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Removal of Basic Yellow 11 from Aqueous Solution by Sorption on *Caulerpalentillifera* (Chorophyceaea)

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Abstract. The sorption capability of green seaweeds, *Caulerpalentillifera* in removing acid yellow 25 (AY25) and basic yellow 11 (BY11) from aqueous solution was investigated. From the study, *C. lentillifera* exhibited better ability to remove basic yellow 11 (98%) than acid yellow 25 (70%). Thus, by emphasizing on BY11, the effects of seaweeds morphology, initial dye concentration and seaweeds concentration on biosorption process were investigated. The results revealed that sorption capacity of *C. lentillifera* increased with increasing of initial dye concentration, and decreased with increasing of seaweed concentration. The sorption mechanism complied well with both Langmuir and Freundlich adsorption isotherm models, indicating the presence of heterogenous and multilayer sorption process. In conclusion, *C. lentillifera* could be used as a potential biosorbent for the removal of basic dyes from wastewater.

Keywords: Batch sorption, Basic yellow 11, *Caulerpalentillifera*, Sortion isotherms

1. Introduction

Colour is the most undesirable pollution in the environment and is mainly cause by dye discharged wastewater. Removal of colour from dye bearing effluents become the major problem in wastewater treatment as they are relatively resistant to microbial degradation due to their complicated structures. Biosorption is one of the popular and effective methods used to treat the wastewater (Gupta and Suhas, 2009). The main advantage of this method is the ability of using low cost biosorption materials in removing the pollutants in the environment. Seaweeds have the potential to be one of the low cost and effective biosorbent. This is because (1) they can be cultured, and (2) the special surface properties of the seaweeds enable them to adsorb different kinds of metallic and organic pollutants. One of the seaweeds that are found abundantly in Malaysian coastal water is the green seaweeds, *Caulerpalentillifera*, which is a potential low cost biosorbents. The seaweeds have abundant functional groups on the surface like hydroxyl, carbonyl and amine groups, which enable them to bind to various pollutants. Thus, this study was undertaken to investigate the efficiency of *C. lentillifera*, as a biosorbent for the removal of basic yellow 11 from synthetic solution.

2. Materials and Methods

2.1. Biosorbent preparation

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Fresh *Caulerpalentillifera* was collected from Port Dickson, Negeri Sembilan, Malaysia. The plants were washed and rinsed with distilled water, then air-dried at room temperature, and stored in an airtight pack with silica at room temperature (30°C).

2.2. Preparation of dye solution

Solutions of acid yellow 25 (AY25) (Sigma-Aldrich, U.K.) and basic yellow 11 (BY11) (Sigma-Aldrich, U.K.) were prepared by adding distilled water to the dye powder. The maximum wavelengths of the dyes were determined by using double beam UV-VIS spectrophotometer.All the experiments were carried out in the condition of 30°C and 130 rpm in orbital shaker. Preliminary tests were carried out on removal of acid yellow 25 and basic yellow 11 by using *C. lentillifera.* Dye which can be adsorbed at the fastest rate was chosen for subsequent studies. Effects of affecting parameters include seaweeds concentration (0.1 g, 0.5 g, 1.0 g, 1.5 g, and 2.0g), initial dye concentration (100 mg/L, 200mg/L, 500mg/L, 1000mg/L and 2000 mg/L), and morphology of seaweed (intact and powderised form) were investigated.

2.3. Batch biosorption experiments

The biosorption capacity of *C. lentillifera* (q) was determined by using Equation 1.

$$q_e = \frac{(C_i - C_e)\ V}{M} \quad \text{[Equation 1]}$$

whereC_i and C_e are the initial and equilibrium dye concentrations (g / L), V the solution volume (L) and M is the sorbent dosage (g)

The percentage of dye removal was calculated using Equation 2.

$$\text{Percentage of dye removal (\%)} = \frac{(C_i - C_e)}{C_i}\ \text{X}\ 100 \quad \text{[Equation 2]}$$

3. Results and Discussion

From the study, *C. lentillifera* was found to be able to remove BY11 (98.2 %) more efficient than AY25 (69.6%) (Fig. 1). It is due to the fact that surface of the seaweed is negatively charge (Maurya et al., 2006) while BY11 is positively charge (El Qada et al., 2007). Thus, this will favours the formation of bonding between dye cations and the surface of seaweed. On the other hand, AY25 is an anionic dye which is negatively charge. Repulsive force is created between the dye molecules and the surface of the seaweed. As a result, the sorption capacity decreased. For the subsequent studies, BY11 was chosen as the key dye.

The removal efficiency (%) of both intact and powderised form of *C. lentillifera* at equilibrium are 90.5 % and 90.7 %, respectively (Fig. 2A). One-way ANOVA showed that there is no significant difference between the sorption efficiency by using two morphologies of *C. lentillifera* ($p > 0.05$). Theoretically, powderised form of particles will provide higher surface area and more binding sites for dye cations. Kannan and Sundaram (2001) found that available surface area increased with the decreased in particle size. There is a possibility that the grinding process did not deteriorate the sorption integrity of the seaweed (Pavasant et al., 2006). Therefore, no visible effect can be observed between the two morphologies. Seaweed in intact form was chosen due to its simplicity in preparation.

The uptake of dye on to seaweeds (mg/g) decreased with the increased of seaweeds concentration (g) (Fig. 2B). As seaweeds concentration increased, the surface area of the seaweeds and binding sites for BY11 increased while the residual concentration of dye in solution decreased. The available dye molecules are not sufficient to cover all the sites on the biosorbent and thus dye uptake decreased (Aravindhan et al., 2007).

