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Biokinetic Study on Chromium Removal from Textile Wastewater Using Azadirachta Indica as a Low Cost Adsorbent

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Abstract- The Contamination of water by toxic heavy metals through the discharge of Industrial wastewater has been causing worldwide concern in the last few decades. Metals that is significantly toxic to human beings and ecological environments. The concentrations of toxic metals in wastewater effluent are higher than permissible discharge levels. Because of all these reasons and some definite regulations measures of precaution, it becomes necessary to remove the heavy metals from wastewater by an appropriate treatment before releasing them into the environment. Azadirachta Indica is used as an adsorbent for the removal of heavy metals from the textile wastewater. The adsorbent exhibits very high adsorption potential for removal of chromium which was achieved maximum at 90% in pH of range 1 to 10. The equilibrium data were fitted well by the Freundlich and Langmuir isotherm models.

Index Terms- Adsorption, pH, Chromium, Azadirachta Indica, isotherm, Biosorbent

I. INTRODUCTION

The industrial wastewater discharged to the ground water after various chemical treatment processes are found to have more toxic effect due to the presence of chemicals. Biosorption is one of the established unit operations used for the treatment of contaminated water such as raw water and wastewater. Adsoption studies are usually conducted over batch studies and column studies. Even though the most promising adsorbent for adsorption is activated carbon, which has a high surface area and a high adsorption capacity, it is very expensive, has high operation costs and there is a need for regeneration after each adsorption cycle (H.Marsh and F.Rodriguez-Reinoso, 2006) and (I.Ali and V.K. Gupta, 2007). Activated carbon is the most used adsorbent. Due to its high cost and considering the enormous quantity of effluent produced by textile industries, researchers are turning toward the use of alternative adsorbents also called non-conventional low-cost adsorbents.

Different methods of treating wastewater containing heavy metal ions have been developed over years which include coagulation, ion-exchange, membrane separation, electro flotation, etc (C. Namasivayam and K. Ranganathan, 1995). However, most of these techniques have some disadvantages such as complicated treatment process, high cost, and energy use. Among these methods, adsorption is a much preferable technique for the removal of heavy metals from polluted water compared to others due to ease of operation and cost-effective process (S. Saxena and S.F.D, Souza, 2006). The removal and recovery of heavy metals from wastewater is significant in the protection of the environment and human health. (Kaewasarn,2002). The inadequate disposal of wastewater contaminated with heavy metals presents a very serious environmental problem, being a risk to the aquatic ecosystems and to human health. (Amarasinghe and Williams, 2007). The present study tends to investigate Neem (Azadirachta Indica) leaves as a low cost adsorbent for the removal of chromium from textile wastewater.

II. MATERIAL AND METHODS

Fresh Azadirachta Indica Leaf

The Neem tree of family Meliaceae is native to the Indian sub-continent, and its leaves and seeds have been used traditionally to treat a number of human ailments and also as a household pesticide. The tree is known as an air purifier and different parts of the tree such as leaves, bark and seeds have been reported to possess a variety of medicinal and germicidal properties.

The Mature Azadirachta indica leaves were collected from a number of tall trees in Veerananallur, Cuddalore Dt.

The raw Azadirachta indica leaves contain the following characteristics:

Moisture content	-	59.4%
Carbohydrates		- 22.9%
Proteins	-	7.1%
Fibre		- 6.2%
Minerals	-	3.4%
Fats		- 1.0%

Preparation of Biosorbent

The mature Azadirachta indica leaves were thoroughly washed with distilled water three to four times to remove dust and other impurities and were allowed to dry first at room temperature in a shade and then in an oven at 60ºC till the leaves became crisp that could be crushed into a fine powder in a mechanical grinder and then screened. Dried Azadirachta indica leaves powder is keeping in plastic containers srored in

humidifier for further use. This fine powders were used as an biosorbent. In the present study the powdered materials in the range of 300 microns of average particle size were then directly used as biosorbent without any pretreatment.

Biosorption Study

A known quantity of biomass is taken and added with the industrial wastewater and the mixture is placed over the mechanical shaker. The samples were taken out at a specific duration of time and centrifuged at 1000 rpm for 15min. The supernatant liquid was separated low residual Chromium ions is analyzed by Atomic Adsorption Spectrophotometer.

Sampling Data

The textile dye waste samples were collected from the Loyal Superfabrics Private Limited, Cuddalore District. The analysis of parameter was carried out in occordance with Standard Methods, APHA (2000).

