Determination of adsorption isotherm models for the biosorption of chromium using cherry leaves (*Muntingia calabura* L.)

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ABSTRACT

Contaminations of industrial metals into the river possess major threat to environment. Chromium is a heavy metal which has the wide applications in tannery and electroplating industries. Above the permitted level of Chromium(VI) into surface water leads to severe health hazards. Therefore, biosorption is a technology used for the sorption of heavy metal. In this present study adsorption isotherm models was studied for the biosorption of chromium by cherry leaves. From the adsorption isotherms it was found that the experimental data fits well with the Langmuir isotherm than the Freundlich isotherm. The monolayer capacity Q_m was fond to be 11.98 mg/l and the adsorption affinity was found to be positive which indicates the efficient biosorption of chromium.

Keywords: Adsorption isotherm model; Monolayer capacity; Adsorption affinity; Cherry leaves

1. INTRODUCTION

An accelerated release of the heavy metals into the aquatic environment poses serious water pollution problems because of their toxicity, persistence and bioaccumulation in food chains. Metals and pesticides, in particular, have an inclination to accumulate and undergo food chain magnification (Klavins *et al*., 2009). Of the important metals such as mercury, lead, cadmium and chromium(VI) are regarded as toxic; whereas others, such as copper, nickel, cobalt and zinc are not as toxic, but their extensive usage and increasing levels in the environment are of serious concerns reported by Vijayaraghavan and Yeoung (2008). Its atomic number is 24. It is a hard metal of steely gray colour and also it has a high melting point of 1907 °C. It is odorless and tasteless metal. Many of it compounds are intensely coloured. Chromium is important metal due to its high corrosion resistance and hardness. According to the International Agency for Research on Cancer (IARC) Cr (VI) is considered as carcinogenic to both humans and animals. Therefore the permitted level of Chromium (VI) into surface water is regulated to below 0.05 mg/l by the U.S. EPA, while total Cr (including Cr(III), Cr(VI) and its other forms) is regulated to below 2 mg/l reported by Deepa prabhu *et al*. (2006) and Donghee *et al*. (2004).

Photo 1. *Muntingia calabura* – tree.

Photo 2. *Muntingia calabura* – flower and fruit.

Effluents can also contain inorganic wastes such as brine salts and metals. The increased industrial activities have reduced the availability of good quality water by producing a large amount of effluents to the rivers. Industrial effluents often contain various toxic metals, harmful gases and several organic and inorganic compounds. Babarinde (2011) stated that neem (*Azadirachta indica)* is a plant that grows across the world and it is used majorly for medicinal purpose. Hossain *et al*. (2007) states that banana peels is a low cost and readily available materials for preparing bioadsorbent. In this present work adsorption isotherm models were tested for the biosorption of chromium using cherry leaves.

2. MATERIALS AND METHODS

2. 1. Selection of the plant

Cherry leaf was selected as adsorbent for removal of chromium ion in this study. The leaves were obtained from a Cherry tree located in K. S Rangasamy College of Technology (Autonomous), Tiruchengode. The plant was identified and authenticated by Botanical Survey of India Southern Circle, Tamil Nadu Agricultural University, Coimbatore. The binomial name of cherry leaves is *Muntingia calabura* L.

2. 2. Preparation of leaf adsorbent

Mature Cherry leaves were collected and it was washed thoroughly under running tap water to remove dust and any adhering particles. The leaves were then dried under sunlight for a few days until it became crisp. The dried leaves were crushed and blended to powder form using a blender. It was stored in an airtight plastic for further use to avoid contact with moisture in atmosphere.

2. 3. Preparation of chromium stock solution

Stock solution of chromium of 1000 mg/L was prepared by dissolving 2.828 g of potassium dichromate in 1 L of distilled water. The working solution was prepared by diluting the stock solution.

2. 4. Chromium analysis

Chromium content was analyzed using spectrophotometric method, as described in the Standard methods for the Examination of Waste and Wastewater (APHA), to measure the concentrations of the Cr. The reaction takes place between Cr and 1,5-diphenycarbazide results in the pink coloured complex. Then it was able to be spectrophotometrically analyzed at 540 nm.

2. 5. Adsorption isotherm model

There are different types of isotherm model from that Langmuir and Freundlich isotherm were tested.

2. 6. Langmuir Isotherm

Maximum adsorption capacity was produced from complete monolayer coverage of adsorbent surface was determined by Langmuir Isotherm. It was given as,

$$C_e/q_e = 1/bq_m + Ce/qm$$

where;
C_e = Concentration of chromium at equilibrium (g/l)
q_e = amount of chromium bioadsorbed at equilibrium (mg/l)
q_m = amount of chromium sorbed per unit mass of the bioadsorbent (mg/g)
$B = Ka/Kb$
K_a = adsorption rate constant
K_b = desorption rate constant
From the plot of (c_e/q_e) vs c_e, the intercept and slope tends to b and q_m value respectively.

