Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2015, 7(2):140-147

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Removal of Ni (II) from aqueous solutions using Sugarcane bagasse

M. G. Bhagyalakshmi and P. N. Sarma*

Bioengineering Environmental Sciences (BEES), Indian Institute of Chemical Technology, Hyderabad, Telangana State, India

---

ABSTRACT

In the present investigations sugarcane bagasse (SCB) was used as an adsorbent for Ni (II) removal from aqueous solutions. The influence of physico-chemical parameters such as the initial metal ion concentration, pH, contact time and adsorbent dosage was investigated in batch studies. Optimum experimental conditions were found to be pH 8.5, contact time of 60 min and adsorbent dose of 2.5 gm/150 ml at an initial metal concentration of 100 mgL^{-1} using standard samples. Maximum removal of Ni (II) (90.09%) was observed at 100 ppm. Studies on kinetics adsorption were carried out and the adsorption was found to fit in pseudo first order model. Reuse and regeneration of the adsorbent was also studied.

Keywords: Adsorption, Biosorption, Sugarcane bagasse, Nickel, Wastewater

---

INTRODUCTION

Heavy metals have a tendency to bio-accumulate and end up as permanent destructive elements in the environment [1]. Heavy metals like Pb, Cd and Ni are known to have toxic effects even at very low concentrations [2]**.** Nickel (II) is implicated as an embryotoxin and teratogen [3]. Higher concentration of Ni (II) causes poisoning effects like headache, dizziness, nausea, tightness of the chest, dry cough, vomiting, and chest pain, shortness of breath, rapid respiration, cyanosis and extreme weakness [4]. Ni (II) finds its way into the water bodies through effluents of silver refineries, zinc base casting and storage battery and electroplating industries [5]. Acceptable limit of Ni (II) in drinking water is 0.01mg/L and industrial discharge limit in wastewater is 2mg/L [6]. Harmful effects of Ni (II) necessitate its removal from waste water before release in to aquatic streams. Conventional methods for the removal of heavy metal ions from aqueous solutions are chemical precipitation, ion exchange, reverse osmosis and electrochemical treatment [7-9]. However those methods have limitations because they often involve high capital and operational cost and may also be associated with the generation of secondary wastes. Many authors used activated carbon [10] and natural adsorbents like activate carbon prepared from rice husk [11] and peat nut husk carbon [12]. Even though activated carbon is having high surface area, micro porous character, and high adsorption capacity for the removal of heavy metals from industrial waste water, it is expensive and relatively costly[13]. Removal of Ni (II) using adsorbents such as blast furnace slag [14], activated alumina [15] fly ash [16] was also investigated. Adsorption using biological materials provides an attractive alternative to physico-chemical methods for the removal of heavy metal ions [17]. Bio-sorbents such as apple waste [18] soybean and cottonseed husk [19] agricultural solid waste [20], peanut hull [21] and waste tea [22] maize cob [23] was used for the removal of heavy metals ions including Ni (II). In above studies removal of Ni (II) studied with active carbon from natural adsorbents, pretreatment with acids and lack of information about reuse and regeneration of bio-sorbent. In recent years, much attention has been focused on the removal of heavy metals using agricultural wastes. In an effort to evolve a useful user-friendly, eco-friendly and economical method for the removal of Ni (II) from aqueous solution the present study was taken up. In the present study, adsorption of Ni (II) using sugarcane bagasse as bio-sorbent was investigated. Kinetic studies and regeneration and reuse of the bio-sorbent were also studied. The results obtained are presented and discussed in this communication.

EXPERIMENTAL SECTION

2.1 Preparation of Sugarcane bagasse

Raw sugarcane collected from a sugar mill was sieved to the desired size and used for bio-sorption experiments. Bagasse is the fibrous residue of the cane stalk left after crushing and extraction of the juice. It contains fibre, water and relatively small quantities of soluble solids - mostly sugar. Sugarcane bagasse used in experiments is shown in Fig 1.