Quantities of dye absorbed increased from 9 to 166.8 mg/g with the increased of initial dye concentration from 100 mg/L to 2000 mg/L (Fig. 2C). The adsorption capacity at equilibrium is linearly proportional to the initial dye concentration. With the increase in initial dye concentration, the dye molecules available for biosorption will be increased. As a result, the collisions between dye cations and the surface of seaweed occurred more frequently (Daneshvar et al., 2007), which will enhance the adsorption process.

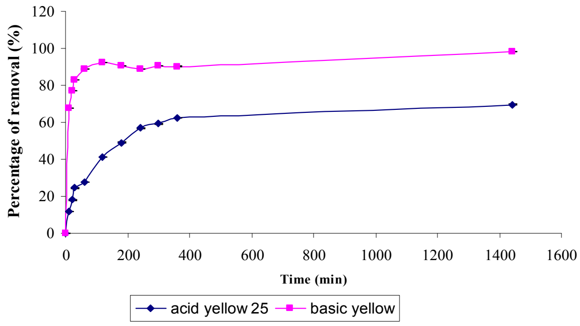

Fig. 1: Adsorption of AY25 and BY11by using *C. lentillifera*.

(A)

(B)

(C)

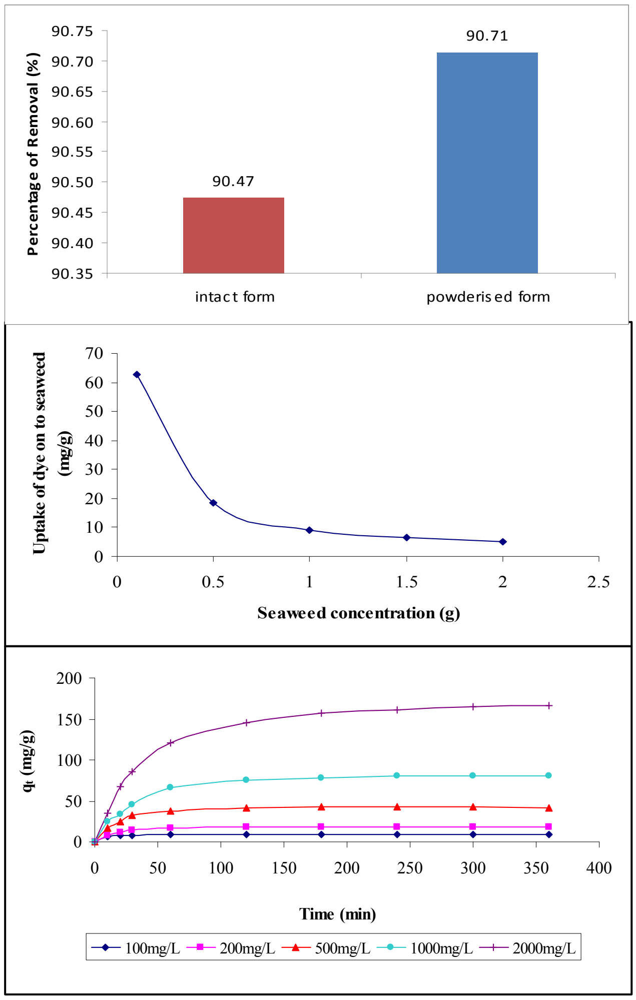

Fig. 2: Uptake of BY11 by *C. lentillifera*.

A. Effect of seaweed morphology. (V, 100 mL; C_o, 100 mg L−1; M, 1.0 g; temp, 30°C; agitation speed, 130 rpm)
B. Effect of seaweed concentration. (morphology: intact; V, 100 mL; temp, 30°C; agitation speed, 130 rpm)
C. Effect of initial dye concentration. (morphology: intact; V, 100 mL; M, 1.0 g; temp, 30°C; agitation speed, 130 rpm)

Langmuir isotherm assumes monolayer coverage of adsorbate over homogenous adsorbent surface. The surface consists of identical sites equally available for adsorption. Sorption of each molecule has equal sorption activation energy (Aravindhan et al., 2007). Langmuir isotherm is expressed by:

$$\frac{1}{q_e} = \frac{1}{q_{max}} + \left(\frac{1}{bq_{max}}\right) X \left(\frac{1}{C_e}\right)$$

whereq_e: the maximum uptake capacity ; C_e: the equilibrium concentration; b: affinity between sorbate and sorbent

Freundlich isotherm assumes that adsorbent consists of a heterogeneous surface composed of different classes of adsorption sites (Aravindhan et al., 2007). The isotherm is expressed by:

$$\text{Log } q_e = \log K_f + \frac{\log C_e}{n}$$

whereK_f and n are Freundlichbiosorption isotherm constants. The plot of logq_e versus log C_e for the biosorption of BY11 onto the biosorbent should give a straight line with a slope of $\frac{1}{n}$ and intercept of log K_f. The value of $\frac{1}{n}$ less than 1 shows favourable adsorption process (Cengiz and Cavas, 2008).

The coefficient correlation values for both of the isotherms are the same which is 0.9739 (Table 3). Therefore, both isotherms can be accepted.

Table 3.Biosorption isotherm constants for biosorption of BY11 onto *C. lentillifera*

Langmuir constants			**Freundlich constants**		
q_m(mg / g)	b (mg / L)	q_m(mg / g)	b (mg / L)	q_m(mg / g)	b (mg / L)
178.571	0.006	178.571	0.006	178.571	0.006

In conclusion, the present studies showed that *C. lentillifera* can be employed to remove BY11 successfully from the synthetic solution and equilibrium data fitted well to both Langmuir and Freundlich isotherms.

4. Acknowledgements

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