TEXTILE WASTEWATER FOLLOWING PURGE WITH *SPIRULINA PLATENSIS*

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Abstract. Though industries promote economy of the country, the pollution caused by them has to be controlled in order to save the environment from degradation. The present work has been aimed for the removal of the dyeing industry effluent pollutants and the reduction of Chemical Oxygen Demand (COD) and Total Solids (TS) using *Spirulina platensis*. The effluents were tested before and after treatment with *Spirulina platensis* by using standard analytical methods (American Public Health Association (APHA), 1992). Before treatment the COD of the effluent was ranging from 1040 to 8010 mg/L and the Total Solids from 1129 to 9700 mg/L. After the treatment using *Spirulina platensis* the COD was reduced to 101–600 mg/L and TS to 152–830 mg/L, respectively. *Spirulina platensis* showed to be effective in the textile industry wastewater treatment.

Key words: dye industry effluents, American Public Health Association (APHA), physico-chemical analysis, cyanobacteria, *Spirulina platensis*.

INTRODUCTION

Textile processing involves many different steps. In almost all of these steps, wastewater is generated. The amount and composition of these wastewaters depends on many different factors, including the industrial process and the type of process used. Changes in machines, used chemicals or other characteristics of the processes also change the nature of the generated wastewater. The effluent can come from any combination of the processes: desizing, washing, bleaching, mercerizing, dyeing, printing or finishing [3].

Dyes contain chromophores (electron system with conjugated double bonds), auxochromes and electron-withdrawing or electron-donating substituents that cause or intensify the colour of the dye by altering the overall energy of the electron system. Usual chromophores are –C=C, –C=N, –C=O, –N=N, $–NO_2$ and quinoid ring and auxochromes are $–NH_3$, –COOH, $–SO_3H$ and –OH [12].

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Dyes are synthetic aromatic organic colorants, dispersible or water-soluble, having potential application in various industries. The dyestuff usage has been increased day by day due to tremendous increase of industrialization since men urge for colours. Today more than 9000 types of dyes belonging to various chemical classes and application classes have been incorporated in the colour [11, 4]. Among various industries, the textile industry ranks first in usage of the dye for colouration of the fibre. The textile sectors only consume 60% of the total dyes for colouration of various fabrics, and around 10–15% of the dyes used for colouration become lost through the effluents [5, 14].

Azo dyes are the largest group of dyes. More than 3000 different varieties of azo dyes are extensively used in the textile, paper, food, cosmetics and pharmaceutical industries [9]. Azo dyes are characterized by the presence of one or more azo groups –N=N–, which are responsible for their colouration and when such a bond is broken the compound loses its colour. They are the largest and most versatile class of dyes, but have structural properties that are not easily degradable under natural conditions and are not typically removed from water by conventional wastewater systems. Azo dyes are designed to resist chemical and microbial attacks and to be stable to light fading and during washing. Many are carcinogenic and may trigger allergic reactions in man. It is estimated that over 10% of the dye used in textile processing does not bind to the fibers and is therefore released to the environment. Some of these compounds cause serious threat because of their carcinogenic potential or cytotoxicity [1].

Bioremediation is a pollution control technology where the biological systems are used to drive the degradation or transformation of various toxic chemicals into less harmful forms. This natural process is expected to clean up the environment in an effective way, being an alternative to conventional remediation methods [15].

The present study is focused on degradation of textile dye effluent, by using *Spirulina platensis*, an oxygenic, photosynthetic autotrophic prokaryotic cyanobacterium.

MATERIALS AND METHODS

SAMPLE COLLECTION AND 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 for 3 days and used without any preliminary treatment.

DYES

Different dyes present in the wastewater are used in this research, namely Rodoman billicon 500%, violet 4BSC, black E ilicon, red NG, yellow N2GL, brown MR, blue FFS, Patan blue ASDC, lemon yellow 6GS, Crisopin Gilicon, Crimson 2GL. All dyes and mixtures of these dyes were obtained from Salem, Kanchipuram, Buvanagiri and Kumbakonam dyeing industries. The different dyes used in this research are azo dyes containing one or more azo groups (–N=N–) as chromophores.

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: $NaHCO_3$ – 8 g, $NaNO_3$ – 1.250 g, $CaCl_2.2H_2O$ – 0.020 g, K_2HPO_4 – 0.250 g, K_2SO_4 – 0.500 g, NaCl – 0.5 g, $MgSO_4.7H_2O$ – 0.100 g, EDTA – 0.004 g, distilled water – 1000 ml, pH – 10–11) in Erlenmeyer flasks exposed to partial sunlight during the day and in an illuminated chamber at night, at 1 klx, at 35°C, for 30 days.

IDENTIFICATION AND CHARACTERIZATION OF *SPIRULINA PLATENSIS*

Spirulina platensis 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 like flagella and heterocysts were absent. The filaments called 'trichomes' were formed by a single spirally twisted cell. The cells exhibited rotatory movements.