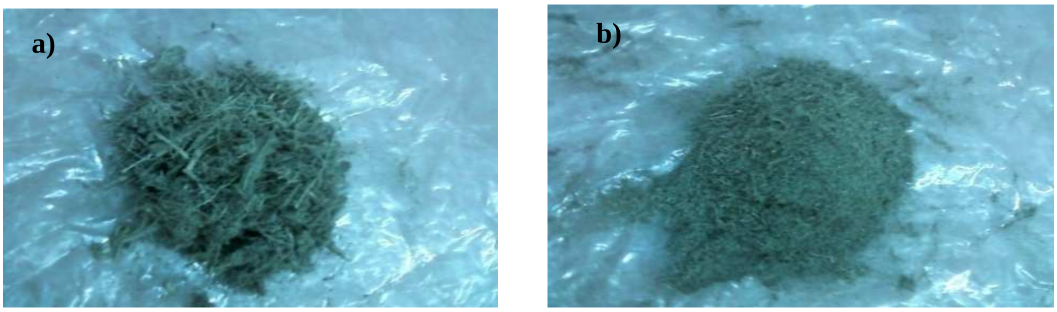

Fig. 1 Sugarcane bagasse used as bio-sorbent: a) Before sieved; b) After sieved

2.2 Preparation of Standard solution

Standard stock solution of Ni (II) 1000 ppm was prepared by dissolving 405.02 mg Ni (II) chloride in distilled water in a 1000 ml volumetric flask. The solution was then made up to 1000 ml and appropriate dilution of stock solution was done to get 100, 50, 25, 10 and 5 ppm of Ni (II). AR grade chemicals and double distilled water were used for all the analyses.

2.3 Batch Sorption Experiments

Batch sorption experiments were carried out in 250 ml conical flasks. 150 ml of stock solution was taken, pH was adjusted and a known amount of adsorbent was weighed and placed in a shaking incubator with constant shaking at 120 rpm and at a temperature 25^0 C. After separation the sample was collected by centrifugation and used to determine Ni (II) content by using atomic absorption spectrophotometer (AAS).

2.4 Optimization of Contact time`

Optimum contact time of the bio-sorbent for maximum adsorption was determined by carrying out experiments, keeping quantity of biomass and pH constant. The experiments were carried out for 8 hours and samples were drawn periodically for analysis.

2.5 Optimization of pH

Experiments were carried out for determining the pH at which maximum bio-sorption takes place by keeping the quantity of biomass and time of contact constant. The pH was varied from 6 to 8.5.

2.6 Optimization of biomass

Experiments were carried out to optimize the quantity of biomass by keeping the pH and contact time constant. The quantity of biomass was varied between 1.0-5.0 g for 150ml of test solution.

2.7 Instrumentation and analysis

Ni (II) content in all the experimental solutions was determined by AAS (Perkin Elmer GBC 932 AA). The extent of Ni (II) adsorbed was calculated from the difference in the concentration of Ni (II) in aqueous phase before and after adsorption.

2.8 TEM

Transmission electron microscopic (TEM) (Tecnai-12, FEI, and Netherlands) analysis of the bio-sorbent was done before and after adsorption to understand the adsorption of the metal.

2.9 Kinetics

Kinetics of adsorption was investigated in 250 ml flasks under optimized experimental conditions (2.5 gm of the adsorbent, 8.5 pH, time 60 min). 150 ml of Ni (II) solution was used for the experiments. The mixture was rotated at 120 rpm for 60 min (6nos). At 10 min time intervals, the flasks were removed from the shaker and the remaining concentration of Ni (II) in each sample was determined by AAS. Kinetics of adsorption was determined by drawing a graph by taking concentration of the metal Ni (II) on the x-axis and natural logarithm of the remaining concentration of Ni (II) on the y-axis.