2. 7. Freundlich Isotherm Model

The Freundlich Isotherm model was used to describe the adsorption on a heterogeneous surface. It was expressed as

$$\log q_e = \log K_f + n\ C_e$$

where;
q_e = amount of chromium bioadsorbed at equilibrium(mg/l).
C_e = Concentration of chromium at equilibrium (g/l).
K_f = Adsorption capacity (l/g)
n = Adsorption affinity (Dimensionless).
From the plot of $\log q_e$ vs $\log c_e$, the intercept and slope tends to K_f and adsorption affinity n.

Pearson's chi-squared test was used to analyze the goodness of fit for pseudo first and second order reactions model. Its properties were first investigated by Karl Pearson in 1900.

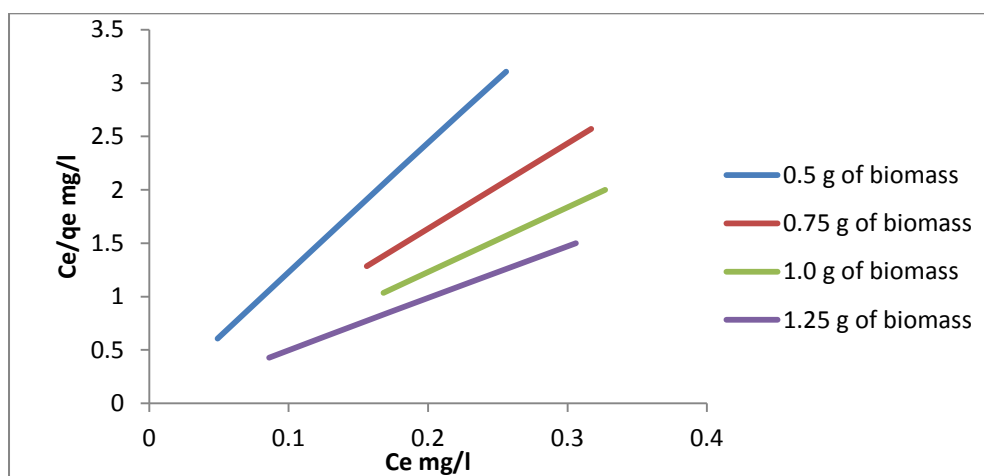## 3. RESULTS AND DISCUSSION

3. 1. Langmuir isotherm model

Fig. 1. Langmuir isotherm for the biosorption of Cr by cherry leaves powder at different biosorbent dosage.

Fig. 1. shows that the plot of (C_e/q_e) vs C_e was found to yield a straight line and the slopes and the intercepts of the plots give a the values of q_m and b. The monolayer capacity of bioadsorbent was found to be q_m 11.98 mg/g which was quite larger than crab shell.

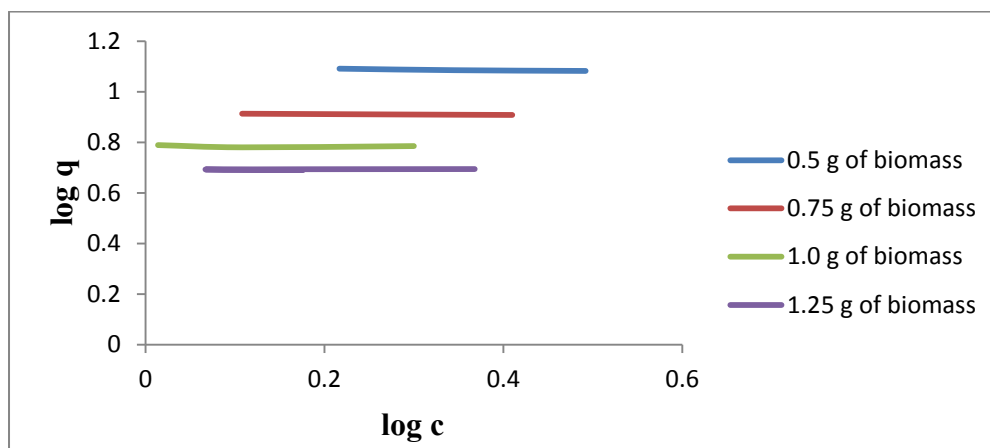### 3. 2. Freundlich Isotherm model

Fig. 2. Freundlich isotherms for the biosorption of Cr by cherry leaves powder at different biosorbent dosage.

Fig. 2. shows that the plot of log q_e vs log c_e found to yield a straight line and the slopes and the intercepts of the plots gives the values of n and k_f. The adsorption affinity '1/n' havingvalues less than 1, which is related to a favourable sorption of chromium.

In both the plots there is a good agreement between experimental and predicted behaviour such that the regression coefficient R^2 was close to 1.

Table 1. Bioadsorption Coefficients for chromium.

D g/l	R^2	Qm mg/g	B l/mg	R^2	K_f l/g	1/ n
0.5	0.97	11.98	0.002	0.91	1.084	0.12
0.75	0.96	7.987	0.038	0.89	0.914	0.16
1.0	0.987	6.067	0.016	0.92	0.789	0.14
1.25	0.968	4.869	0.011	0.878	0.690	0.06

4. CONCLUSION

From the adsorption isotherms the experimental data fits well with the Langmuir isotherm than the Freundlich isotherm. The monolayer capacity Q_m was fond to be 11.98 mg/l and the adsorption affinity was found to be positive which indicates the efficient biosorption of chromium.

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