Isotherm study for removal of copper from copper electroplating industry effluent using *Moringa Oleifera* seed powder

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ABSTRACT

The copper (Cu) in a Cu electroplating industry effluent was removed using *Moringa oleifera* seed powder, which was studied by batch method. The effect of rapid mixing contact time, slow mixing contact time and adsorbent dosage for removing Cu from Cu electroplating industry effluent have been evaluated. The results of the present study indicated that the maximum adsorption capacity of *Moringa oleifera* seed powder for removing Cu in an electroplating industry effluent was 84.5 %. The study was extended to fit the experimental data into isotherm models. The model result showed that the Freundlich isotherm model was fitted well with the experimental data of electroplating industry effluent. Based on experimental and model studies, *Moringa oleifera* seed powder is effectively used as adsorbent for removing Cu in an electroplating industry effluent.

KEY WORDS: Electroplating industry effluent, Copper, *Moringa oleifera*, process parameters, the Freundlich isotherm.

1. INTRODUCTION

Electroplating industry producing effluent with different quality is due to lack of technology for process control and management. Electroplating industry effluent contains the general parameters like Turbitity, colour, pH, EC, BOD, COD, TDS, TS, and SS, and specific parameters like heavy metals, oil, grease, organic and inorganic components particularly cyanide. The various processes involved in electroplating industry are cleaning, degreasing, plating, rinsing, passivating and drying, which in turn is producing huge quantity of effluent. The quality (toxicity) of effluent depends on type of processes used and chemical used (Sivakumar, 2015). The degree of toxicity also depends on the handling of effluent interms of treatment and disposal (Sivakumar2013; 2011).

There are various conventional methods used for reducing the impact of various contaminants present in the electroplating industry wastewater, the adsorption method is widely used because it is producing less secondary waste and the adsorbent used in the adsorption method has large active surface area, which in turn used for removing the contaminants present in the effluent. (Sivakumar, 2013).

Previous researchers are used agro products and agro based derived products used for removing the contaminants and heavy metals from various industry wastewaters. Some of the agro based products in the recent past are, groundnut husk, corncob, tea leaves carbon, rice husk, saw dust and agricultural wastes (Sivakumar, 2012; 2014). Further, in the laboratory and field studies, seed of moriga oleifera (as a coagulant) was used for treating water (Sivakumar, 2013) in addition to other treatment processes like electro-dialysis (Sivakumar, 2014), ozonation, filtration, chemical precipitation, reverse osmosis, bioremediation (Sivakumar, 2013; 2014) etc. This paper dealt with effect of *Moringa oleifera* seed powder for removing Cu in a Cu electroplating industry effluent at different dosages, different agitation speed against the contact time. The adsorption study is also extended to isotherm points of view (Senthil Kumar and Kirthika, 2009).

2. MATERIALS AND METHODS

The entire experimental work was planned in three distinct phases which include preparation of coagulant using *Moringa oleifera* seed powder (Phase I), collection of electroplating industry effluent (Phase II) and conducting experiments for determining the suitability of *Moringa oleifera* seed powder to remove Cu present in a Cu electroplating industry effluent (Phase III).

2.1. Phase I: *Moringa oleifera* seed in dried form was collected from the Department of Agriculture, Government of Tamil Nadu. The pod was pulverized and sieved through 0.40 µm sieve to get the uniform size. Since, *Moringa oleifera* seed powder is an agro-based product, *Moringa oleifera* seed powder was kept in the refrigerator at a temperature of 4^0C, which is used for conducting experiments in later stage.

2.2. Phase II: Cu electroplating industry effluent from the Ambatur, Industrial Estate was collected with the help of air tight bottles. The quality was analyzed using standard procedure (APPA, AWWA, and WEF, 2005). The primary focus of the present study is to reduce the Cu concentration in a Cu electroplating industry effluent using *Moringa oleifera* seed powder at various process parameters. The initial Cu value in the Cu electroplating industry effluent is 183 mg/l.

2.3. Phase III: In the present study, adsorption processes were evaluated with the help of Phipps and Bird jar test apparatus (Sivakumar, 2013). Cu electroplating industry effluent was filled in four glass beakers of 1 litre capacity and was kept in the Phipps and Bird jar test apparatus for agitation. In the present investigation, the experiments were performed at different adsorbent dosage of 20 g/l to 140 g/l with an increment of 20 g/l, different agitation speed of 25 to 100 rpm with an increment of 25 rpm.