2.10 Reuse

Reuse of the bio-sorbent after one use was also investigated. During the batch adsorption studies after experiments were carried out under optimized conditions the biomass was reused for 5 cycles by adding 150 ml of fresh Ni (II) solution to examine the efficiency of biomass at different concentrations viz; 100,50,25,10 and 5 ppm.

2.11 Regeneration

Regeneration of biomass was studied at different concentrations viz; 100, 50, 25 and 10 ppm to understand that how many times the biomass could be used. The biomass was washed 5 times with distilled water and a fresh Ni (II) solution was added every time. The removal efficiency of the bio-sorbent was determined.

RESULTS AND DISCUSSION

3.1 Optimization of time

Optimum contact time for the bio-sorption of Ni (II) on to sugarcane bagasse was carried out by taking 100 ppm Ni (II) solution. The quantity of the adsorbent was kept constant at 3.0 gm and the pH was maintained at 6.5. The experiment was carried out for 8 hrs. Samples were drawn at different time intervals and the remaining concentration of Ni (II) was determined by AAS. A graph was drawn by taking the time on the x-axis and the remaining concentration of Ni (II) on the y-axis (Fig-2). It could be observed from Fig-2 that maximum bio-sorption of Ni (II) was observed at 60 min contact time. No further increase in bio-sorption was observed with increase in time of contact. Therefore it was concluded that optimum time for bio-sorption was 60 min.

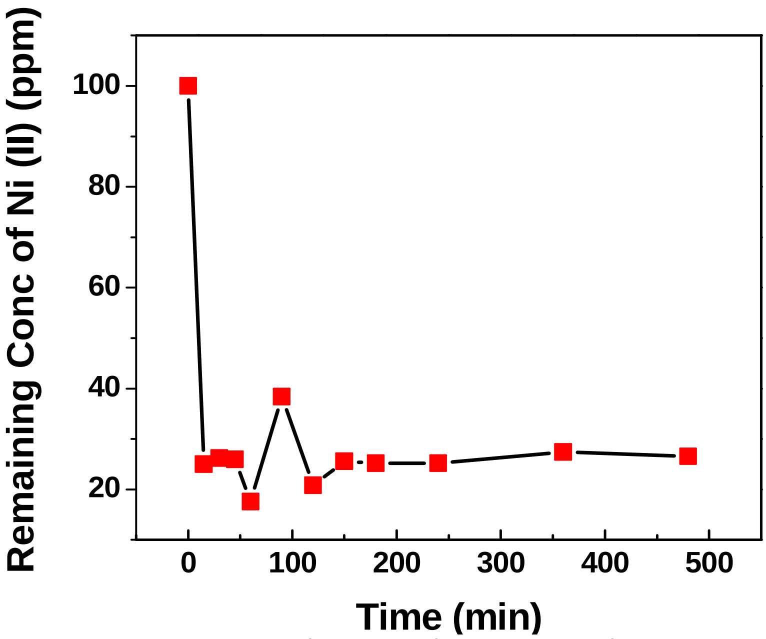

Fig. 2: Optimization of contact time for the adsorption of Ni (II)

(Initial conc.100mg/l, pH 6.5 and biosorbent dosage 3.0 g/150 ml)

3.2. Optimization of pH

pH is an important parameter for adsorption of metal ions from aqueous solution because it affects the solubility of the metal ions and the degree of adsorption. To find out optimum pH for the adsorption of Ni (II) experiments were carried out by taking 3.0 g of the bio-sorbent. 100 ppm Ni (II) solution (150 ml) was used for the experiments. The experiments were done for 60 min. contact time. The pH was varied from 6.0 to 8.5. Remaining concentration of Ni (II) was determined in the test solutions by AAS. The results obtained are shown in Fig-3. At pH 8.5 the maximum adsorption was observed.

