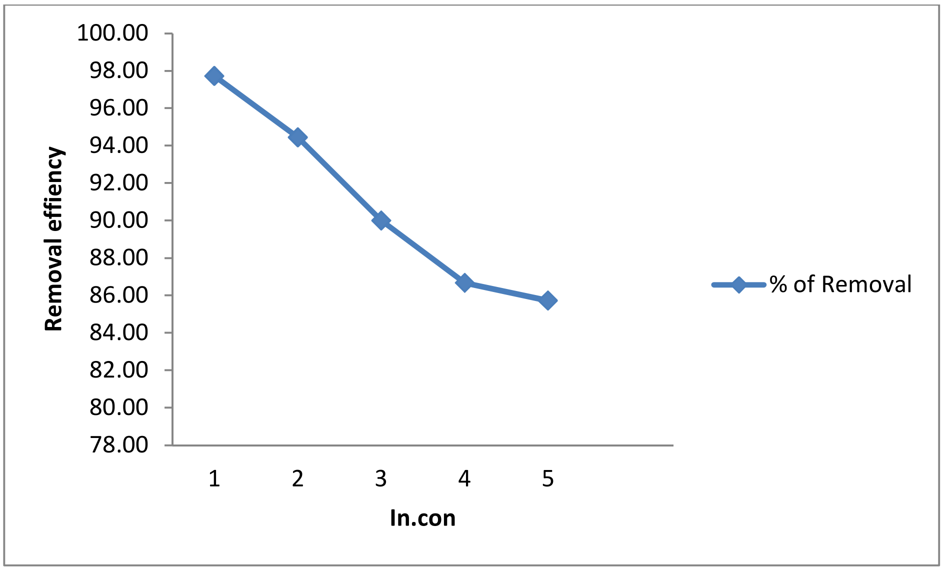

Fig 2: Effect of initial conc. On Zn (II) adsorption by Alexandrian laurel oil cake
(experimental conditions: Dosage=3g, Time=10 Sec, pH=6)

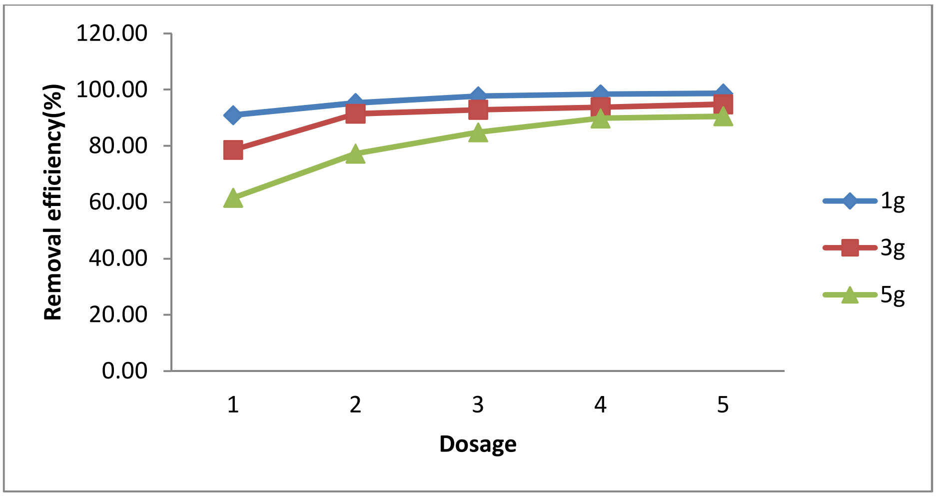

Fig 3: Effect of dosage on Zn (II)adsorption by Alexandrian laurel oil cake
(experimental conditions: pH=6, Time=30min,In.con=1g/L,3g/L,5g/L)

