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Biosorption of Zinc (II) Ions from Sugar Cane Effluent Using *Borassus Flabellifer* Fiber

S.K. Thiyakarajan[1], S. Jothi Ramalingam*[1], B. Ashok kumar[1],
T. Hidayathulla Khan[2], V. Thirumurugan[1]

[1]*PG & Research Department of Chemistry, A.V.V.M. Sri Pushpam College (Autonomous), Poondi, Thanjavur (Dt), Tamil Nadu, India.*
[2] *PG & Research Department of Chemistry, Khadir Mohideen College, Adirampattinam Thanjavur (Dt), Tamil Nadu, India.*

ABSTRACT : *The effective removal of heavy metals from the sugar industry is the most important issue of the many industrialized countries. Removal of* Zn^{2+} *from Sugar cane effluent where studied using borassus flabellifer fiber. Batch adsorption was performed as a function of pH, initial metal ion concentration, equilibrium time and bio-sorbent dose. The optimum pH obtained from results found to be 5. The maximum contact time for the equilibrium concentration is 60 minutes. The biosorbent dose is 6g. The maximum efficiency of removal of metal ion by bio-mass is 77 % .The results are fit exactly by both Langmuir and freundlich isotherm model.*

KEYWORDS: *Biomass; Biosorption; Isotherm; Kinetics; Removal of Zinc*

I. INTRODUCTION

The presence of heavy metal in the environment is one of the major content because of their toxicity and threat to human life. This toxic metal can cause accumulation poisoning, cancer and brain damage found above the tolerance level [1]. Several conventional method exist for the removal of heavy metal pollutants from waste water include chemical precipitation, coagulation, solvent extraction, electrolysis, membrane separation, ion exchange and adsorption[2]. But the high cost of the materials these method are not generally use. Therefore now a days a very innovative and cost effective methods are used for the removal toxic substance from waste water[3]. Bio-sorption of heavy metal from aqueous solution is an efficient technology in industrial waste water treatment[4,5,6]. This new technology has been loosely grouped together under the term biosorptions[7]. The recent studies has showed that heavy metals can be removed using a variety of low cost bio mass has been studied by various workers for controlling pollutions from the diverse sources in different part of the world[8]. They include agricultural materials rice brown, soya beans and cotton seed hulls, crop milling wastes ground net husk, maize cop meal, coir, jute and saw dust [9]. The most convenient means of determining metal uptake ability is through a batch reaction process. In the present study by modified waste PFF from sugar cane effluent to offer this biosorbents as local substitute for existing commercial adsorbent materials.

II. MATERIALS AND METHODS

2. 1. Collection and preparation of biomass

The *borassus flabellifer* fibers were collected from the road side of Sadayangal village, Valangaiman (T.k), Tiruvarur (Dt). The collected biomaterial is washed extensively in running water and deionized water to remove the dirt and other impurities. The dirt-free fibers were dried in the shade. Then the fiber was crushed using pulveriser. Then the fiber powders were sieved using 50 Mesh and fine biomass obtained was used as biosorbent without any pretreatment for adsorption.

2.2 Collection and analysis of sugar cane effluent solution

The raw effluent was collected from sugar cane industries, Thirumandankudi, Thanjavur District, India and transported to the laboratory in plastic can. The heavy metal analysis was carried out using Atomic Adsorption spectrophotometer (AAS, 6VARIO, Analystic Jenk, Germany)

2.3 Batch biosorption experiments

The affinity of biomass to adsorb Zn^{2+} ions was studied in batch experiments. In all sets of experiments fixed volume of Zn^{2+} solution (50ml) was stirred with desired biosorbent dose (6g) of 50 mesh size at 33+1oc and 650 rpm for 3 hours. Different conditions of pH (1, 2, 3, 4, 5, 6, 7), initial metal ion concentration (20.88 to 83.50 ppm) and contact time (15, 30, 45, 60, 75mins) with 30min increased were evaluated during study. The solutions were separated from biomass by filtrations through whatmann 40 filter paper. The Sugar cane effluent has Zn^{2+} roughly around 80 ppm. So the effluents are diluted for four different concentration and the batch equilibrium studies are carried out.