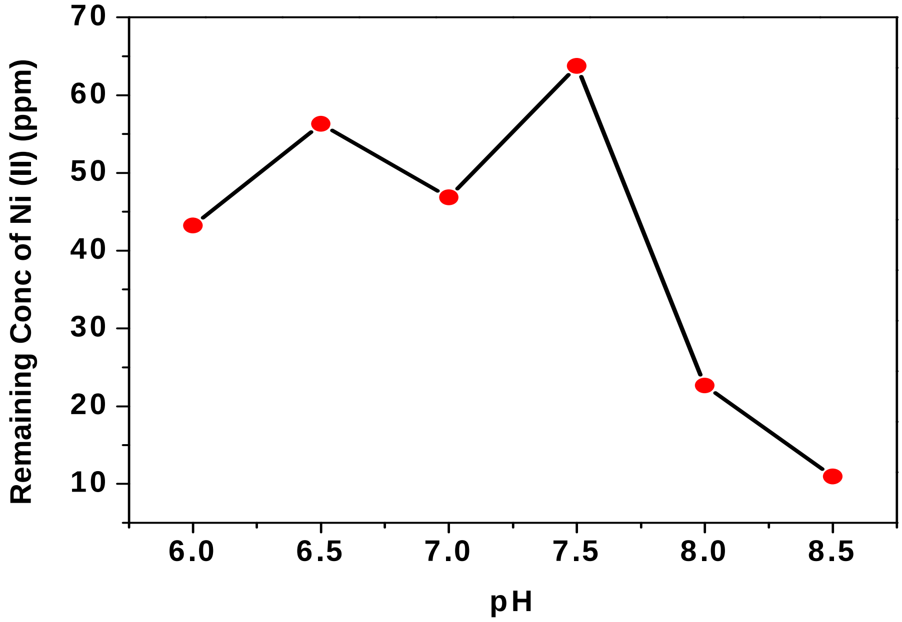

Fig. 3: Optimization of pH for the adsorption of Ni (II)
(Initial conc.100mg/l, contact time 60 min. and biosorbent dosage 3.0 g/150 ml)

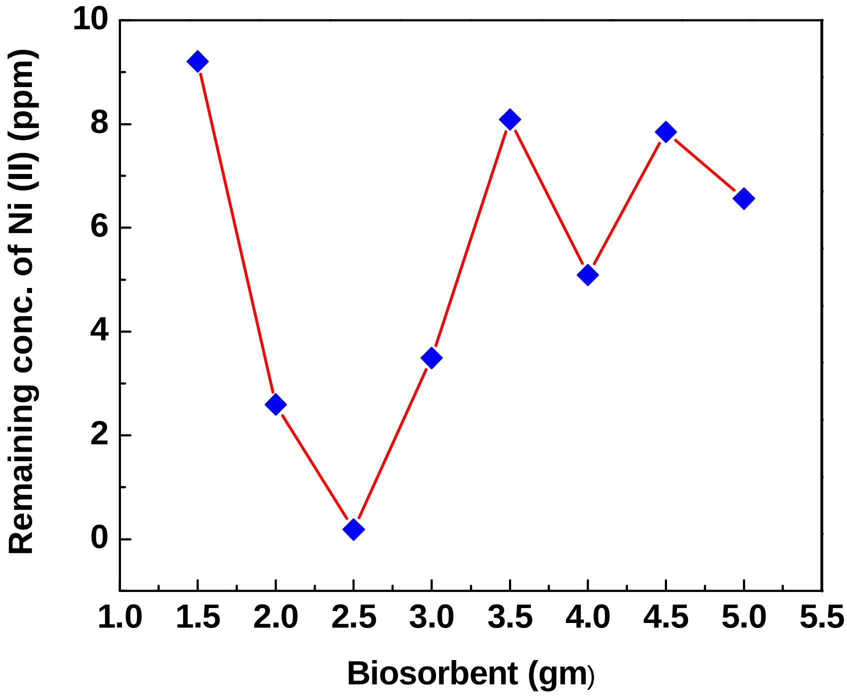

Fig .4: Optimization of bio-sorbent dose for the adsorption of Ni (II)
(Initial conc.100mg/l, contact time 60 min. and pH 8.5)

