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Evaluation of Phycoremediation Potentials of Microalgae with Reference to Textile Dyeing Industrial Effluent

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Abstract

In this research work the phycoremediation potential of eleven different microalgae was investigated. The pH and TDS were recorded in the effluent treated with microalgae. *Chlorococcum vitiosum, Chlorococcum humicola, Chlamydomonas* and *Dactylococapsis spfound to be* tolerated and grew. These four algae were employed for the study of colour removal and sludge reduction in the dye effluent treatment. The result showed that *Chlorococcum humicola* and *Chlamydomonas* sp reduced sludge to 16.66% and 13.33% respectively. With reference to colour removal, *Chlorococcum vitiosum* has shown considerable reduction with a percentage value 19.15% followed by *Dactylococapsis* sp with a value of 15.45%.

INTRODUCTION:

Phycoremediation is the use of macro or micro algae for the removal or biotransformation of pollutants, including nutrients and xenobiotic from wastewater and carbondioxide from waste air,(Olguin,2003). Microalgae play an important role during the tertiary treatment of domestic wastewater in nutrition ponds or the treatment of small-middle-scale municipal waste water in facultative and aerobic ponds.(Oswald,1995,and Abeliovich,1986).

Dyes are used to colour the final products in many industries (Mohan *etal.*, 2003; Gupta *et al*., 2003). The effluents of the dyeing industry are highly coloured along with high pH & TDS. The sludge content is also high in dye effluent. The disposal of untreated effluent into land and water bodies will cause aconsiderable environmental impact. The dye effluents are toxic and carcinogenic. They also disturb the ecology of aquatic organism (Ozer *et al*., 2005).

It is very difficult to treat dye waste water by conventional methods. This is due to complex aromatic molecular structure of dyes (Fu and Viraraghavan, 2002).

Sludge reduction and colour removal of the dye effluent is an important requisite for dye effluent treatment. The microalgae *Chlorococcum humicola* have been used for reducing the pH, colour and TDS of textile dyeing effluent(Muthukumaran *et al.*,2008). Recent studies have shown that microalgae have a very high potential for phycoremediation.

MATERIAL AND METHODS

Microalgae employed:

Chlorococcum humicola, Desmococcus sp, *Chroococcus* sp, *Chlorella vulgaris, Chlamydomonas* sp, *Scenedesmus* sp, *Dactylococapsis* sp *Scenedesmus incrasantulus, Chlorella sp Chlorococcum vitiosum* and *Palmellococcus sp* were used in the preliminary study. The above algae were obtained from the culture collected from Vivekananda Institute of Algal Technology (VIAT), Chennai.

Growth Condition:

The culture were grown at 24+_1^0C in a thermostatically controlled room and illuminated with cool white florescence lamp (Philips 40W, cool day light 6500K) at an intensity of 2000 lux in a 12hours light dark region.

Medium Composition:

Micro algae can be grown in the laboratory condition for Bold Basal medium (Nichols & Bold, 1965) and CFTRI medium (Venkatraman & Becker, 1985).The above condition can be followed for micro algal growth.

Microscopic Examination:

The micro algal cultures were microscopically examined using Olympus (HB) microscope.

Growth Measurement:

Growth was measured by counting cells using a Haemocytometer (Neubauer, improved) and the result were plotted in a semi-logarithmic graph. Growth rate (division / day) was arrived using the formula.

$$\frac{\text{Log N} - \text{Log No}}{\text{Log 2 X t}}$$

Where,

N = No. of cells per ml at the end of log phase or mg weight/l

No= Initial count of cells ml or mg weight/l

t = Days of log phase

For dry weight method the algal cultures were pellated by centrifugation at 3000 rpm (Remi centrifuge) for 15 minutes. Cells were washed with distilled water, centrifuged and dried in an oven for 24 hours.

pH & TDS:

pH was measured using digital pH meter (ElicoL +_ 120) and TDS using digital TDS meter (Equiptronics EQ-660A).The spectroscopic analysis was carried out using UV-visible spectrophotometer SHIMADZU (300-800nm).The dyeing effluent was analysed before and after decolourization. The spectral analysis of effluents were carried out using UV-visible spectrophotometer SHIMADZU (300-800nm).

RESULTS AND DISCUSSION:

Table 1 shows the micro algal species occurring in samples collected from various sites of dyeing industry. Cyanobacteria dominated the algal flora followed by Chlorophyceae and bacillariophycea

Table 1. Micro algal flora of samples from dyeing industry.