III. RESULTS AND DISCUSSION

EFFECT PH

The Batch equilibrium studies at different pH are studied from the range 1-7. They are presented in the Table.1 and Fig. 1 the graph is plotted using metal uptake mg/L to initial pH. The solution pH is one of the important variables governing biosorption materials by sorbents. It is found that the uptake of Zn^{2+} ion by biomass depend on pH.There is a steep increase up to pH 5 after that there is a gradual decrease, as seen in the graph of *borassus flabellifer* Fiber powder. It is interesting to note that fiber adsorbed Zn^{2+} ion at pH 6 is very high. The result shows adsorption of biomass depends on pH of medium. So pH 6 is optimized for this batch equilibrium studies.

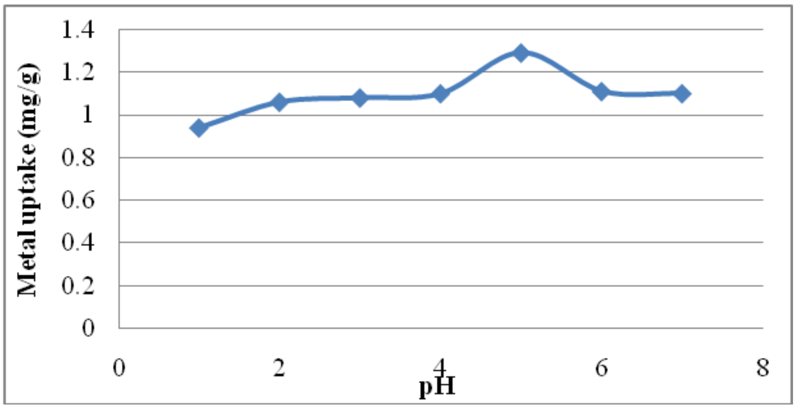

Fig. 1 Effect of initial solution pH of Zn^{2+} on the metal uptake, Time 60 min, Biosorbent dose 6 g/L, Volume of the solution 50 mL, Temperature 33 ± 1oc. using Borassus Flabellifer Fiber powder in sugarcane effluent.

3.2 Effect on biosorbent dose:

The effect of solid to liquid ratio on the Zn^{2+} is studied by keeping all other parameters constant ranging from 3 g/L to 15 g/L. This range of biosorbent dose is used to determine the suitable quantity of biomass for maximum sorption. The values are presented in the Table 2 and the graph is plotted for percentage removal efficiency against biosorbent dose is shown in the Fig. 2 for the biomass *borassus flabellifer* Fiber powder. It is evident from the graph that an adsorbent dose 7.5 g/L is sufficient to removal of Zn^{2+} metal by the biomass. From the observations it is interesting to note that further increment in sorbent did not cause significant improvement in the sorption.

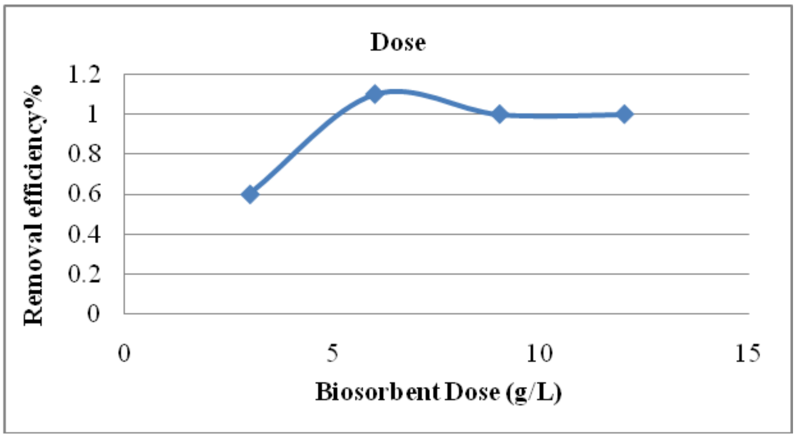

Fig. 2 Effect of adsorbent dose on removal efficiency (%) of Zn^{2+} Time 60 min , pH 5, Volume of the solution 50 mL, Initial metal ion concentration 20.88 mg/L, Temperature 33±1oc, using Borassus Flabellifer Fiber powder in sugarcane effluent.

