The International Journal Of Engineering And Science (IJES)
|| Volume || 3 || Issue || 6 || June || 59-64|| 2014 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

Biosorption of Copper and Chromium from Industrial Waste Water

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ABSTRACT
In this present work, biosorption process has been implemented for heavy metals of Chromium (Cr) and Copper (Cu) by using Thespesia populnea, from the industrial waste. In this experiment, 100 ml (millilitre) quantity of constant sample dosage has been taken for each and every test, by using spectrophotometer. Experiments have been carried out for finding the variation in pH, biosorbent concentration and percentages of removal of metals with variation of time interval. The outcome result shows that, less pH value and best biosorbent concentration obtained by Cr then Cu, followed by the increase in percentage of removal by Cr then Cu, variation of time interval. Mechanisms of metals sorption by Thespesia populnea have given by better fits for Freundlich and Langmuir models.

KEYWORDS : *Biosorption, Cr; Cu Heavy Metal, Industrial Waste, Isotherms, Thespesia populnea*

Date of Submission: 9 May 2014 Date of Publication: 10 June 2014

I. INTRODUCTION

Present environment has been polluted mainly by heavy metals from the industrial and synthetic wastages. This metal pollution causes Acid rain, Damages green house effect, etc. Mainly pollutants like copper, Zinc, cadmium, chromium, lead etc... , play a vital role of heavy metal, which damage the environment. Out of the above mentioned pollutant producers, the industrial waste has taken the major role, which emits harmful heavy metals of Chromium (Cr) and Copper(Cu). The harmful heavy metal compounds have been emitted from the industrial works of metal finishing, welding, platting. Dying, lathe works and petroleum industries. Also the industrial waste affects human parts of liver, kidney, nerve system, bone marines etc. [1] Biosorption process is one among the new technique, which is used to remove the heavy metal at fewer economical cost strategies. Also this process is particularly suitable for the treatment of waste water stream containing dilute heavy metal concentration or when very low concentrations are required. The biosorbents have been derived from suitable bio mass have been used for the effective removal and recovery of heavy metals from industrial waste water. In this process, presently bio leaves (dry in condition), have been used to remove the heavy metals from industrial waste. The major advantageous of biosorption technology has its effectiveness in reducing the concentration of heavy metals to very low level and the use of inexpensive bio sorbent materials [2].The aim of the work is to remove the heavy metals of Cr and Cu by biosorption method from the industrial waste water, by using Thespesia populnea (dry leaf). The study is based on the difference in low level of pH, best biosorbent concentration between the two heavy metals of Cr and Cu and increase in percentage removal of heavy metals with variable time duration.

II. MATERIALS AND METHODS

2.1 Metal Ion Determination

(For Chromium)

By using spectrophotometer, the change in Cr concentration has been determined [4]. The percentage removal of Cr = Ce – Ci/ Ce x 100, where, Ce = Equilibrium Concentration of Cr, Ci = Initial Concentration of Cr.

(For Copper)

By using the spectrophotometer, the change in Cu concentration has been determined. The percentage removal of Cu = Ce – Ci/ Ce x 100, where, Ce = Equilibrium Concentration of Cu, Ci = Initial Concentration of Cu.

2.2 Preparation of Biosorbent

The locally available Thespesia populnea has to be washed with deionized water to remove dirt and foreign materials. The leaves have to be dried and powdered into required size of 2 mm (millimetre) and stored in desiccators.

2.3 Pre-treatment of Biosorbent

To increase the metal uptake efficiency, the pre treatment of biosorbent has been carried out. In this process, 100 grams of Thespesia populnea leaves dry power has to be taken and treated with 1000ml of 1N formalin. After the 24 hours time duration, the substance has to be show for the water bath (Constant water temperature of 70°C), rest of the half – an –hour. After the finishing of the treatment, it is cooled and neutralized with 500ml of NaOH[5].

2.4 Biosorption Studies

Batch experiments have been conducted in screw cap bottles of 500ml capacity. 250 ml of the solution containing predetermined concentration of the adsorbent under investigation has been taken in the bottle. After the addition of known quantity adsorbent, the bottles have to be equilibrated for a known period of time in an orbital rotor speed for 250rpm (revolution per minute) condition. After the equilibrium period, the solutions have been separated by using membrane filters and the residual adsorbate in solution has been determined. The pH of the test solution has been adjusted by using pH meter. All biosorption experiments have been performed in triplicate and mean values recorded.

2.5 Effect of pH

(For Chromium)

Adsorption of metal ions by biomass has been studied at pH values from 1 to 8. A fixed biomass of 2g has been added to 100 ml/l of chromium solution, which contains Cr. Due to the biomass addition, to avoid change in pH, it has been adjusted with 0.1N H_2SO_4 or 1N NaOH after the solution had been in contact with the adsorbent.

