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BIOREMEDIATION OF TEXTILE DYE EFFLUENT BY USING *SPIRULINA PLATNESIS*

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ABSTRACT

An experiment to find out the decolourisation potential of *Spirulina platensis* obtained from Centre for advanced studies in Botany to remove dyes such as Violet 4BSDC, Crisopin Gilicon, Crimson 2GL, Yellow N2GL and Red NG from aqueous dye solution was performed. The results were subjected for Langmuir and Freundlich isothermal analysis to find it applicability for the dye removal.

Keywords: Decolourization, *Spirulina platensis*, textile dyes, bioremediation.

INTRODUCTION

Spirulina sp. is planktonic photosynthesis filamentous cyanobacterium [1], identified by the main morphological feature of the genus, i.e. the arrangement of multicellular cylindrical trichomes in a helix along the entire length of the filaments. Native people harvested biomass of *Spirulina* from Cha Lake (Africa) a Texcoco Lake (Mexico) as a source of food for centrie [2]. However, *Spirulina platensis* has been commercially cultivated due to its biotechnological importance since 1970s [2]. It is known that *Spirulina* is a versatile organism due to its high nutritional value such as rich in protein content [3, 4], polyunsaturated fatty acid (γ-linoleic acid) [5], pigment [6, 7], vitamin and phenolics [8, 9]. Optionally, biomass of *Spirulina* has been performed to removal unwanted materials such as excess fertilizer, heavy metals, textile and pesticides from wastewaters [10, 11, 12, and 13].

Dyeing industry effluents constitute one of the most problematic wastewaters to be treated not only for their high chemical and biological oxygen demands, suspended solids and content in toxic compounds but also for color, which is the first contaminant to be recognized by human eye. Dyes may significantly affect photosynthetic activity in aquatic life reducing light penetration and may also be toxic to some aquatic life due to the presence of aromatics, metals, chlorides, etc., [14, 15, 16, 17 and 18].

Color in any water is undesirable and is therefore considered a pollutant. Dyes are stable to light and oxidizing agents and are sometimes resistant to biooxidation. Partial degradation products of azo dyes are aromatic amines which have toxic effects. The strong color of discharged dyes even at very small concentrations has a huge impact on the aquatic environment caused by its turbidity and high pollution strength [19].

Effluents from these industries are toxic, carcinogenic and mutagenic to various microorganisms, fish an even mammal. Biodecolourisation constitutes an attractive alternative to physicochemical methods as a low cost, eco-friendly and publicly acceptable technology. A large number of microorganisms that can degrade dyes, so far considered non-degradable have been isolated in recent years [20].

The present study aims to investigate the potential of commonly available *Spirulina* species from Centre for advanced studies in Botany, University of Madras, and Chennai for its degradation potential of textile dye effluent.

MATERIALS AND METHODS

Sample Collection & Preservation

The textile dye effluent was collected from a dyeing unit in Salem, Kumbakonam, Buvanagiri & Kanchipuram (Tamil Nadu, India). It was refrigerated at 4˚ C and used without any preliminary treatment.

Dyes

Dyes used in this research are Violet 4BSDC, Crisopin Gilicon, Crimson 2GL, Yellow N2GL and Red NG.

Collection of Algal Culture

Spirulina platensis was obtained from Centre for advanced studies in Botany, University of Madras, Chennai and used throughout the study.

Maintenance of Spirulina Isolates

The pure culture of *S.platensis* was maintained in Zarrouk's medium (composition : $NaHCo_3$-8g, $NaNo_3$-1.250g, $CaCl_2.2H_2O$-0.020g, K_2HPO_4-0.250g, K_2SO_4-0.500g, NaCl - 0.5g, $MgSO_4.7H_2O$-0.100g, EDTA-0.004g, Distilled water- 1000 ml, pH-10-11) in Erlenmeyer flasks exposed to partial sunlight in the day and illuminated light chamber in the night.

Identification & Characterization of Spirulina Platensis

It was identified using a compound microscope. The pure culture of *S.platensis* was spread over the glass slide, covered with cover glass and observed under low and high power objectives of the compound microscope. It consisted of multicellular, filamentous, unbranched and helicoidal trichomes. Motile cell structure likes flagella and heterocysts were absent. The filaments called 'trichomes' were formed by a single spirally twisted cell. The cells exhibited rotary movements.

