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Use of *Chlorella vulgaris* for bioremediation of textile wastewater

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ABSTRACT

The potential application of *Chlorella vulgaris* UMACC 001 for bioremediation of textile wastewater (TW) was investigated using four batches of cultures in high rate algae ponds (HRAP) containing textile dye (Supranol Red 3BW) or TW. The biomass attained ranged from 0.17 to 2.26 mg chlorophyll a/L while colour removal ranged from 41.8% to 50.0%. There was also reduction of NH_4–N (44.4–45.1%), PO_4–P (33.1–33.3%) and COD (38.3–62.3%) in the TW. Supplementation of the TW with nutrients of Bold's Basal Medium (BBM) increased biomass production but did not improve colour removal or reduction of pollutants. The mechanism of colour removal by *C. vulgaris* is biosorption, in accordance with both the Langmuir and Freundlich models. The HRAP using *C. vulgaris* offers a good system for the polishing of TW before final discharge.

1. Introduction

The textile industry is the third largest foreign exchange earner after the electronic and palm oil industries in Malaysia, contributing total earnings of RM 18.0 million (US$ 5.4 million) from manufactured exports in 2007 (Malaysian Textile Manufacturers Association, 2008). There are about 1500 textile factories in Malaysia, many of which operate as backyard or cottage industries producing the local 'batik'. There is concern about the large volumes of effluent discharged from textile processing, which consumes large amounts of water. Colour has been included in the water quality standards for the discharge of industrial effluents in Malaysia. Under the Environmental Quality (Industrial Effluents) Regulations, 2009, the limits of colour for discharge of effluents according to standards A and B are 100 and 200 Platinum–Cobalt (PtCo) units, respectively (DOE (Department of Environment), 2010). It is difficult for most textile factories to adequately treat their wastewater.

Textile wastewater is characterised by strong colour, high salinity, high temperature, variable pH and high chemical oxygen demand (COD) (Mantzavinos and Psillakis, 2004). The coloured wastewater affects aesthetics, water transparency and gas solubility in water bodies and can be toxic to aquatic flora and fauna, and this causes severe environmental problems worldwide (Vandevivere et al., 1998). Furthermore, most synthetic azo dyes and their metabolites are toxic, carcinogenic and mutagenic, posing a potential hazard to human health (Nilsson et al., 1993).

The treatment of textile effluent involves mainly physical and chemical methods, which are often very costly (Robinson et al., 2001). It is difficult to treat dye wastewater by chemical and physical processes because of the complex molecular structures. Furthermore, the disposal of the concentrated sludge creates another problem. There has been increased interest in using biological methods for remediation of textile wastewater, especially in colour removal. Most studies have concentrated on the use of fungi and bacteria to treat coloured wastewater (Tastan et al., 2010; McMullan et al., 2001). However, additional carbon sources are required for such systems. In recent years, the use of microalgae in bioremediation of coloured wastewater has attracted great interest due to their central role in carbon dioxide fixation. In addition, the algae biomass generated has great potential as feedstock for biofuel production (Huang et al., 2010).

Both living and non-viable algae have been used in colour removal from dyes and wastewater. The mechanisms involved include biosorption and bioconversion. For instance, non-viable biomass of *Spirogyra* has been shown to be a useful biosorbent for removal of reactive dye (Synazol) from textile wastewater (Khalaf, 2008). Living biomass of macroalgae such as *Caulerpa lentillifera* (Marungrueng and Pavasant, 2006) and *Caulerpa scalpelliformis* (Aravindhan et al., 2007) are able to remove basic dyes by biosorption. Through bioconversion, some algae can break down the dyes to more simple compounds. For instance, *Chlorella vulgaris* can remove 63–69% of the colour from the mono-azo dye tectilon yellow 2G by converting it to aniline (Acuner and Dilek, 2004). The ability to remove colour by algae can be enhanced by stimulating their growth. For instance, the removal of reactive dye by the

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