The concentration of Cu in a Cu electroplating industry effluent before and after equilibrium was determined as per standard procedure (APPA, AWWA, and WEF, 2005). Further, equilibrium studies were conducted at different concentration dilution from 0 to 4. The equilibrium experimental data for Cu removal against the different contact time and for the different dilution ratio (concentration) is used to fit the isotherm model. Using a mass balance, the concentrations of Cu at different time adsorbed by *Moringa oleifera* seed powder was calculated as

$$q_t = \frac{(C_0 - C_t)V}{M} \quad \text{(Equation.1)}$$

Where q_t is the amount of Cu adsorbed by *Moringa oleifera* seed powder at time t, C_0 is the initial concentration of Cu, C_t is aqueous phase concentration of Cu at time t, V is the volume of the aqueous phase, M is the weight of *Moringa oleifera* seed powder.

3. RESULTS AND DISCUSSION

3.1. Effect of *Moringa oleifera* seed powder Dosage: Fig.1 shows the effect of *Moringa oleifera* seed powder as adsorbent dose on Cu reduction in a Cu electroplating industry effluent with an agitation speed of 100 rpm and the initial concentration of Cu electroplating industry effluent (0 dilution factor). From Fig.1, it may be observed that up to 100 g/l of *Moringa oleifera* seed powder dosage, concentration of Cu in a Cu electroplating industry effluent decrease, beyond which they increase. In other words, the reduction of Cu in a Cu electroplating industry effluent increases, beyond which Cu decreases.

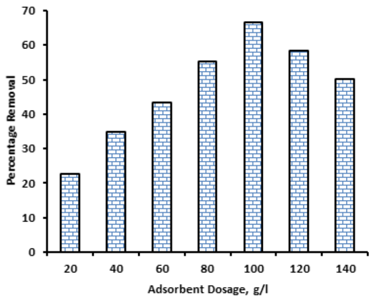

Fig.1.The effect of Adsorbent Dosage on Cu reduction in a Cu electroplating industry effluent with an agitation speed of 100 rpm nd an initial concentration of Cu of 183 mg/l

The percentage reduction in concentration of Cu for a *Moringa oleifera* seed powder dosage of 20, 40, 60, 80, 100, 120 and 140 g/l respectively were found to be 22.6 %, 34.8 %, 43.3 %, 55.3 %, 66.5 %, 58.5 % and 50.2 %. From the Fig.1, it may be found that the maximum removal of Cu occurs at the adsorbent dosage of 100 g/l. Further, an optimum dosage (100 g/l), which is corresponding to the lowest residual of Cu obtained for an Cu electroplating industry effluent were 61.3 mg/l.

3.2. Effect of Agitation speed: Fig.2 represents the effect of agitation speed on Cu reduction in a Cu electroplating industry effluent with an optimum adsorbent dosage of 100 g/l and the initial concentration of Cu electroplating industry effluent (0 dilution factor). From Fig.2, it may be observed that up to 50 rpm of agitation speed, the concentration of Cu in a Cu electroplating industry effluent decrease, beyond which they increase. In otherwords, the reduction of Cu in a Cu electroplating industry effluent increases, beyond which Cu decreases.

The percentage reduction in concentration of Cu for an agitation speed of 25, 50, 75 and 100 rpm respectively were found to be 46.8 %, 71.3 %, 55.3 %, 42.2 %. From the Fig.2, it may be found that the maximum removal of Cu occurs at the agitation speed of 50 rpm. Further, an optimum agitation speed (50 rpm), which is corresponding to the lowest residual of Cu obtained for an Cu electroplating industry effluent were 52.5 mg/l.

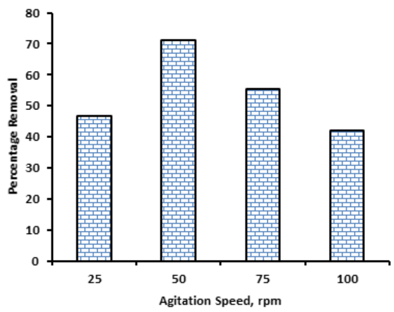

Fig.2.The effect of agitation speed on Cu reduction in a Cu electroplating industry effluent with an optimum adsorbent dosage of 100 g/l and an initial concentration of Cu of 183 mg/l.

3.3. Equilibrium Study: Adsorption isotherms are mathematical models that describe the distribution of the adsorbate species among liquid and adsorbent. There are several isotherm models usually described the interaction between adsorbate and adsorbent. The famous isotherm models are Langmuir and Freundlich isotherms. These isotherms are relating the metal uptake per unit mass of adsorbent, q_e, to the equilibrium adsorbate concentration in the bulk fluid phase C_e. In this study, Freundlich model only described in details.