3.3. Optimization of quantity of bio-sorbent

The effect of bio-sorbent dosage was studied by varying the amount of adsorbent from 1.5- 5.0 gm. The adsorbent was added to 150 ml of Ni (II) solution of 100 mgL-1 concentrations and equilibrated for 60 min at pH 8.5. After the equilibrium time, the solutions were centrifuged and analyzed for the amount of Ni (II) and the extent of adsorption was estimated. The data in Fig.4 indicate that maximum removal was achieved with an adsorbent dose of 2.5 gm.

3.4. Analysis of different concentrations of Ni (II) solutions

Batch experiments were carried out by using 100,50,25,10 and 5 ppm Concentrations of Ni (II). The experiments were carried out under optimized experimental conditions. Samples were drawn at regular intervals of 30 min upto a maximum time of 90 min. Ni (II) content in each experimental sample was determined by AAS. The results obtained are given in Fig.5

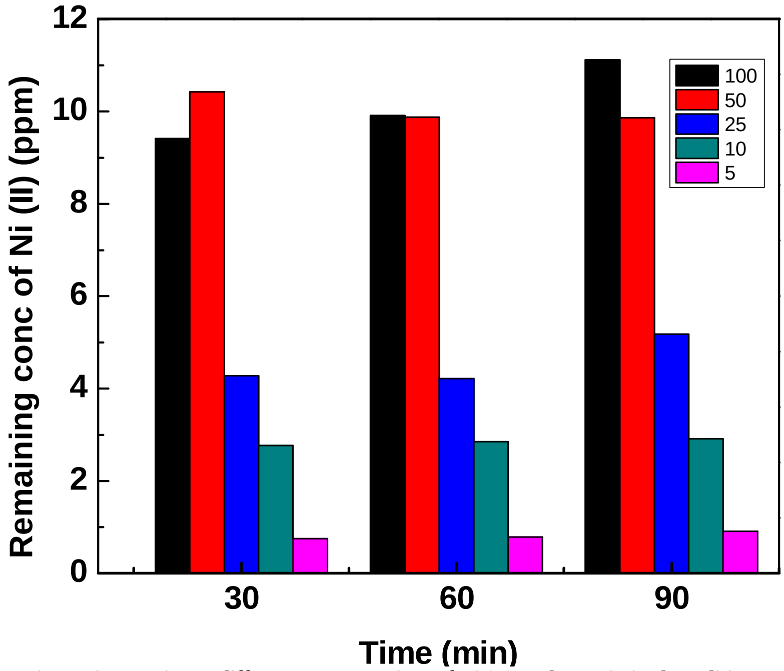

Fig.5: Bio-sorption at different concentrations of Ni (II) under optimized conditions

(Initial conc.100mg/l, contact time 60 min. pH 8.5 and biosorbent dosage 2.5 g/150 ml)

3.5. Adsorption kinetics

A graph was drawn by taking contact time at different intervals of time on the x-axis and natural logarithm of the remaining concentration of Ni (II) on the y-axis. The graph is shown in Fig.6. Kinetics of adsorption was determined from the graph. The graph was observed to be a straight line fit with a relatively good correlation coefficient (r^2 = 0.93). Therefore it was concluded from graph that adsorption followed first order kinetics.

3.6 Characterization of the bio-sorbent before and after Ni(II) adsorption

TEM images of the bio-sorbent before and after adsorption experiments are given in Fig-7-a and 7-b. It could be observed from the figures that Ni (II) ions got adsorbed to the bio-sorbent after the adsorption experiments.

