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Equilibrium and Isotherm Studies on 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 total dissolved solids and sulphate in an 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 Langmuir 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 wastewater, *Moringa oleifera* seed powder, Adsorption, Isotherm.

1. INTRODUCTION

Electroplating units have potential to generate the effluent consisting of heavy metals like chromium, copper, zinc, cadmium etc. and various organic compounds such as phenols, formaldehyde etc. The toxicity of the effluent obviously depends on the concentration of the respective metals as well as duration and type of discharge. With the increasing use of variety of heavy metals in electroplating industry problem may arise from potential toxicity in the environment to a great extent as equal that of heavy metals toxicity from other sources. Wastewater management in the electroplating industry wastewater is well documented, but wastewater production and disposal remain a problematic issue, since, surface water and groundwater is contaminated due to industrial wastewater when it is not discharged properly (Sivakumar Durairaj, 2013c; Sivakumar, 2011).

With a view to recycle and reuse the wastewater, adsorption process was adopted as single stage treatment instead of the existing physical, chemical and biological methods. The greatest advantage of this method is that desired materials are separated from a solution by a simple and compact process, producing less secondary waste. Other advantages are large active surface area for a given mass of particles, and the ability to process a solution that contains suspended solids.

Exploration of good low cost and non-conventional adsorbent may contribute to the sustainability of the environment and offer promising benefits for the commercial purpose in future. The costs of the activated carbon prepared from biomaterials are negligible when compared to the cost of commercial activated carbon. Some of the activated carbons used to treat the industrial wastewater in the recent past are, corncob, groundnut husk, rice husk, tea leaves carbon, saw dust, eucalyptus bark, and agricultural wastes. Further, in the laboratory and field studies, seed of *Moringa oleifera* (as a coagulant) was used for treating water in addition to other treatment processes are adsorption (Sivakumar and Shankar, 2012; Sivakumar, 2013b; Sivakumar, 2014c; Sivakumar, 2014f; Sivakumar, 2014g; Sivakumar, 2014k; Shankar, 2014a; Sivakumar and Nouri, 2015), ion exchange, chemical precipitation, bioremediation (Shankar, 2014b; Sivakumar, 2014d, Sivakumar, 2014e), constructed wetland (Sivakumar, 2013a; Sivakumar, 2014h; Sivakumar, 2015) and electro-dialysis (Sivakumar, 2014i; Sivakumar, 2014j) 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.

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).

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 and then powdered form of *Moringa* *oleifera* seed was kept in the refrigerator at a temperature of 4 °C for conducting experiments in later stage. This method was used to avoid the decomposition of powder, because the *Moringa oleifera* seed powder is an agro-based product. The use of natural materials of plant origin to purify water and wastewater is not a new idea. This study mainly pays attention to *Moringa oleifera*, a natural material of plant origin, used to purify municipal solid waste leachate. *M. oleifera* belongs to the family Moringaceae. *M. oleifera* originates in India and spread throughout the tropics from Northeastern Pakistan (from 33°N to 73°E) to Northern West Bengal State in India and Northeastern Bangladesh. It can grow at elevations from sea level to 1,400 m. It is cultivated in most parts of Pakistan, India, and Nepal, as well as in Afghanistan, Bangladesh Sri Lanka, Southeast Asia, West Asia, the Arabian Peninsula, East and West Africa, throughout the West Indies and Southern Florida, in Central and South America from Mexico to Peru, as well as in Brazil and Paraguay. *M. oleifera* is a slender softwood tree that branches freely and can grow extremely fast to a height of 10 m. It will survive in a temperature range from 25 to 40 °C, but has been known to tolerate temperature of 48 °C and light frosts. *M. oleifera* grows neutral to slightly acidic soils and grows best in well-drained loam to clay-loam. It tolerates clay soils but does not grow well in waterlogged condition.

Phase II: Cu electroplating industry effluent from the Ambattur Industrial Estate was collected with the help of air tight bottles. The quality was analyzed using standard procedure (APHA, 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.

Phase III: In the present study, the Phipps and Bird jar test apparatus was used for evaluating and optimizing the adsorption process [4]. In this study, 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 given by APHA, 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

$$q_t = \frac{(C_0 - C_t)V}{M}$$

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.

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 shows 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.

3.3. Equilibrium Study: Adsorption isotherms are mathematical models that describe the distribution of the adsorbate species among liquid and adsorbent, based on a set of assumptions that are mainly related to the heterogeneity/homogeneity of adsorbents, the type of coverage and possibility of interaction between the adsorbate species. Adsorption data are usually described by adsorption isotherms, such as Langmuir and Freundlich isotherms. These isotherms relate metal uptake per unit mass of adsorbent, q_e, to the equilibrium adsorbate concentration in the bulk fluid phase C_e. In this study, Langmuir model only described in details.