The adsorption capacity of the biosorbent at equilibrium was calculated using the equation.

$$q_e = \frac{(C_0 - C_e)V}{m}$$

where

q_e = Adsorption capacity of the biosorbents at equilibrium (mg/g)

C_0 = The initial concentration of the adsorbate in solution (mg/l)

C_e = The equilibrium concentration of the adsorbate in solution (mg/l)

V = The volume of the solution (l)

m = The Mass of the biosorbent used (g)

III. RESULTS AND DISCUSSION

Effect of Adsorbent

The percentage adsorption of the dye, on Neem Leaf Powder for removal of Chromium at pH 7 was (0.5gm, 1gm, 1.5gm and 2gm) depicted in Fig. 1. Neem Leaf Powder dose of 0.5gm showed 68.57% removal at 30 minutes contact time but the adsorption increased to 88.5% for 150 minutes. On the other hand, if the Neem Leaf Powder dose was increased to 2.0gm, the adsorption % was achieved from 85.24 to 90% at 150 minutes.

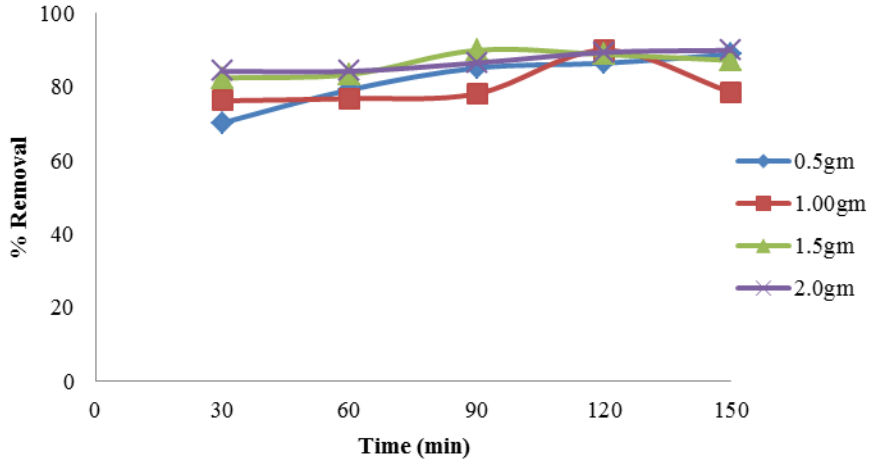

Fig.1 Characteristics curves on Time Vs % removal effect of Cr for Neem Leaf powder (NLP)

Influence of pH

The solution pH is one of the parameter having considerable influence on the biosorption of metal ions, because the surfaces changes density of the adsorbent and the charge of the metallic specimen present on the pH. In the present work, the extend of Chromium biosorption was investigated in pH range 1 to 10 with a constant amount of Neem leaf powder for 0.5gm/100ml. A maximum chromium of 86.6% (10mg/g) was reported at pH=3 onto treated sawdust (Volesky et al., 1995) as pH was varied from 2 to 10. The results are shown in Fig. 2. The percentage removal of the metal was increased from 70.30 to 88.95% for 0.5gm/100ml and percentage. Biosorption was increased steeply from 84.28 to 90.00% (2gm/100ml) as pH increase from 1 to 7.

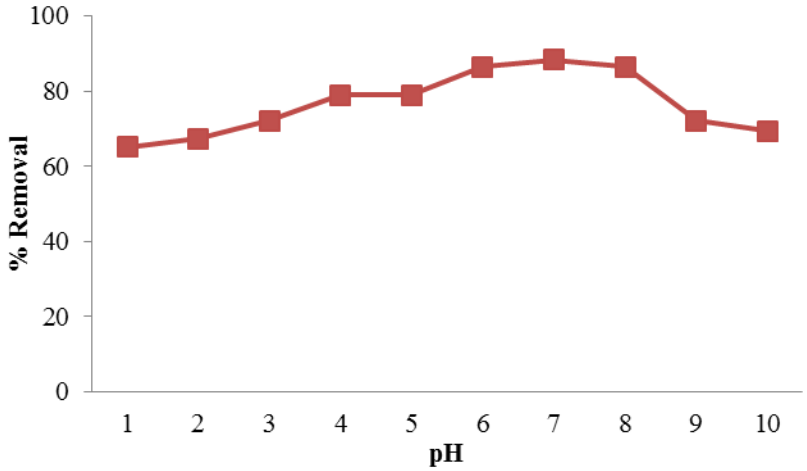

Fig. 2 Characteristics curves on pH Vs % removal of Cr for Neem Leaf Powder

Effect of Adsorbent Dosage

The % removal of chromium was increased with the increase in adsorbent dosage. In case of Neem, the % removal was increased from 70.30% to 90% as the amount of Neem powder increased from 0.25 gm/L to 2 gm/L as shown Fig.3.