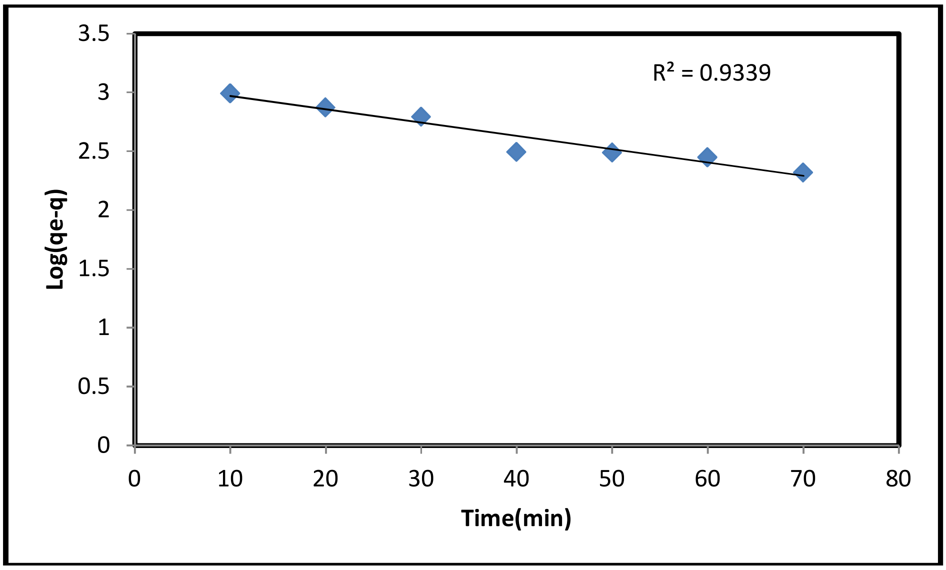

Fig.6: Graph showing the kinetics of adsorption of Ni (II) on the sugarcane bagasse

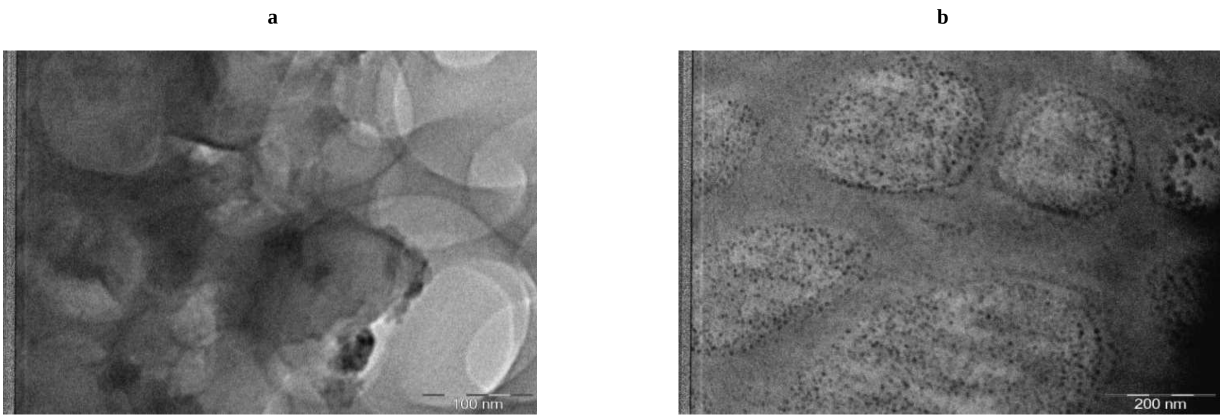

Fig.7 Transmission electron microscopy image of bio-sorbent a) before adsorption experiments; b) after adsorption experiments

3.7 Reuse
Experiments were carried out to understand the sustainability of the bio-sorbent. Reuse of the same bio-sorbent was done 5 times by taking 100, 50, 25, 10 and 5 ppm concentrations of Ni (II). The results obtained are presented in Fig.8. It could be seen from the graph that the bio-sorbent could be reused once at 10 and 5 ppm only.