(For Copper)

Adsorption of metal ions by biomass has been studied at pH values from 1 to 8. A fixed biomass of 2g has been added to 100 ml/l of copper solution, which contains Cu. Due to the biomass addition, to avoid change in pH, it has been adjusted with 0.1N HCl or 1N NaOH after the solution had been in contact with the adsorbent.

2.6 Effect of Biosorbent Dose

(For Chromium)

To find the influence of the biosorbent sample, the Cr solution has been taken 10mg/litre and equilibrating with varying amount of biosorbent 0.2 to 4g after adjusting the pH, for 30 minutes at room temperature and at keeping maintain the agitation orbital rotor speed of 500rpm. After the require equilibration time, using filters the solutions have been separated and the supernatant is analyzed for residual Cr concentration to find the percentage of removal in each case.

(For Copper)

To find the influence of the biosorbent sample, the Cu solution has been taken 10mg/litre and equilibrating with varying amount of biosorbent 0.2 to 4g after adjusting the pH, for 30 minutes at room temperature and at keeping maintain the agitation orbital rotor speed of 250rpm. After the require equilibration time, using filters the solutions have been separated and the supernatant is analyzed for residual Cu concentration to find the percentage of removal in each case.

2.7 Effect of Contact Time:

(For Chromium)

For finding the optimal incubation time, a fixed adsorbent concentration of 2g biomass has been added to 100 ml/l of solution containing Cu samples. The readings have been taken from 10 to 150 minutes and analysed for removal.

(For Copper)

For finding the optimal incubation time, a fixed adsorbent concentration of 2g of biomass has been added to 100 ml/l of the solution containing Cr samples. The readings have been taken at 10 to 150 minutes and analysed for removal.

2.8 Effect of Initial Metal Ion Concentration:

(For Chromium)

The effect of initial metal ion concentration has been calculated by adding 20mg to 100mg/l of chromium solution to a variable biomass from 0.5 - 3g. The pH has been adjusted to 6 with 0.1N H_2SO_4 and 1N NaOH. The samples have been mixed well by good agitation. For sorption isotherm experiments, the flasks have been agitated with the help of orbital rotor at a constant speed of 500rpm, for 120 minutes. After that, the samples have been filtered using filters. Triplicate samples have been analysed by using spectrophotomer.

(For Copper)

The effect of initial metal ion concentration has been calculated by adding 10mg to 50mg/l of chromium solution to a variable biomass from 0.5 to 2g. The pH has been adjusted to 5 with 0.1N HCl and 1N NaOH. The samples have been mixed well by agitation. For sorption isotherm experiments, the flasks have been agitated with the help of orbital rotor at a constant speed of 250rpm, for 75 minutes. After that, the samples have been filtered using filters. Triplicate samples have been analysed by using atomic absorption spectrophotometer.

2.9 Adsorption Isotherm:

(For Chromium)

The sorption of chromium by Thespesia populnea has been carried out at different initial chromium ion concentration ranging from 10 to 100mg/l at optimum pH 6 at 500rpm and the adsorbent dosage has been varied from 0.5 to 3g. Freundlich and Langmuir models have been applied to the adsorption isotherm and different constants have been generated.

(For Copper)

The sorption of copper by Thespesia populnea has been carried out at different initial chromium ion concentration ranging from 10 to 50mg/l at optimum pH 5 at 250rpm and the adsorbent dosage has been varied from 0.5 to 2g. Langmuir and Freundlich models have been applied to the adsorption isotherm and different constants have been generated.

IV. RESULTS AND DISCUSSION

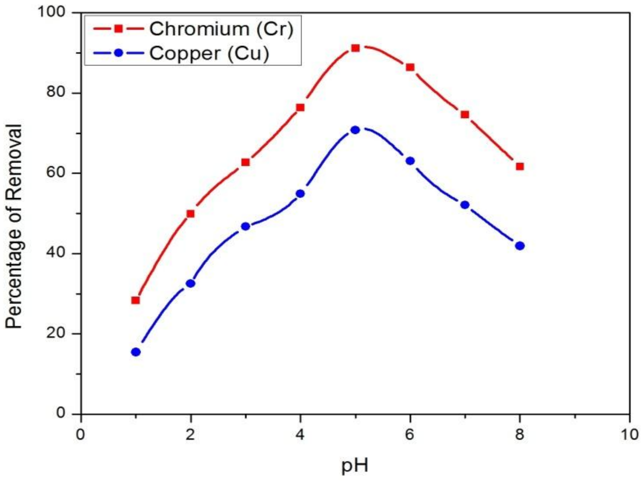

Figure :1 Percentage Removal based on the pH values

Figure 1 shows the variation of the percentage removal of metal with respect to pH values. The pH values staring from 0 to 8. The result shows that, increase and decrease Values of pH for both the heavy metals. The peak values have been attained by the Cr and Cu were 91.2%and 70.8% at the pH value of 5. The reason for increasing and decreasing is, due to the electrostatic force of attraction acting on the substances.