PREPARATION OF SAMPLES

Before treatment

The collected wastewater samples were 10 times diluted with distilled water and directly used for physico-chemical analysis.

After treatment

The collected wastewater samples were 10 times diluted with distilled water; 100 mL of each diluted samples were taken in a 250 mL conical flask and 1 mL of Zarrouk's medium ($NaHCO_3$ – 8 g, $NaNO_3$ – 1.250 g, $CaCl_2.2H_2O$ – 0.020 g,

K_2HPO_4 – 0.250 g, K_2SO_4 – 0.500 g, NaCl – 0.5 g, $MgSO_4.7H_2O$ – 0.100 g, EDTA – 0.004 g, distilled water – 1000 ml, pH – 10–11) was added after sterilization (10^7 cfu mL^{-1}). *Spirulina platensis* culture (1 g / 500 mL) was inoculated and incubated in a sterile chamber with CO_2 at 35 °C for 30 days, at light. During incubation period decolourization of the dye was noted and physico-chemical parameters were determined.

PHYSICO-CHEMICAL CHARACTERISTICS

The physico-chemical parameters, such as colour, odour, temperature, pH, total dissolved solids (TDS), total suspended solids (TSS), total solids (TS), hardness, chloride, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), oil and grease and sulphate, were determined using standard analytical methods [2].

RESULTS AND DISCUSSION

Biodegradation of textile effluents, namely Rodoman billicon 500%, violet 4BSDC, black E illicon, red NG, yellow N2GL, brown MR, blue FFS, Patan blue ASDC, lemon yellow 6G, Crisopin Gilicon, Crimson 2GL, and a mixture of all these dyes was performed using *Spirulina platensis*.

IDENTIFICATION AND CHARACTERIZATION OF *SPIRULINA PLATENSIS*

The morphological characteristics of *S. platensis* are presented in Table 1. Morphology of the used algae was found to be similar to that reported in literature: multicellular, filamentous, unbranched and helicodial trichomes. The characters measured were spiral number, distance between spirals, length and width of trichomes, number of long trichomes and short trichomes.

Table 1

Characters of *Spirulina platensis*

CHARACTERS	*SPIRULINA PLATENSIS*
Average number of spirals	2–3
Distance between spirals	50–50 µm
Length of trichome	270 µm
Width of trichome	10.5 µm
Number of long trichomes	62%
Number of short trichomes	22%

PHYSICO-CHEMICAL CHARACTERISTICS

The physico-chemical parameters such as colour, odour, temperature, pH, TS, TDS, TSS, DO, BOD, COD, Oil and grease and sulphate were determined before and after treatment with *S. platensis* and the values are tabulated in Table 2 and Table 3.

Before treatment

The effluents were rose, violet, black, red, yellow, brown and blue in colour with an objectionable odour. The pH of the effluent ranged from 7 to 10.5 and TDS 475–9000 mg/L. The total solids and total suspended solids of the effluent were found to be 1129–9700 mg/L and 130–803 mg/L respectively, the COD of the effluent ranging from 1040–8010 mg/L. The concentrations of BOD and DO found in the effluent were 409.47–1476.19 and 1176–7407 mg/L. Sulphate, oil and grease were found to be 16–70, 10–100 mg/L. The chloride and total hardness were found to be 500.99–6267 and 119–1230 mg/L, respectively.

Table 2

Physico-chemical characteristics of textile dyeing effluent

TESTS	RB 500%	V 4BSDC	B E ILICON	RED NG	Y N2GL	BROWN MR	BIS (reference value)
Colour	Rose	Violet	Black	BR	LY	Brown	–
Odour	O	No	O	p	O	F	–
Temp°C	30.2	29	28	29	30	28	–
PH	7	8.5	10.5	10.5	8.5	10	5.5–9.0
TS (mg/L)	4260	2360	3251	3969	1129	1278	–
TSS (mg/L)	300	160	130	569	249	803	100
TDS (mg/L)	3960	2200	3121	3400	880	475	2100
DO (mg/L)	1176	7407	1333	1176	4255	6249	–
BOD (mg/L)	1282.05	1408.4	724.60	952.38	694.49	624.99	30
COD (mg/L)	8000	3200	1840	1040	1600	2080	250
Oil and grease (mg/L)	10	31	80	24	30	10	–
Sulphate (mg/L)	68	48	70	64	32	45	1000
Chloride (mg/L)	3780	669.99	500.99	558.99	1830	6267	1000
Total hardness (mg/L)	408	119	150	285	216	718	100

Table 2 (continued)