3.8 Regeneration
Regeneration of the same bio-sorbent was done four times under optimized conditions. Experiments were carried out with 100, 50, 25 and 10 ppm concentrations of Ni (II). The results obtained are presented in Fig 9. It could be concluded from the results obtained that the biomass can be regenerated at 25 and 10 ppm once only.

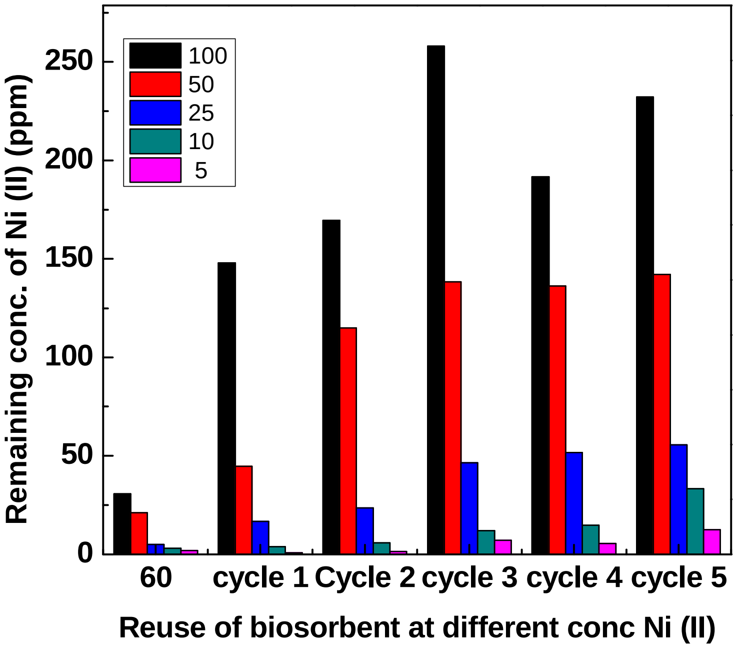

Fig.8 Reuse of the sugarcane bagasse for the adsorption of Ni (II) under optimized conditions
(Initial conc.100mg/l, contact time 60 min. pH 8.5 and biosorbent dosage 2.5g/150 ml)

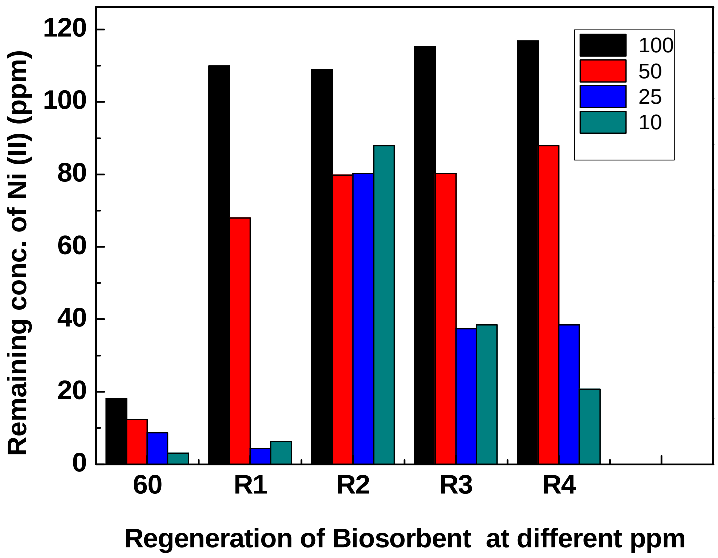

Fig.9 Efficiency of the bio-sorbent for the adsorption of Ni (II) after regeneration
(Initial conc.100mg/l, contact time 60 min., pH 8.5 and biosorbent dosage 2.5g/150 ml)