Preparation of Aqueous Dye Solutions

Accurately 0.10-0.30 mg of each dye was weighed and dissolved in separate 100ml distilled water to get 10, 15, 20, 25, 30 ppm dye solution. The absorbance was measured at different wavelength from that maximum absorbance of the dye was used for further studies by using UV-Vis Spectrophotometer SL 159.

Dye Decolourization Experiments

Aqueous dye solutions containing 10, 15, 20, 25, 30 ppm were prepared with sterile distilled water which contain basal medium (KH_2PO_4-2g, KCl-0.2g, $MgSO_4$-0.2g, distilled water-1000ml, and pH-7). About 100ml of the dye solution was dispensed in 250ml conical flasks. 1ml (1×10^7 cfu ml^{-1})

Spirulina platensis culture were inoculate in each different flask and were incubate for 21 days in light chamber. During incubation period dye decolourization was noted.

Samples were drawn at 10, 15, 20, 25, 30 days intervals for observation. 10ml of the dye solution was filtered and centrifuged at 5000 rpm for 20 minutes. Decolourization was assessed by measuring absorbance of the supernatant with the help of UV-Vis spectrophotometer SL 159 at wavelength for violet 4BSDC (λm=480nm), Crimson 2GL (λm=401nm), Yellow N2GL (λm=434nm), Red NG (λm=580nm), Crisopin Gilicon (λm=598) at maximum wavelength of respective dyes.

Decolourization Assay

Decolourization assay was measured in the terms of percentage was calculated as follows:

Percentage dye removal = Initial OD-Final OD X100/Initial OD

Langmuir and Freundlich Isotherm

The results were subjected for the analysis of Langmuir & Freundlich isotherm to correlate the extent of adsorption.

Langmuir Isotherm

Langmuir isotherm model is expressed as,

$$q_e = Q°bC_e/1+bC_e$$

Where,

q_e (mg/g) = amount of adsorbed pollutant

C_e (mg/l) = Unadsorbed pollutant conc. in effluent at equilibrium

Q° (mg/g) = maxi amount of pollutant adsorbed

b = constant related to with affinity of binding sites.

Freundlich Isotherm

Freundlich [21] found that adsorption equilibrium data were often better described by the relationship

$$q_e = K_F C_e^{1/n}$$

Where K_F & n = Freundlich constants and the indicators of adsorption capacity and adsorption intensity.

$\text{Log } q_e = 1/n \log C_e + \log K_F$

A linear plot confirms the applicability of the isotherm.

RESULTS AND DISCUSSION

The textile dyes namely Violet 4BSDC, Crimson 2GL, Yellow N2GL, Red NG and Crisopin Gilicon was obtained from Salem, Kanchipuram, Buvanagiri and Kumbakonam. Decolourization of textile dye effluent was studied against *Spirulina platensis* obtained from Centre for advanced studies in Botany, University of Madras, Chennai.

Identification and characterization of *Spirulina Platensis*

It was identified using a compound microscope. The morphological characteristic of *S.platensis* was presented in Table 1. Morphologically they were found to be similar, multicellular, filamentous,

unbranched and helicoidal trichomes. The characters measured were spiral number, distance between spirals, length and width of trichomes, number of long trichomes (62 percentage) and short trichomes (22 percentages).

Table 1: Characters of *Spirulina platensis*

CHARACTERS	***Spirulina platensis***
Average number of spirals	2-3
Distance between spirals	50-50µm
Length of trichomes	270 µm
Width of trichomes	10.5µm
Number of long trichomes	62 percentage
Number of short trichomes	22 percentage

Dye Decolourization

The per centage removal of Violet 4BSDC, Crimson 2GL, Yellow N2GL, Red NG, Crisopin Gilicon by *S.platensis* was found to increased with a reduction in dye concentration. A maximum removal of 92.9% and 86% was recorded with *Spirulina platensis* at 10 and 30 ppm dye concentration respectively after 21 days.

The equilibrium time which has resulted in a higher removal of dyes using *S.platensis* was 21 days. Similarly Jothimani and Prabakaran [22] has reported 59% dye removal from a dyeing industry effluent using *Pseudomonas* after 4 days of inoculation and with *Bacillus*, it was 65.8% removal, whereas with Cashew nut hull cardon the removal was about 86.4% at 20 ppm after 80 minutes.