3.3 Determination of Equilibrium time:

Equilibrium time is maximum time taken by the sorption experiment to achieve equilibrium after which no further metal uptake is adsorbed. The results for the determination of equilibrium time are given in the Table.3 and the graph is plotted for the biomasses and is shown in the

Fig. 3. It can be noticed from the graph that the contact time significantly affects the metal uptake. The metal sorption increases sharply for the biomasses individually in the first 60 min and then equilibrium approached according to the result.From the observation it is concluded that 60 min are sufficient for the sorption to attain equilibrium for *borassus flabellifer* Fiber biomasses.

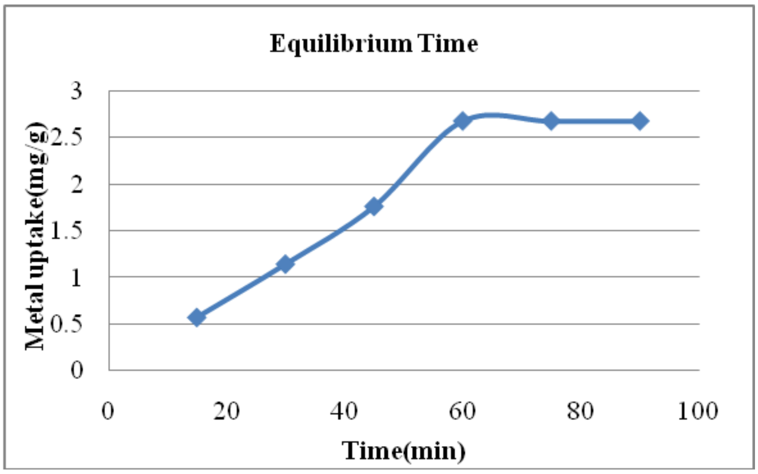

Fig. 3 Equilibrium time for Zn^{2+} biosorption, pH 5, Biosorbent amount 6 g/L, volume of the solution 50mL, Initial metal ion concentration 20.88 mg/L, Temperature 33±1oc, using Borassus Flabellifer Fiber powder in sugarcane effluent.

3.4 Effect of Initial metal ion Concentration:

The rate of sorption is function of initial concentration of metal ion which makes it an important factor to be considered for effective biosorbent. The initial metal ion concentrations provide driving force overcome mass transfer ions between aqueous and solid phase. The initial concentrations are changed in the range of 20.88 mg/L to 83.50 mg/L by keeping all other parameters constant. The results are shown in the Table.4 and Fig. 4. The sorption capacity increases with increasing initial metal ion concentration for Zn^{2+} for *borassus flabellifer* Fiber biomass.

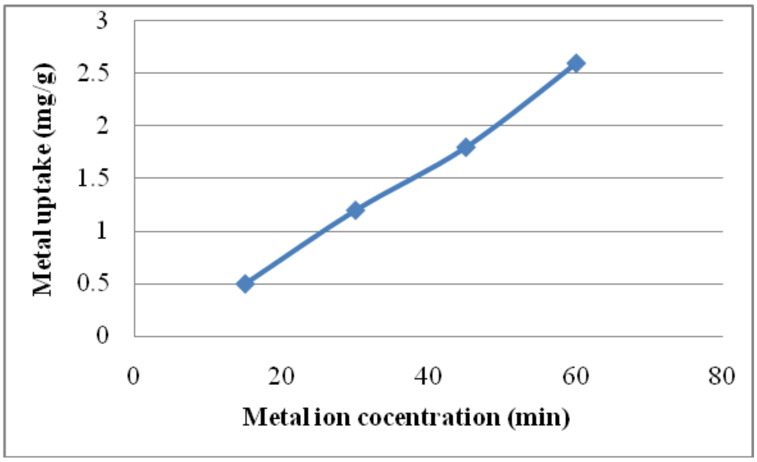

Fig. 4 Effect of initial metal ion concentration on biosorption of Zn^{2+}, Time 60 min, pH 5, Volume of the solution 50 mL, Biosorbent amount 6 g/L, Initial metal ion concentration 20.88 mg/L to 83.50 mg/L, Temperature 33±1oc, using Borassus Flabellifer Fiber powder in sugarcane effluent

3.5 Pseudo first order kinetic model

Generally kinetic models have been used to test the experiment data to investigate the mechanism of bio-sorption and potential rate controlling step such as mass transfer and chemical reaction process. The transistance behaviour of batch bio-sorption process is analysed using pseudo first order kinetic model.