From 0 to 5 the increase values obtained because of the decrease in obsorbation with increase of pH have been implemented based on the increase in electrostatic force of attraction between the sorbate ions and sorbent. Also for 5- 8 decreasing values have been obtained because of the reciprocal result of increase in obsorbtion with decrease of pH have been implemented based on the decrees in electrostatic force of attraction between the sorbate ions and sorbate [6].

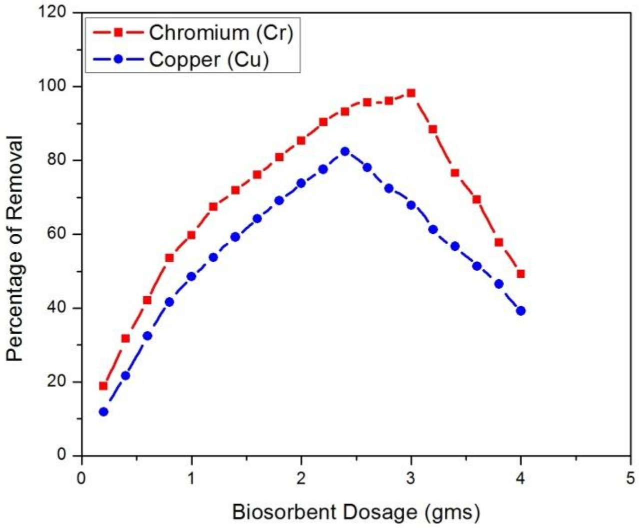

Figure: 2 Percentage Removal based on the Biosorbent Dosage

Figure 2 shows the variation of percentage removal based on the Biosorbent dosage. Here is also increase and decrease in values obtained based the variables. It is easily understood that gets increased up to one stage the decreasing in the next stage. Hence the optimum hike values obtained for the both the heavy metals. Also the percentage of remove is much maximum for Cr than Cu. The peak value obtained by Cr is 98.2% at 3 grams itself. But in the other case of Cu, obtained the peak value of 82.45% at 2.4 grams. This absorption is mainly based on the property of the metals and the percentage of dosage, binding sites in biomass for the complexation of Cr and Cu. Also, the increase in percentage of removal is due to an increase in adsorption surface area. The falling of the values is due to the aggregates formed during Biosorption which takes place at high biomass concentration causing a decrease of the effective adsorption area [2,7].

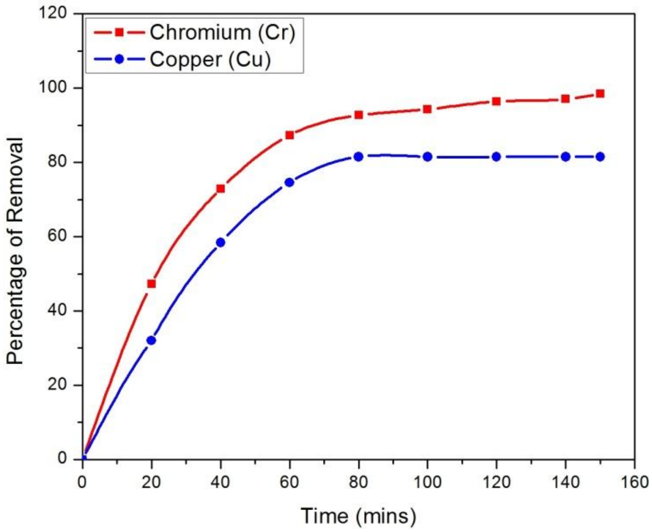

Figure: 3 Percentage Removal based on Time Variation

Figure 3 shows the details for the removal of metals with variation of time interval. Here is also Cr and Cu have taken the maximum and minimum values respectively. Viewing the Cr curve, the percentage of metal removal with respect to time gets gradually increased from the initial and reaches the maximum up to

150 minutes. But in the other case of Cu, the percentage of removal of metal achieved at 80 minutes itself, after that up to 150 minutes it maintained the constant equilibrium level. The percentage of removal increases based on the orbital rotor speed increases. Also, the rapid removal of metal at the initial stage of reaction has been carried out by believed to be presents of a number of vacant site (pores) in biomass. The percentage for removal is increased, when the free ions has been reached the saturation level. If the free ion assigned to complete /solution absorbing capacity reaches the minimum level, the metal absorption maintained at the equilibrium stage [8].