TESTS	BLUE FFS	PB	LY6GS	CG	C2GL	MIX	BIS
Colour	RB	Blue	LY	Rose	GY	BV	–
Odour	pu	Off	O	O	F	F	–
Temp °C	30	28	30.2	29	28	30	–
PH	8	8	8.5	7	8.5	9.5	5.5–9.0
TS (mg/L)	7655	9700	3179	3825	5313	5740	–
TSS (mg/L)	355	700	270	425	313	295	100
TDS (mg/L)	7300	9000	2909	3400	5000	5445	2100
DO (mg/L)	6666	4761	1538	7142	1428	5714	–
BOD (mg/L)	444.44	674.60	820.512	1428.57	490.47	1476.19	30
COD (mg/L)	1600	1280	2080	8010	6240	7861	250
Oil and grease (mg/L)	40	42	10	100	40	99	–
Sulphate (mg/L)	50	40	Nil	Nil	16	32	1000
Chloride (mg/L)	3800	1553	924	1605	948	1884	1000
Total hardness (mg/L)	731	1025	181	1230	1076	867	100

Abbreviations: Temp °C = temperature, RB 500% = Rodoman billicon 500%, V 4BSD = violet 4BSD, B E ILICON = black E ilicon, Y N2GL = yellow N2GL, PB = Patan blue ASDC, LY 6GS = lemon yellow 6GS , CG = Crisopin Gilicon , C2GL = Crimson 2GL , Mix = mixtures of all these dyes, BIS = BIS limit is 2490–2009, O = objectionable, no = no smell, p = paint smell, F= fishy, pu = pungent, off = offensive, BR = brownish red, LY = light yellow, RB = royal blue, GY = golden yellow, BV = blackish violet.

The physico-chemical characteristics of dyeing industry effluent clearly show the need for treatment, as the Total Solids, COD and DO were higher in their values. The higher values may be due to the processes involved in dyeing [8]. The pH of the dyeing wastewater has been reported to be 9.2 to 11 generally [6].

After treatment

After the treatment with *Spirulina platensis* the effluent was light green in colour some of them remain in the same colour with an odourless (no bad smell) TDS 137–800 mg/L. The total solids and totally suspended solids of the effluent were found to be 152–830 and 10–80 mg/L respectively, the COD of the effluent ranging from 101–600 mg/L. The BOD and DO found in the effluent were 111.11–718.95 and 105–770 mg/L. Sulphate, oil and grease were found to be 8–48, 1.2–56 mg/L. The chloride and total hardness were found to be 79–125.55 and 43.6–286 mg/L, respectively.

Table 3

Physico-chemical characteristics of textile dyeing effluent after treatment with *Spirulina platensis*

TESTS	**RB 500%**	**V 4BSDC**	**B E ILICON**	**RED NG**	**Y N2GL**	**BROWN MR**	**BIS (reference value)**
Colour	Dull rose	Light green	Black	Dull red	Light green	Dull brown	–
Odour	No smell						
Temp °C	35						
PH	10–11	10.5	10	11	10.5	10	5.5–9.0
TS (mg/L)	830	245	330	696	444	255	–
TSS (mg/L)	30	16	13	56	24	80	100
TDS (mg/L)	800	229	317	640	420	175	2100
DO (mg/L)	233	105	358	210	308	350	–
BOD (mg/L)	718.95	169.75	111.11	163.39	294.1	377.7	30
COD (mg/L)	600	160	150	101	300	204	250
Oil and grease (mg/L)	1.6	20	1.2	10	15	5	–
Sulphate (mg/L)	34	24	35	48	12	23	1000
Chloride (mg/L)	945	285	125.55	79	453	520	1000
Total hardness (mg/L)	102	59.2	75	71.5	43.6	118	100

TESTS	**BLUE FFS**	**PB**	**LY6GS**	**CG**	**C2GL**	**MIX**	**BIS (reference value)**
Colour	Blue	Blue	Light green	Light green	Light green	Light green	–
Odour	No smell						
Temp °C	35						
PH	10.5	11	10.5	10	10.5	11	5.5–9.0
TS (mg/L)	152	707	321	368	422	563	–
TSS (mg/L)	15	10	27	25	13	20	100
TDS (mg/L)	137	697	294	343	409	543	2100
DO (mg/L)	263	165	770	358	654	263	–
BOD (mg/L)	222.22	129.7	410	322.8	142.5	123.5	30
COD (mg/L)	400	250	104	322.8	142.5	123.5	250
Oil and grease (mg/L)	15	22	4	56	25	45	–
Sulphate (mg/L)	16	24	Nil	Nil	8	12	1000
Chloride (mg/L)	780	517.66	424	535	448	628	1000
Total hardness (mg/L)	105.1	175	90.5	205	215.6	286	100

CONCLUSION

The physico-chemical characteristics of the effluents such as TS, TSS, TDS, DO, BOD, COD, oil and grease, sulphate, chloride and total hardness were much reduced after the algal treatment. The results indicate that *S. platensis* might be an effective treatment for textile dye effluent. Thus, the present study clearly concluded that *S. platensis* was used as a good microbial source for waste water treatment.

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