The model is as below

$$\log (qe-qt)=\log qe-kt/2.303$$

Where qe is the mass of the metal ion adsorbed (mg/g) at equilibrium time,
qt is the amount of the metal ion adsorbed at time t (min-1),
k is the rate constant of adsorption.
The sorption coefficient and equilibrium capacity qe can be determined from the linear plot of log (qe-qt) versus time from the Table 5 for different concentrations of Zn^{2+} from the Figs. 5 to 8 for *borassus flabellifer* Fiber.

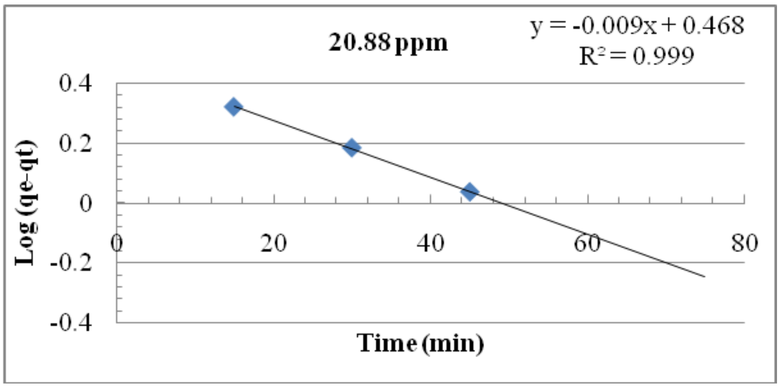

Fig. 5 Linearised pseudo-first order biosorption kinetics of Zn^{2+} for 20.88 ppm using *borassus flabellifer* Fiber powder in sugarcane effluent.

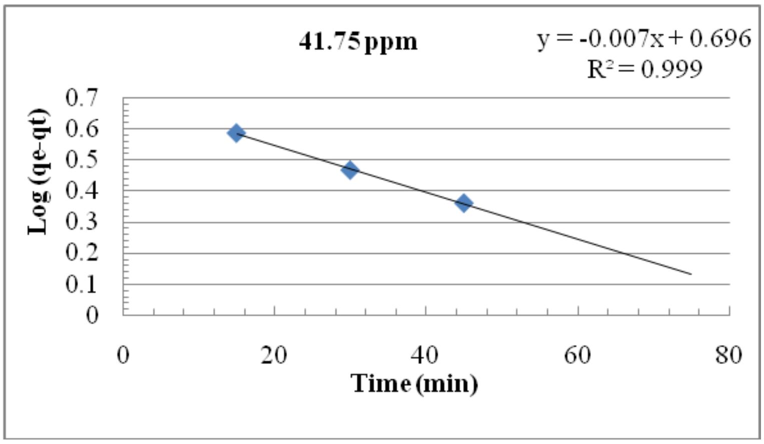

Fig. 6 Linearised pseudo-first order biosorption kinetics of Zn^{2+} for 41.75 ppm using *borassus flabellifer* Fiber powder in sugarcane effluent.

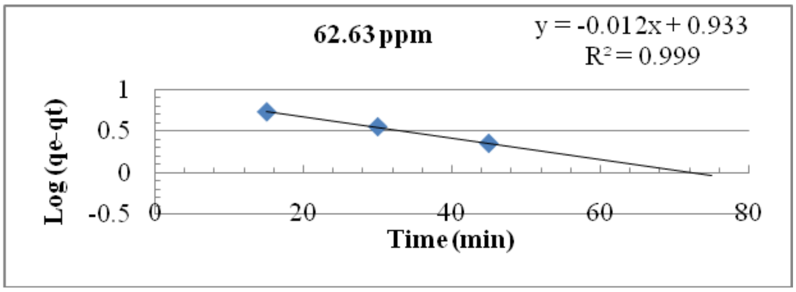

Fig. 7 Linearised pseudo-first order biosorption kinetics of Zn^{2+} for 62.63 ppm using *borassus flabellifer* Fiber powder in sugarcane effluent.