Langmir Isotherm

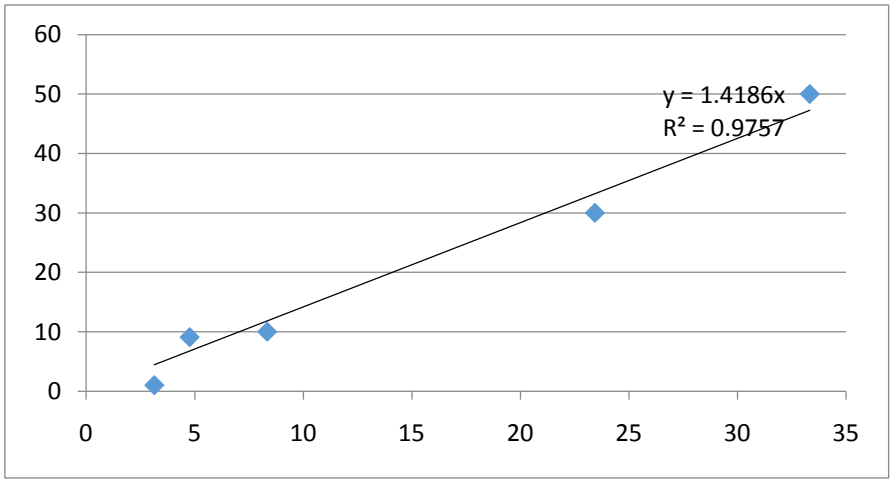
The higher decolourization potential of the algal strain was confirmed by subjecting the data for the analysis of Langmuir isotherm. The R2 values were less than 1 (Table 2) and the plot was linear suggesting the applicability of the Langmuir isotherm (Fig 2).

Table 2: Langmuir adsorption constants obtained for each dye at different dye

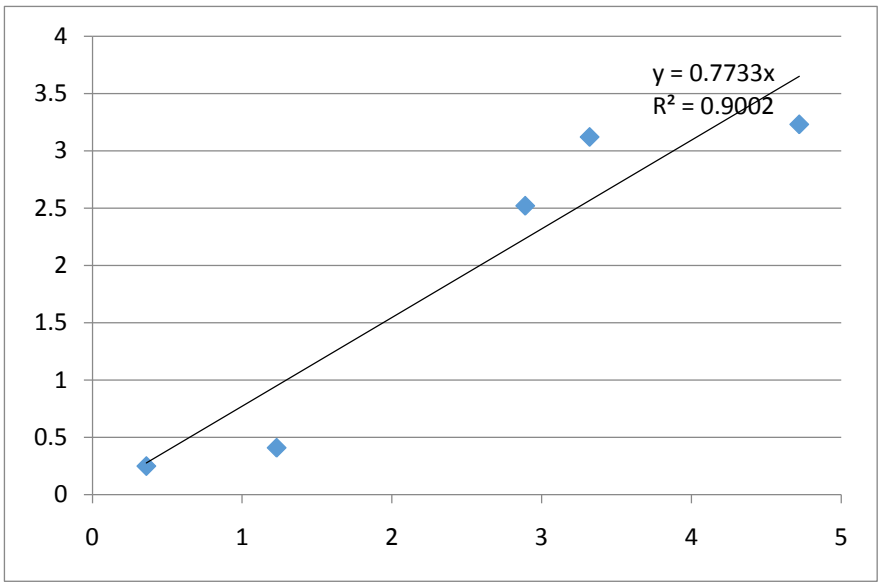
Concen. of dyes	Crimson 2GL		Yellow N2GL		Red NG		Crisopin Gilicon		Violet 4BSDC	
	$1/c_e$	$1/q_e$	$1/c_e$	$1/q_e$	$1/c_e$	$1/q_e$	$1/c_e$	$1/q_e$	$1/c_e$	$1/q_e$
10	33.33	50	4.72	3.23	23.8	7.04	12.69	9.05	166.67	7.4
15	23.43	30	3.32	3.12	12.6	4.67	12.63	7.32	90.9	3.96
20	8.33	10	2.89	2.52	8.26	2.97	8.25	5.96	47.61	0.99
25	4.76	9.09	1.23	0.41	6.66	1.88	4.33	3.87	38.46	0.89
30	3.13	1.01	0.36	0.25	5.34	0.82	2.57	1.87	13.51	0.84

Figure 2: Langmuir adsorption constants obtained for each dye at different dye concentration