The Freundlich isotherm model is an empirical relationship describing the adsorption of solutes from an aqueous solution to a solid surface. The development of Freundlich isotherm model assumes that involvement of different sites with several adsorption energies.

Freundlich adsorption isotherm describes the relationship between the amounts adsorbed per unit mass of adsorbent, q_e, and the concentration of the nickel at equilibrium, C_e.

$$q_e = K_f C_e^{1/n} \qquad (2)$$

The equation 2 may be rewritten in logarithmic form as,

$$\log q_e = \log K_f + \frac{1}{n}\log C_e \qquad (3)$$

Where, K_f and n are the Freundlich constants. K_f and n are the indicators of the adsorption capacity and adsorption intensity, respectively. For this case, the plot of log C_e vs log q_e was employed to find the value of K_f and n. The optimum adsorbent dosage of 100 g/l and an optimum agitation speed of 50 rpm was used to conduct the equilibrium study against the different concentration of Cu electroplating industry effluent at different contact time. The effect of concentration on Cu reduction in a Cu electroplating industry effluent with an optimum adsorbent dosage of 100 g/l and agitation speed of 50 rpm against the different contact time is shown in Fig.3.

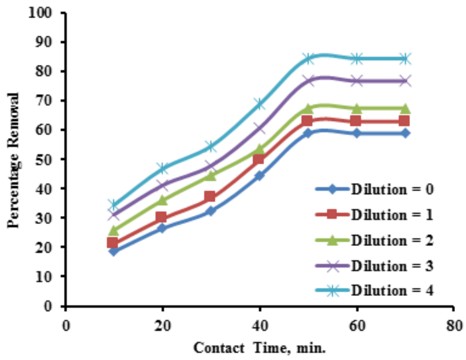

Fig.3.The effect of concentration on Cu reduction in a Cu electroplating industry effluent with an optimum adsorbent dosage of 100 g/l and an optimum agitation speed of 50 rpm

From Fig.3, it was found that the adsorption ability of *Moringa oleifera* seed powder to remove Cu in a Cu electroplating industry effluent increased with decreasing of initial concentration. The maximum removal percentage was achieved for the dilution ratio of 4. Further, it was observed that within the first 20 min., adsorption of Cu by *Moringa oleifera* seed powder occurred very rapidly but attained the equilibrium at 50 min. for all dilution factors.

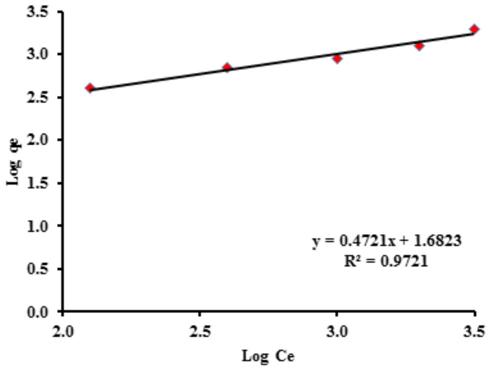

Fig.4.Freundlich Adsorption Isotherm for Cu in a Cu Electroplating Industry Effluent

The removal efficiency of Cu in a Cu electroplating industry wastewater in Fig.3 was used for fitting the Freundlich isotherm model. Fig. 4 represents the Freundlich isotherm for removing Cu in a Cu electroplating industry effluent. From Fig.4, it was found that the experimental data fitted well with Freundlich equation (R^2=0.9721) for Cu in a Cu electroplating industry effluent. From Fig.4, the values of K_f and n were found to be 48.11 and 2.118 for the parameter Cu. Based on the results obtained from the isotherm model, Freundlich isotherm model could be reproduced the experimental results for removing Cu in a Cu electroplating industry effluent.

4. CONCLUSION

The experiments have been performed to know the effect of *Moringa oleifera* seed powder for removing Cu in a Cu electroplating industry effluent. The experimental investigation was done at an optimum dosage of 100 mg/l, agitation speed of 50 rpm and concentration dilution of 4. The result of this study indicated that maximum of 84.5 % Cu was removed in a Cu electroplating industry effluent by the *Moringa oleifera* seed powder. Further, an optimum of 50 min. contact time, the maximum removal was occurred. Freundlich isotherm model is used to fit the experimental data of this study. Results of the isotherm model indicated that the equilibrium experimental data found fitted well with Freundlich isotherm model. Thus, the results of experimental and model studies indicated that use of *Moringa oleifera* seed powder for removing Cu in a Cu electroplating industry effluent seems to be most economical and worthwhile alternative method over conventional methods.

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