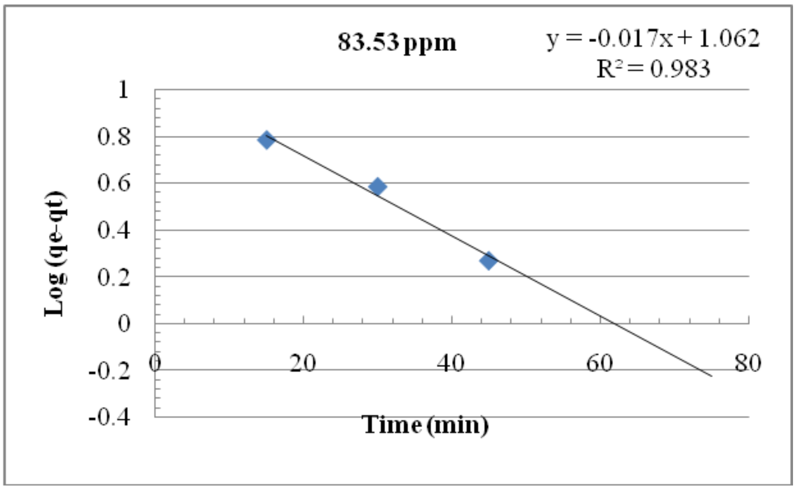

Fig. 8 Linearised pseudo-first order biosorption kinetics of Zn^{2+} for 83.50 ppm using *borassus flabellifer* Fiber powder in sugarcane effluent.

The results indicate that the metal ion concentration has known significant effect. The coefficient correlation R2 is approximately in the range of 0.98 to 1. This fact suggests the sorption of Zn^{2+} ion follows first order kinetic for *borassus flabellifer* Fiber biomass for the heavy metal Iron sugar cane effluent solution.
At different concentration of solution say 20.88, 41.75, 62.63 and 83.50 ppm. The slope K values are given in the Table 6.

Table.6 K values of Zn^{2+} from pseudo first order kinetics for 20.88 ppm to 83.50 ppm using Borassus Flabellifer Fiber powder in sugarcane effluent.

Metal ion Concentration (ppm)	K value min^{-1}
20.88	$0.9 X 10^{-3}$
41.75	$0.7 X 10^{-3}$
62.63	$1.2 X 10^{-3}$
83.50	$1.7 X 10^{-3}$

The k values are calculated from the slopes of the linear plots. These results indicate that the metal ion concentration has no significant effect in the rate of the reaction.Modelling the equilibrium data is fundamental for the industrial application of biosorption. Since it give information for designing and optimizing operating procedure. It is also helpful to comparing different biomaterial and different operating condition. To find the relation between aqueous concentration Ce and sorbed quantity qe at equilibrium mostly sorption isotherms model fitting data Langmuir and Freundlich widely used. Langmuir parameters can be determined from the linearized form of the equation given below

$$\frac{C_e}{q_e} = \frac{1}{q_{\max}} b + \frac{C_e}{q_{\max}}$$

where q_e is the metal ion adsorbed (mg/g),
C_e is the equilibrium concentration of metal ion solution,
q_{max} and b is the Langmuir constant.
The Freundlich model is expressed as

$$q_e = k_f C_e^{1/n}$$

Above equation can be rearranged into following form

$$\ln q_e = \ln k_f + \frac{1}{n} \ln C_e$$

where q_e is the metal ion adsorbed (mg/g),
C_e is the equilibrium concentration of metal ion solution (mg/L),

K_f and n are the Freundlich constant.

From the equilibrium batch studies the following optimising parameters can be arrived. *borassus flabellifer* Fiber reduce heavy metal Zn^{2+} at pH 5 in higher rate, the sorbent dose is best for 6 mg/L and the equilibrium attained at 60 min by keeping these parameter constant the following Freundlich and Langmuir isotherms are arrived in Fig. 9 and 10.