The Langmuir model is based on the assumption that the maximum adsorption occurs when a saturated monolayer of solute molecules is present on the adsorbent surface, the energy of adsorption is constant and there is no migration of adsorbate molecules in the surface plane. The Langmuir isotherm is given by:

$$q_e = \frac{q_m K_L C_e}{1 + K_L C_e}$$

The constants in the Langmuir isotherm can be determined by plotting ($1/q_e$) versus ($1/ C_e$) and making use of above equation rewritten as:

$$\frac{1}{q_e} = \frac{1}{q_m} + \frac{1}{q_m K_L}\frac{1}{C_e}$$

where, q_m and K_L are the Langmuir constants, representing the maximum adsorption capacity for the solid phase loading and the energy constant related to the heat of adsorption respectively. The optimum adsorbent dosage of 100 g/l and agitation speed of 50 rpm was used for conducting the equilibrium study against the different concentration of Cu electroplating industry effluent for the 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. From the Fig.3, it may be observed that the adsorption capacity of *Moringa oleifera* seed powder for removing 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 is found that adsorption of Cu by *Moringa oleifera* seed powder occurred very rapidly within the first 20 min., but attained the equilibrium at 50 min. for all dilution factors.

The removal efficiency of Cu in a Cu electroplating industry wastewater in Fig.3 was used for fitting the Longmuir isotherm model. The results of Longmuir isotherm for the removal of Cu in a Cu electroplating industry effluent is presented in Fig.4. It can be seen from Fig.4 that the isotherm data fits the Langmuir equation well (R^2=0.9912) for Cu in a Cu electroplating industry effluent. From Fig.4, the values of q_m and K_L were found to be 1.54 mg/g and 0.0018 L/mg for the parameter Cu. Based on the results obtained from the isotherm model, Langmuir isotherm model could be reproduced the experimental results for the removal of Cu in a Cu electroplating industry effluent.

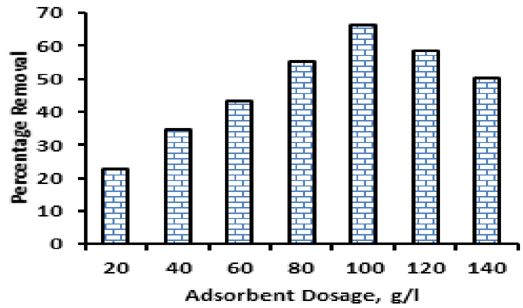

Fig.1 The effect of Adsorbent Dosage on Cu reduction in a Cu electroplating industry effluent with an agitation speed of 100 rpm nd an initial concentration of Cu of 183 mg/l

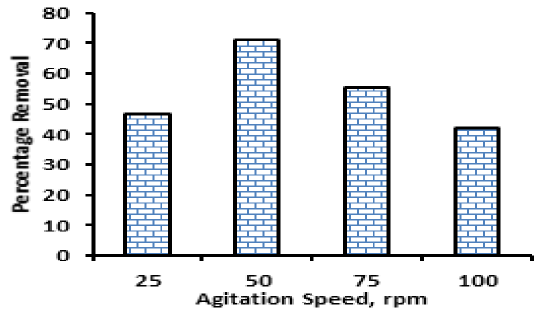

Fig.2 The effect of agitation speed on Cu reduction in a Cu electroplating industry effluent with an optimum adsorbent dosage of 100 g/l and an initial concentration of Cu of 183 mg/l.

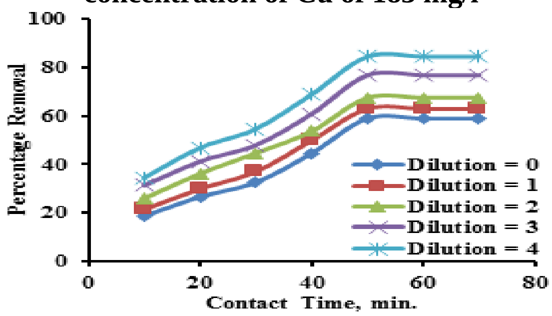

Fig.3.The effect of concentration on Cu reduction in a Cu electroplating industry effluent with an optimum adsorbent dosage of 100 g/l and an optimum agitation speed of 50 rpm