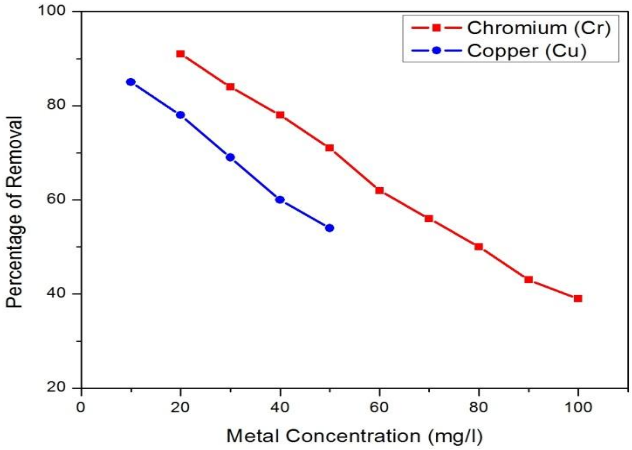

Figure: 4 Percentage Removal based on Metal Concentration

Figure 4 shows the variation in percentage of removal with respect to concentration of heavy metal solution. Here the Cr and Cu metals concentration have been obtained by maximum and minimum respectively. At low concentrations the metal ions present in the solution interacts with the binding sites. But in the higher concentrations more metal ions have been left and unabsorbed in solution due to the saturation of binding sites. Hence the percentage of removal of metal ions has been higher and fewer at low and high concentration respectively. Also, the percentage of removal for Cr and Cu leads up to 100mg/l and 50mg/l respectively, based on the heavy concentration of metals[7,9].

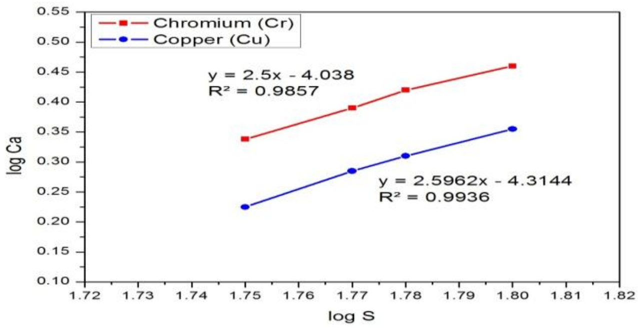

Figure: 5 Freundlich Isotherm Plot of Cr and Cu Adsorption by Thespesia populnea

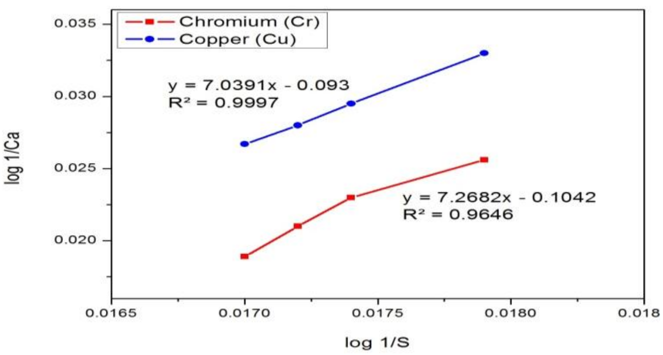

Figure: 6 Langmuir Isotherm Plot for Cr and Cu Adsorption by Thespesia populnea

Figure 5 and 6 Shows the Freundlich and Langmuir isotherms for heavy metals of Cr and Cu metal adsorption by Thespesia populnea. The Cr and Cu uptake capacities by Thespesia populnea have been evaluated using the Freundlich[10] and Langmuir[11] equations. The Freundlich equation is an empirical equation based on adsorption on a *heterogeneous* surface given by $Ca = kS^n$, where Ca is the amount of solute adsorbed and S is the solute concentration in the liquid phase. The results obtained from varying initial metal concentration study have been modelled with various isotherms equations. Similarly the Langmuir equation, which has been valid for monolayer sorption on to a surface with a finite number of identical sites, which have *homogeneously* distributed over the adsorbent surface has given by Ca = CoS/k + S, where Co and k are constants, Ca is the amount of solute adsorbed per unit amount of adsorbent, S is the solute concentration in the liquid phase.

Freundlich Isotherm				Langmuir Isotherm		
#	k_f	n	R^2	Ca	k	R^2
Cr	0.083	2.5	0.98	53	3.81	0.96
Cu	0.053	2.6	0.99	38	4.28	0.99

VII. CONCLUSION

From the above it is understood that, the following parameters:

- Percentage removal based on the pH values is high for Cr than Cu.
- Percentage removal based on the Biosorbent Dosage is high for Cr than Cu.
- Percentage removal based on Time Variation is high for Cr than Cu.
- Percentage removal based on Metal Concentration is high for Cr than Cu.

On the whole, the chromium heavy metal performed better in the Biosorption process than the copper heavy metal, by using the Thespesia populnea. The result has been confirmed by using the Freundlich and Langmuir models.

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