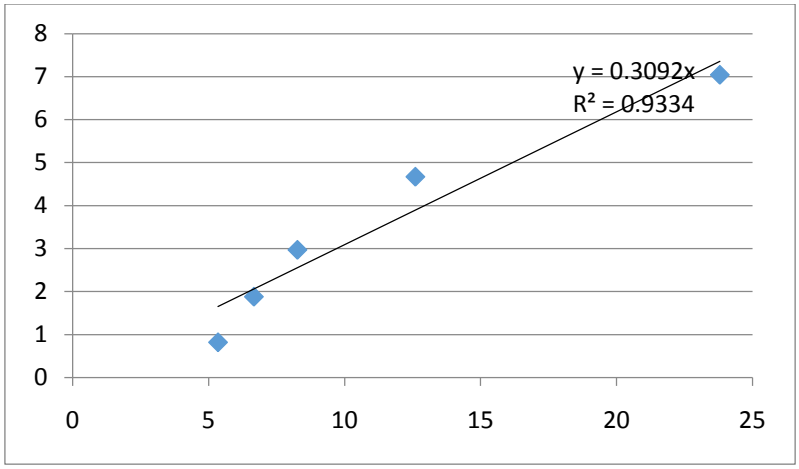
Crimson 2GL



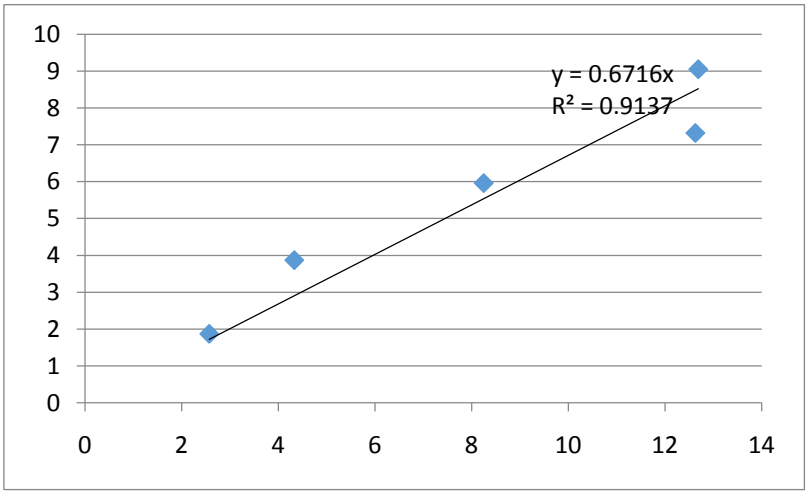
Yellow N2GL



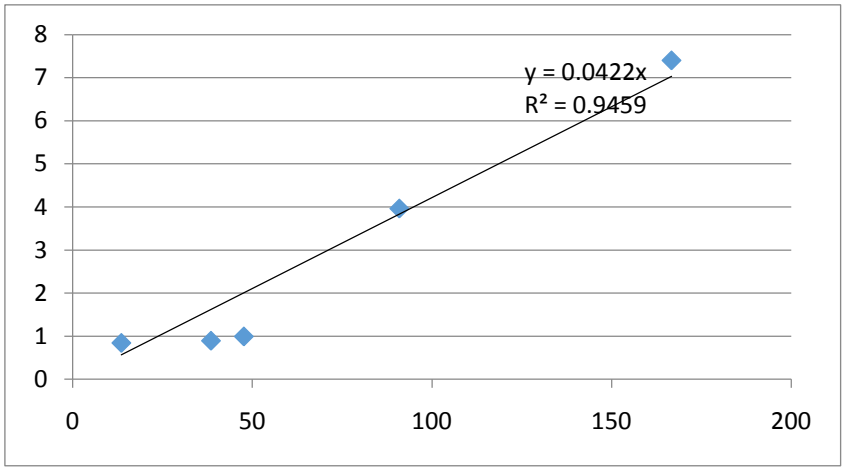
Red NG



Crisopin Gilicon



Violet 4BSDC



The Q° value for the removal of POMQR using Cashew nut hull carbon has been reported to be 9.8mg/g Vasanthy [23] and Mary [24] has reported a Q° value of 100mg/g for the removal of Procion Brilliant Blue MR using *Aspergillus flavus.*