Effect of Biosorbent Dosage

The biomass dosage is an important parameter because this determines the capacity of a biosorbent for a given initial metal concentration [25]. In present work, the effect of dosage on the adsorption of Zn (II) onto solid biomass was carried for different dosage of oilcake (1,3,5(g))with initial concentration of Zinc as 3g/L, pH 6 and time interval of 10 min. The result was given in the figure 3. The result shows that the removal efficiency of biosorbentfor1g/L was found to be very less when compared to other dosages. But for the dosage of 3g/L and 5g/L, the removal efficiency was found to be more. This shows that as the dosage increases the efficiency was found to be increasing. This appears to be due to the increase in the available binding sites in the biomass for the complexation of Zinc. In the present study, the optimum dosage was found to at 3g for the oil cake as biosorbent for the absorption of Zn(II) from the aqueous solution.

Effect of Contact Time

Contact time is one of the important parameters for the successful use of biosorbents in practical applications and rapid sorption is among the desirable parameters [25, 26]. The adsorption data for the uptake of Zn(II) at various contact time(10,20,30,40,50)min for a fixed adsorbent dosage of 3g and with initial concentration of (1,3,5(g/L)) and with pH of 6 was carried out. The result was given in the figure 4. The experimental result shows that for 1g/L of initial concentration the adsorption was found to be less. As the concentration increases (3g/L and5g/L), the removal efficiency also increases from 55% to 80%. It was reported that the biosorption rate was higher in the initial stage, due to a larger surface area of the biosorbent being available for the biosorption of the metal ions[26].

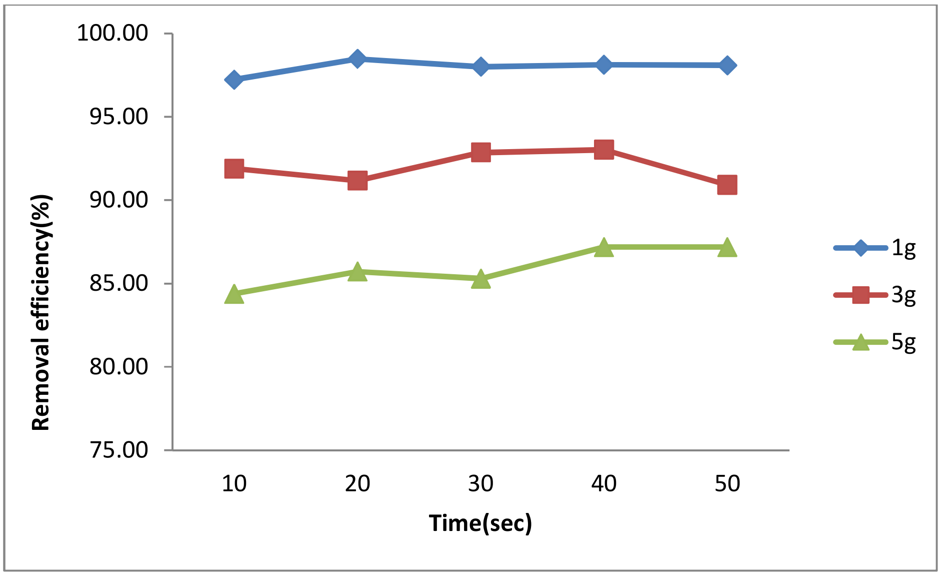

Fig 4: Effect of time on Zn (II) adsorption by Alexandrian laurel oil cake
(experimental conditions: Dosage=3g, In.con=1g/L3g/L,5g/L, pH=6)

CONCLUSION

The biosorption characteristic has been determined at various biosorption parameters that include pH, contact time, biomass dosages and initial concentrations. The present work shows that the Alexandrian laurel oil is a potential and inexpensive biosorbent for the removal of Zn(II) ions from an aqueous solution. The zinc adsorption increased with increase in pH values. The maximum biosorption was observed at pH 6. Thus, it can be concluded that oil cake should be a promising and cost effective biosorbent for treatment of Zinc wastes.