CONCLUSION

Adsorption studies of Ni (II) from aqueous solutions using sugarcane bagasse were carried out. Optimum experimental conditions (pH, contact time and quantity of bio-sorbent) were established. Different concentrations of Ni (II) were prepared and analyzed using the optimum conditions. Maximum removal of 90.09% was achieved. Kinetics of adsorption was investigated and it was found that the kinetics of adsorption followed first order. Reuse and regeneration experiments were conducted. The bio-sorbent could be reused once below 10 ppm concentration of Ni (II) once. The bio-sorbent could be regenerated and used below 25 ppm concentration of Ni (II) once. The results showed that bagasse has considerable potential as an adsorbent for the removal of nickel (II) from aqueous solutions.

Acknowledgements
The authors wish to thank the Director, CSIR-IICT for her encouragement in carrying out this work. The authors also wish to thank Dr.S.Venkata Mohan for his valuable suggestions during the course of this research work.

REFERENCES

[1] RH Krishna; AVVS Swamy, *Chemical Scienc Journal,* **2011,** CSJ-31.
[2] Reena singh; Neetu Gautam; Anurag mishra;Rajiv Gupta, *Indian J Pharmacol*., **2011**, 43(3), 246-253.
[3] CY Chen;TH Lin, *Journal of Toxicology and Environmental Health Part A.*, **1998**, 54,37-47.
[4] Revathi M, *Journal of Environmental Engineering*., **2005**, 45, 1.
[5] Volesky B, Biosorption and biosorbents. In: *Biosorption of heavy metals*.,**1990** Boston, USA, CRC, 3-5.
[6] YC.Sharma;G Prasad;DC.Rupainwar, *International Journal of Environmental Studies.*, **1992**,40, 535.
[7] Z Elouear; J Bouzid;A Boujelben; M.Feki; F Jamoussi;A Montiel, *Journal of Hazardous Materials.*,**2008,** 156., 412-420.
[8] K Santhy; P Selvapathy, *Seperation Science and Technology*., **2004,**39, 3331-3351.
[9] M.Chan-jun; L.Jung-Heon, *Process Biochemistry*., **2005**,40, 1279-1283.
[10] S.Amalraj, *Indian Journal of Environmental Protection.,* **2005,** 24 (7)., 530-533.
[11] VK Gupta; A Mittal; R Jain, *et al*. *Journal of Colloid Interface Science.*, **2006**,303 (1) 80-86.
[12] K Periasamy; C.Namasivayam, *Waste Management*., **1995**,15, 63-68
[13] I Ali; VK Gupta, *Nature Protocols.*, **2007**, 1 (6) 2661-2667.
[14] SV Dimitrova, *Water Research.*, (**1996**),30, 228-232.
[15] AK Meena, National Conference on Carbon **2003**, National Institute of Ayurvedic Pharmaceutical Research, Kanpur, 131-141.
[16] PP Viswakarma; KP Yadava; VN Singh, *Pertankika.*, **1989**,12, 357-366.
[17] A Kapoor; T Viraraghavan; *Bioresource Technology*., **1995**, 53(3) 195-206.
[18] E Maranon; H Sastre, *Bioresource Technology*., **1991**,1, 39-43.
[19] WE Marshall; ET Champagne;WJ.Evans, *Journal of Environmental Science and Health*., **1995**,9A.,1977-1992.
[20] K.K.Kadirvelu; Thamaraiselvi;C Namasivayam, *Bioresource Technology.*, **2001**,76, 63-65.
[21] K.Periasamy; C.Namasivayam, *Waste Management*. **1995**,15, 63-68.
[22]PE Aikpokpodion;RR Ipinmoroti; SM.Omotoso, *American–Eurasian Journal of Toxicological Sciences*., **2010**, 2(2), 72-82.
[23] P Muthusamy; S Murugan;Manothi smitha, ISCA *Journal of Biological Sciences.*, **2012**,1 (2), 7-11.