Frendlich Isotherm

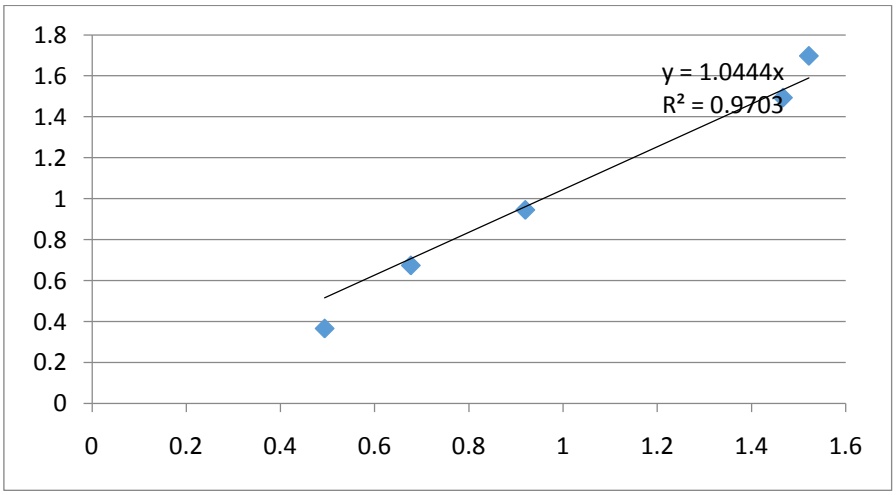
The higher decolourization potential of the algal strain was confirmed by subjecting the data for the analysis of Freundlich isotherms. The R^2 values were less than 1 (Table 3) and the plot was linear suggesting the applicability of the Freundlich isotherm (Fig 3).

Table 3: Frendlich adsorption constants for each dye at different concentration

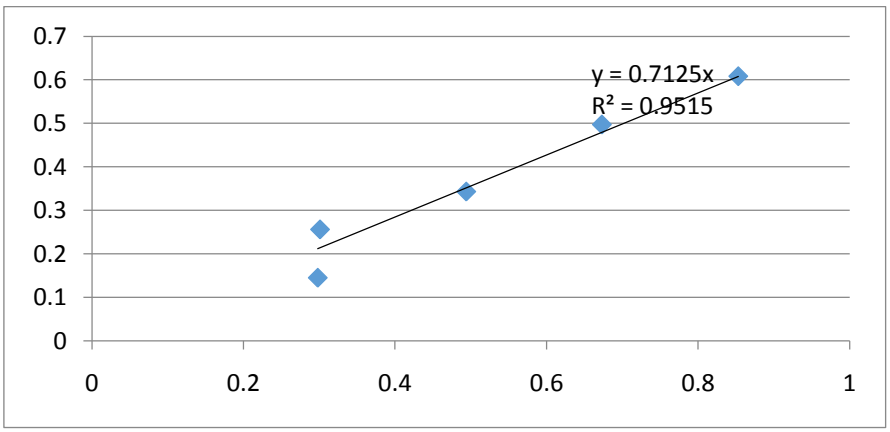
Concen. of dyes	Crimson 2GL		Yellow N2GL		Red NG		Crisopin Gilicon		Violet 4BSDC	
	log c_e	log q_e	log c_e	log q_e	log c_e	log q_e	log c_e	log q_e	log c_e	log q_e
10	1.522	1.698	0.853	0.608	0.917	0.847	1.35	2.84	1.86	2.958
15	1.467	1.494	0.673	0.497	0.823	0.669	1.42	2.65	1.56	2.221
20	0.92	0.946	0.494	0.343	0.728	0.83	0.35	0.54	0.346	0.877
25	0.677	0.675	0.301	0.256	0.376	0.36	0.12	0.45	0.15	0.678
30	0.494	0.367	0.298	0.145	0.075	0.053	0.02	0.34	0.07	0.334