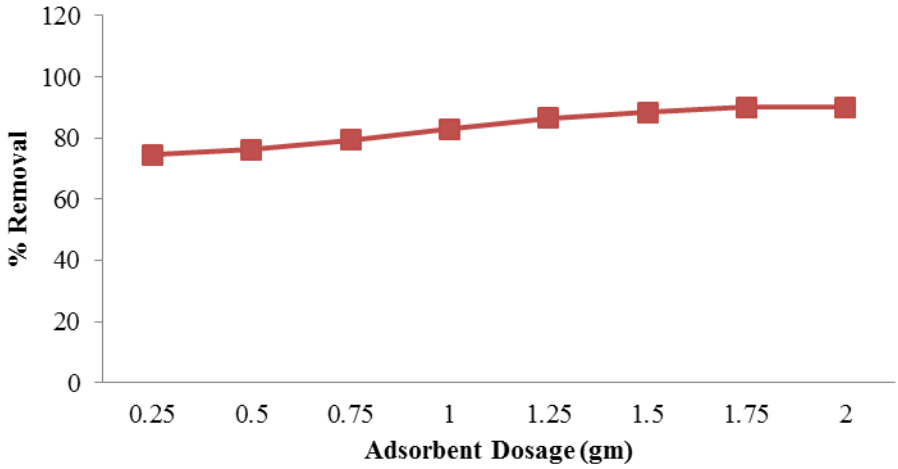

Fig.3 Characteristics curves on effect of dosage Vs % removal of Cr for Neem Leaf Powder Kinetics of biosorption

Freundlich isotherm

The Freundlich equation predicts that the concentrations of metal ion on the adsorbent will increase as long as there is an increase in the metal ion concentration in liquid, as represented by Eq.(1).

$$\frac{x}{m} = K_F C_e^{1/n} \quad \text{.....(1)}$$

where *x/m* is the mass of adsorbate adsorbed per unit mass of adsorbent, K_F is Freundlich capacity factor, C_e, is equilibrium concentration of adsorbate in solution after adsorption and 1/n represents Freundlich intensity parameter. The constants in Freundlich isotherm can be determined by plotting log *(x/m)* versus log C_e from the best-fit straight line.

Langmuir isotherm

The Langmuir adsorption isotherm assumes that the adsorbed layer is one molecule in thickness and that all sites are equal, resulting in equal energies and enthalpies of adsorption. The sorption data were analyzed according to the linear form of the Langmuir isotherm, as represented in Eq (2).

$$\frac{m}{x} = \left(\frac{1}{ab}\right) \times \frac{1}{C_e} + \frac{1}{a} \quad \text{.....(2)}$$

where *x/m* is the mass of adsorbate adsorbed per unit mass of adsorbent, C_e. is equilibrium concentration of adsorbate in solution after adsorption, a is a Langmuir constant which is a measure of adsorption capacity expressed in mg/g and *b* is also a Langmuir constant which is a measure of energy of adsorption expressed in 1/mg.

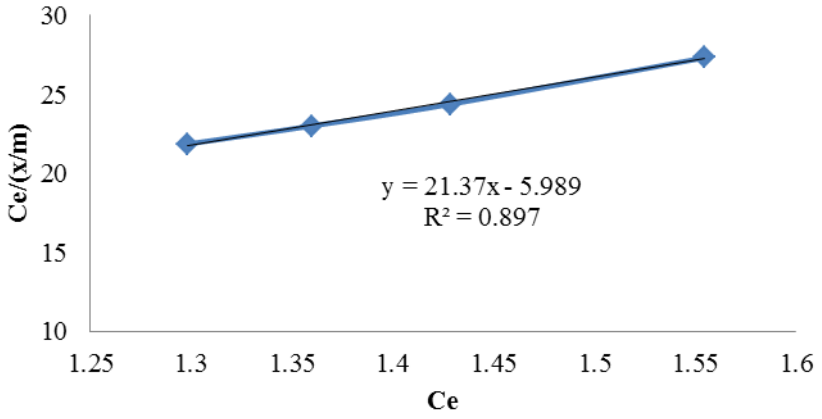

Fig.4 Linearised Langmuir isotherm plot for the adsorption of Cr by Neem Leaf powder

Intercept a = -2.817
Slope b = 19.128
Ce(x/m) = -0.0185+0.052Ce

Langmuir Isotherm characteristics

SYSTEM	a in (l/mg)	b in (mg /g)	Ce (x/m) = 1/(ab)+ (1/b) Ce	R^2
Neem leaf powder	14.538	0.1054	Ce(x/m) =-0.0185+0.052Ce	0.897

Freundlich adsorption isotherm

The experimental results are shown in Fig.5 and fitted in Freundlich model.

Log(x/m)=log k + (1/n) log Ce

The intercept 1/n is the estimation of the sorption capacity and K is an estimate of sorption intensity.