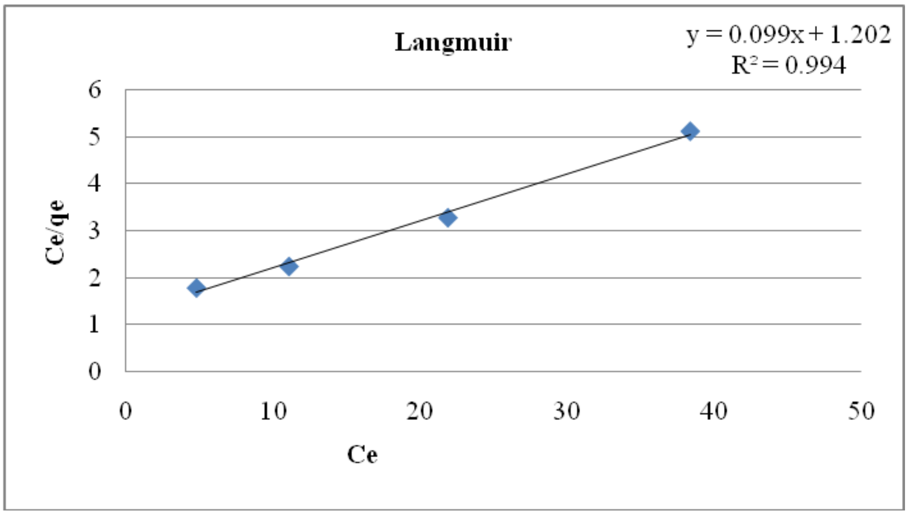

Fig. 9 Langmuir isotherm plot of Zn^{2+} adsorption on Borassus Flabellifer Fiber powder in sugarcane effluent.

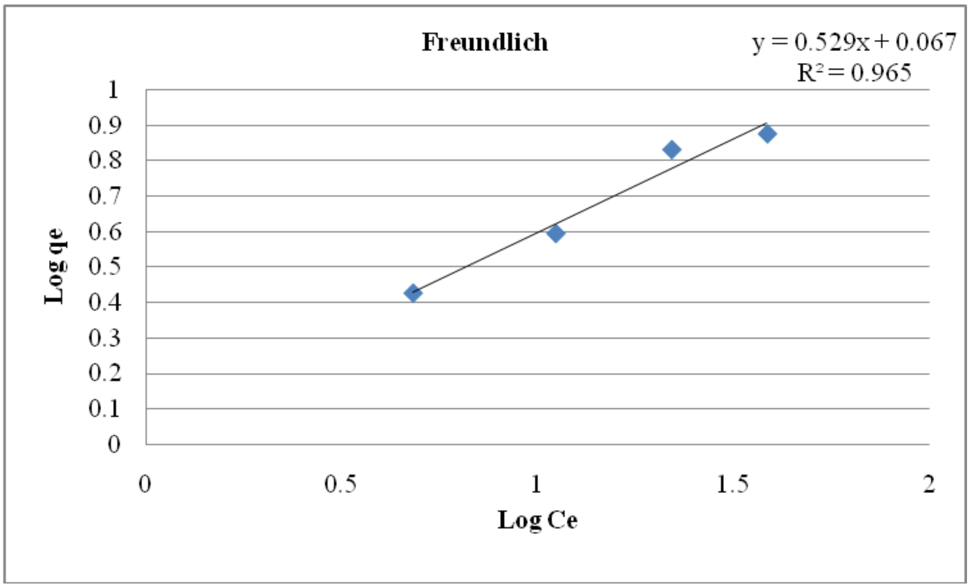

Fig. 10 Freundlich isotherm plot of Zn^{2+} adsorption on Borassus Flabellifer Fiber powder in sugarcane effluent.

IV. CONCLUSION

I. The effect of different factors on the sorption abilities of inexpensive fiber *borassus flabellifer* powder was studied for the removal Zn^{2+} from Sugar cane effluent solution. The following conclusion drawn from the present studies *borassus flabellifer* powder is a suitable material for Zn^{2+} adsorption. pH, Biosorbent dose, Equilibrium time and Initial metal ion concentration highly affect the over all metal uptake capacity of biosorbent. The sorption was pH dependent and sorption capacity increased in pH value upto 5. After that there is a decrease in sorption. The optimum time was observed to be 60 min. with sorption capacity of 0.8 mg/g. The optimum dosage was 6 g/L. Present result show that both Freundlich and Langmuir model fits better for the adsorption equilibrium data. In the examined concentration range 20.88-83.50 mg/L the results also reveals, it follows pseudo first order kinetic model. Hence *borassus flabellifer* powder can be used to remove heavy metal Zn^{2+} from the effluent. Engineering technologies can be developed by using the results of isotherm model for removal of effluent in most efficient way.

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