REFERENCES

[1] B Volesky.Biosorption of heavy metals. CRC,Boca Raton. **1990**.
[2] MNM Ibrahim;WS Wan Ngah; MSNorliyana,WR Dawood; M Rafatullah; O Sulaiman; MN Hashim Ibrahim.*Journal of Hazardous **Materials***__2010__, 377-385
[3] RKGautam; AMudhoo; G Lofrano;M Chattopadyaya.*Journal of EnvironmentalChemical Engineering;* **2014**, *239-259*
[4] JH Gardea-Torresdey,;KJTiemann,; ORodriguez;G Gamez.*J Hazard Mater* **1998**, 57:29-39
[5] JWPatterson.Industrial wastewater treatment technology. Butterworth Publishers, Stoneham, MA, **1985**.
[6] LIZhang;LIZhao; YYu;C Chen. *Water Res.*, **1998**, 32:1437-1444.
[7] JMMogak;KA Natarajan. *Miner metal Process*.,**1995** 12:189-196
[8] JTaniguchi; HHemmi; KTanahashi*ApplMicrobiolBiotechnol.*,**2000** 54, 581-588

[9] DWGreen; RGHardy;P Beri;CD Vickburg. Make activatedcarbon from coke. Hydrocarbon Process Int Ed,**1971**, 50(1):105–108
[10] JD Lopez-Gonzalez;F Martinez-Vilchez;F Rodriguez-Reinoso.*Carbon* **1980**, 18:413–418
[11] WTTsai;CY Chang; SY Wang;CF Chang; SFChien; HF Sun. *ResourConservRecy*.,**2001**, 32:43–53
[12] KSKim;HC Choi.*Water Sci Technol*.,**1998**,38:95–101
[13] AMWarhurst;GL McConnachie;SJT Pollard .*Water Res.*,**1997**, 31:759–766
[14] Nilanjana Das; R Vimala; P Karthika. Indian Journal of Biotechnology, **2008**, 7, 159-169.
[15] M Shanmugaprakash; VSivakumar; M Manimaran; JAravind.*Environ Prog Sustain Energy.*,**2013**, doi:10.1002./ep.11781
[16] UK Garg;MP Kaur;VK Garg;D Sud. *J Hazard Mater*.,**2007**, 140:60–68
[17] Abidin,; MA MohdSalleh;MY Harun; N Abu Bakar.Journal of Scientific and Industrial Research., **2014**,73; 191-194
[18] P Lodeiro;JL Barriada;R Herrero; ME Sastre de Vicente. *Environ Pollut*., **2006**, 142:264–273
[19] Nour T. Abdel-Ghani; Ghadir A. El-ChaghabyChaghaby. International Journal of Latest Research in Science and Technology.,**2014**, 3(1):.24-42.
[20] N Feng;X Guo;S Liang; Y Zhu; J Liu .*J HazardMater*.,**2011**,185:49.549
[21] A Yipmantin, HJ Maldonado;M Ly;JM Taulemesse; E Guibal.*J. Hazard. Mater*.**2011**, 185, 922–929
[22] X Tang;Z Li; Y Chen; Z Wang. *Desalination*, **2009**, 249, 49-57.
[23] WiwidPranata Putra, AzlanKamari,SitiNajiahMohdYusoff,CheFauziahIshak.*Journal of ncapsulation and Adsorption Sciences*, **2014**, 25-35
[24] H Pahlavanzadeh;R Keshtkar;J Safdari; ZAbadi. *J Hazard Mater*;**2010**, 175:304.10
[25] J Acharya;JN Sahu; CRMohanty; BC Meikap.*ChemEng J* **2009**, 149:249–262
[26] A Ozer; D Ozer *J Hazard Mater*., **2003**, 100:219–229
[27] Shanmugaprakash Muthusamy; Sivakumar Venkatachalam; Prasana Manikanda; Kartick Jeevamani;Nandusha Rajarathinam. *Environ SciPollut Res*., **2013**. DOI 10.1007/s11356-013-1939-8