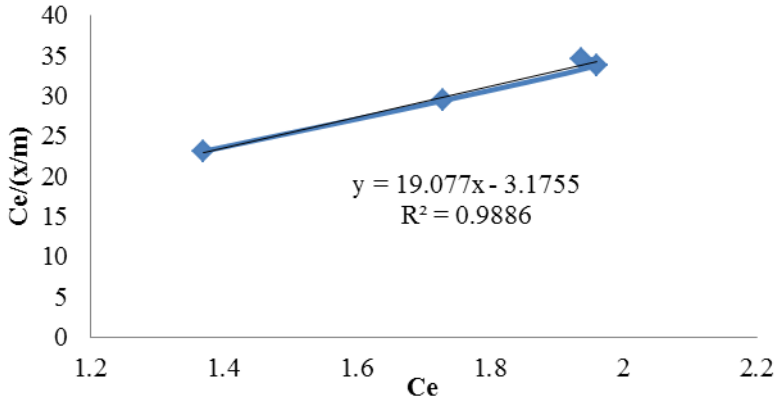

Fig. 5 Linearized Freundlich Isotherm plot for the adsorption Cr by Neem leaf powder

Intercept k = -3.175
Slope 1/n = 19.07
log (x/m) = log k+ (1/n) log Ce
log (x/m) =0.50 + 19.07 log Ce

Freundlich Isotherm characteristics

SYSTEM	K	1/n	R^2

Neem leaf powder	-3.175	19.07	0.988

Comparison of Isotherm characteristic for heavy metal

Adsorbent	**Heavy metal**	**Langmuir Isotherm**	**Freundlich Isotherm**	**R^2 Langmuir Isotherm**	**R^2 Freundlich Isotherm**
Neem leaf powder	Chromium	Ce(x/m)= -0.0185+0.052Ce	Log (x/m) =0.50+19.07 log Ce	0.897	0.988

IV. CONCLUSION

In the present study, Bisoprtion experiments for the removal Cr ions from aqueous solutions have been carried out using dried neem leaf as low cost and natural available adsorbents. It was found that the biosoprtion was rapid and increased by the decrease in biosorbent average particle size. The adsorption isotherm data was satisfactory explained by Langmuir and Freundlich isotherm models. The frendlich isotherm had been well fitted the bisorption of Cr with chemically modified neem leaf powder. Among the various desorbing agents tested, 90.0% Cr recovery was achieved with 2 gm for Neem Leaf Powder. The overall results indicated that Neem Leaf Powder is an effective low cost biosorption for the removal of chromium from the textile wastewater. The equilibrium data was anlaysed used Langmuir, Freundlich equation. Their results shows that the experimental data are best correlated by Freundlich isotherm.

REFERENCES

[1] Amarasingihe, B.M.W.P.K., Williams, R.A., (2007). "Tea waste as a low cost adsorbent for the removal of cu and Pb from wastewater", Chem. Eng. J. 132, pp. 299-309.

[2] APHA, (2000) "Standard Methods for the Estimation of Waste and Wastewater", 16th ed., American Public Health Association, Washington, DC.

[3] Barala S.S., Das S.N., Rath. P., and Choudary G.R,(2007), "Biochem", Eng. J., 34,p.69.

[4] H.Marsh, F.Rodriguez-Reinoso, (2006), "Applicability of activated carbon, Activated Carbon", pp. 383-453.

[5] Horitsu H., Futo S., Miyaawa Y., Ogai S., and Kawai. K., (1987), "Enzymatic reduction of hexavalent chromium by hexavalent chromium tolerant pseudomonas ambiua G-1", Agric, Bio1, chem. 51, pp. 2417-2420.

[6] I. Ali, V.K. Gupta., (2007) "Advances in water treatment by adsorption technology", Net. Protoc. 1 pp. 2661-2667.

[7] Kaewsarn, P., (2002). "Biosorption of Copper (II) from aqueous solutions by pre-treated biomass of marine algae" Padina sp. Chemosphere 47, pp. 1081-1085.

[8] Kota. J., Stasicka. Z., (2000), "Chromium occurance in the environmental and methods of its speciation", Environ. Pollut. 107, pp.263-283.

[9] Langumir. I,(1916) "The constitution and fundamental properties of solid & liquids", J.Am, chem. Soc. 38, pp.2221-2295.

[10] Namasivayam C., and Ranganathan K., (1995) "Removal of Pb (II), CD (II) and Ni (II) and mixture of metals ions by adsorption on the waste FE (III)/Cr(III) hydroxide and fixed bed studies", Environ. Technol. 16, pp.851-860.

[11] Saxena. S, S.F.D' Souza, (2006), "Heavy metal pollution abatement using rock phosphate mineral", Environ. Int. 32, pp199-202.

[12] Volesky B., and Holan Z.R., (1995), "Biotechnol", Prog. 11, pp.235-250.

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