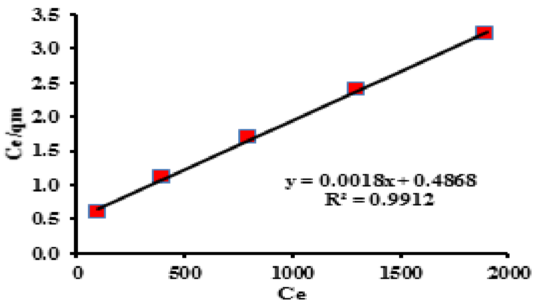

Fig.4 Longmuir Adsorption Isotherm for Cu in a Cu Electroplating Industry Effluent

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 results showed that the maximum adsorption by the *Moringa oleifera* seed powder for removing Cu in a Cu electroplating industry effluent found to be 84.5 % and were obtained at an optimum dosage of 100 mg/l, agitation speed of 50 rpm and concentration dilution of 4. Further, the maximum removal was occurred at an optimum contact time of 50 min. The experimental data were fitted to Langmuir isotherm model. Based on the results obtained from the isotherm model, the equilibrium data found fitted well with Langmuir 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 an economical and worthwhile alternative over conventional methods.

REFERENCES

APHA, AWWA, and WEF, Standard methods for the examination of water and wastewater, 20th edition, APHA Publication, Washington D.C, 2005.

Shankar D, Sivakumar D, Thiruvengadam M, Manojkumar M, Colour removal in a textile industry wastewater using coconut coir pith, Pollution Research, 33, 2014a, 490–503.

Shankar D, Sivakumar D, Yuvashree R, Chromium (VI) removal from tannery industry wastewater using fungi species, Pollution Research, 33, 2014b, 505–510.

Sivakumar D, A study on contaminant migration of sugarcane effluent through porous soil medium, Int. J. Environ. Sci. Tech., 8, 2011, 593–604.

Sivakumar D, Balasundaram V, Venkatesan G, Saravanan S.P, Effect of tamarind kernel powder for treating dairy industry wastewater, Pollution Research, 33, 2014c, 519–523.

Sivakumar D, Gayathri G, Nishanthi R, Vijayabharathi V, Sudeshna Das, Kavitha R, Role of fungi species in colour removal from textile industry wastewater, International Journal of ChemTech Research, 6, 2014d, 4366–4372.

Sivakumar D, Hexavalent chromium removal in a tannery industry wastewater using rice husk silica, 1(4), 2015, 27-40.

Sivakumar D, Kandaswamy A.N, Gomathi V, Rajeshwaran R and Murugan N, Bioremediation studies on reduction of heavy metals toxicity, Pollution Research, 33, 2014e, 553–558.

Sivakumar D, Murugan N, Rajeshwaran R, Shobana T, Soundarya C, Vanitha V.S, Role of rice husk silica powder for removing Cr(VI) in a tannery industry wastewater, International Journal of ChemTech Research, 6, 2014f, 4373–4378.

Sivakumar D, Nouri J, Removal of contaminants in a paper mill effluent by Azolla Caroliniana, 1(4), 2015, 297-304.

Sivakumar D, Role of low cost agro-based adsorbent to treat hospital wastewater, Pollution Research, 2014g, 33, 573–576.

Sivakumar D, Shankar D, Dhivya P, Balasubramanian K, Bioaccumulation study by lemna gibba lin., Pollution Research, 33, 2014h, 531–536.

Sivakumar D, Shankar D, Gomathi V and Nandakumaar A, Application of electro-dialysis on removal of heavy metals, Pollution Research, 33, 2014i, 627–637.

Sivakumar D, Shankar D, Kandaswamy A.N and Ammaiappan M, Role of electro-dialysis and electro-dialysis cum adsorption for chromium (VI) reduction, Pollution Research, 33, 2014j, 547–552.

Sivakumar D, Shankar D, Nithya S, Rajaganapathy J, Reduction of contaminants from leachate using *moringa oleifera*– A kinetic study, Pollution Research, 33, 2014k, 529-529.

Sivakumar D, Shankar D, Vijaya Prathima A.J.R, Valarmathi M, Constructed wetlands treatment of textile industry wastewater using aquatic macrophytes, International Journal of Environmental Science, 3, 2013a, 1223–1232.

Sivakumar Durairaj, Adsorption study on municipal solid waste leachate using moringa oleifera seed, Int. J. Environ. Sci. Technol., 10, 2013b, 113–124.

Sivakumar Durairaj, Experimental and analytical model studies on leachate volume computation from solid waste, Int. J. Environ. Sci. Tech., 10, 2013c, 903–916.

Sivakumar Durairaj, Shankar Durairaj, Colour removal from textile industry wastewater using low cost adsorbents, International Journal of Chemical, Environmental and Pharmaceutical Research, 3, 2012, 52–57.