Fig 3: Frendlich adsorption constants for each dye at different concentration

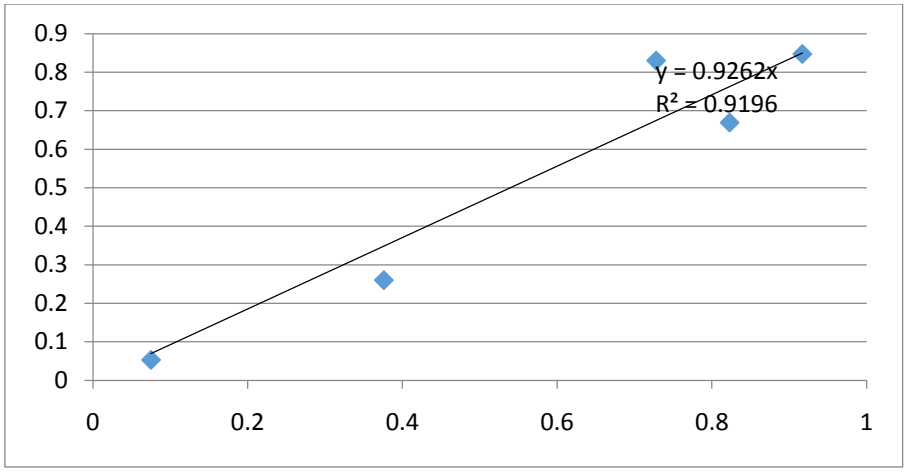
Crimson 2GL



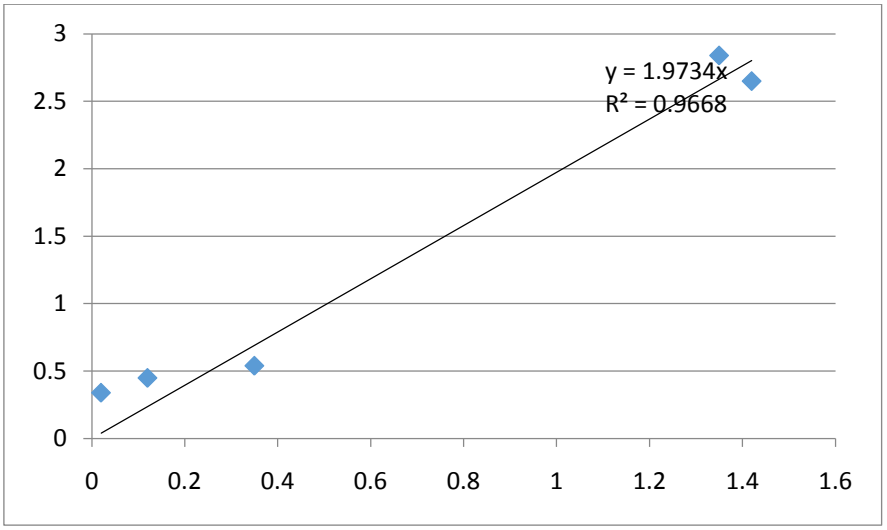
Yellow N2GL



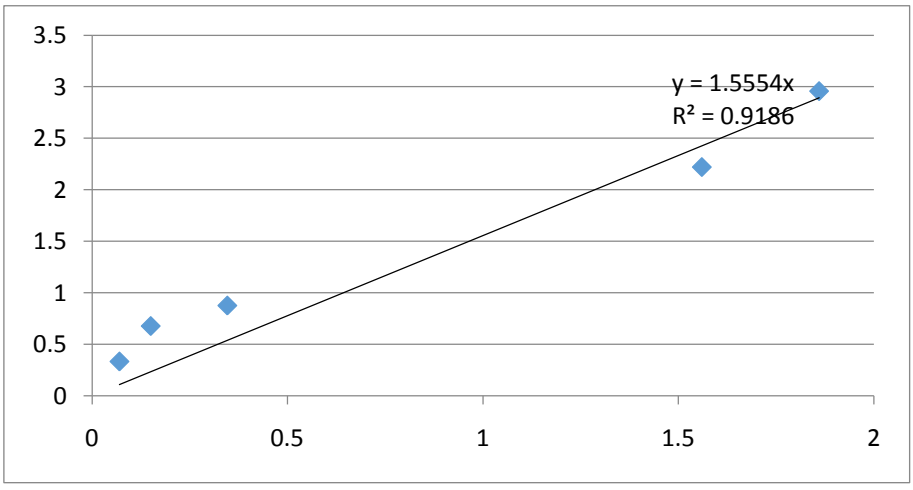
Red NG



Crisopin Gilicon



Violet 4BSDC



The algae have the potential to rapidly, efficiently and effectively remove various dyes at various concentrations.

CONCLUSION

Langmuir and Freundlich isotherm was well fitted to the experiment data and it could be regarded as sufficient to decolorized by *Spirulina platensis*. It may be thus concluded that the decolourization potential of *S.platensis* may be utilized effectively for the treatment of dyeing industry wastewater along to make the other treatment procedures adapted to make the recycling of wastewater possible.

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