S.No	ORGANISM NAME	A	B	C
	Chlorophyceae			
1	*Chlorella vulgaris*	✓	✓	✓
2	*Coelastrum cambricum*	✓	✓	x
3	*Chlorococcum vitiosum PRINTZ*	✓	x	✓
4	*Scenedesmus bijugatus (TURP)*	✓	x	x
5	*Chlorococcum humicola (NAEG)*	✓	✓	✓
6	*Ankistrodesmus sp*	✓	x	x
7	*Selenastrum gracile*	x	x	✓
8	*Oocytis sp*	x	x	✓
9	*Cruciginia sp*	x	x	✓
10	*Cosmarium sp*	x	x	✓
11	*Tetraedron minimum (A.Braun) Hansging*	x	x	✓
				✓
	Bacillariophyceae			
1	*Navicula sp*	✓	✓	✓
2	*Pinnularia sp*	✓	✓	✓
3	*Gomphonema sp*	x	x	✓
	Euglenineae			
1	*Euglena sp*	✓	x	x
	Myxophyceae			
1	*Oscillatoria curviceps*	✓	x	✓
2	*Stigonema minutum (Ag.) Hass*	✓	x	x
3	*Gomphosphaeria aponina kutz*	✓	x	x
4	*Chroococcus turgidus Nag*	✓	x	✓
5	*Oscillatoria claricentrosa*	✓	✓	✓
6	*Microcystis robusta*	✓	x	x
7	*Chroococcus schizodermaticus west*	✓	x	x
8	*Aphanocapsa biformis A.Br*	x	x	✓
9	*Anabaena sp*	x	x	✓
10	*Gloeocapsa calcarea Tilden*	x	x	✓
11	*Gloeocapsa punctata Nag*	x	x	✓
12	*Myxosarcina burmensis skuja*	x	x	✓
13	*Chlorogloea fritschii*	x	x	✓

A – Tap water storage tank **C** – Effluent storage tank

B – Effluent running canal

Table 2. Growth Rate of microalgae in Dyeing effluent

SI.No	ORGANISM NAME	Initial cells (x 10^4 cells/ml)	Final cells (x 10^4 cells/ml)	Growth rate (divisions/day)
1	*Chlorococcum humicola*	60.8	152	0.1888
2	*Desmococcus* sp	176.8	152	-0.0311
3	*Chroococcus* sp	239.2	160	-0.0828
4	*Chlorella vulgaris*	67.2	56	-0.1658
5	*Chlamydomonas* sp	2.7	11	0.2903
6	*Scenedesmus* sp	1.8	-	-0.8542
7	*Dactylococapsis* sp	100.8	120	0.0359
8	*Scenedesmus incrasantulus*	43.2	40	-0.0158
9	*Chlorella* sp	94.4	20	-0.03198
10	*Chlorococcum vitiosum*	27.2	32	0.0335
11	*Palmellococcus sp*	109.6	20	-0.3560

The growth rate of different microalgae on dyeing effluent was studied. 11 different micro algae shown in Table 2 were grown on the dyeing effluent. The growth of algae was studied after 7 days after inoculation.

The increase in the growth rate was noted in the following four micro algae and the remaining showed a negative trend. The four micro algae which showed the increase in ncrease were

1. *Chlamydomonas* sp
2. *Chlorococcum vitiosum*
3. *Chlorococcum humicola*
4. *Dactylococapsis sp*

The highest growth rate was shown by *Chlamydomonas* sp and *Chlorococcum vitiosum*. The rate of increase in growth of the four forms is also given in the Table 2.

The pH & TDS of the effluent with different algae were studied on the day of inoculation and after 7 days. The overall result showed a reduction in pH in all the effluent treated with algae. The pH reduction was significantly high with application of *Chlorococcum vitiosum which is shown in the* Tables 3.

Table 3. Micro algal growth and pH in the dyeing effluent

SI.No	ORGANISM NAME	Initial pH	Final pH
1	Control	11.76	9.66
2	*Chlorococcum humicola*	11.71	9.63
3	*Desmococcus sp*	11.69	9.64
4	*Chroococcus sp*	11.72	9.63
5	*Chlorela vulgaris*	11.74	9.64
6	*Chlamydomonas sp*	11.73	9.64
7	*Scenedesmus sp*	11.74	9.63
8	*Dactylococapsis sp*	11.74	9.65
9	*Scenedesmus incrasantulus*	11.75	9.64
10	*Chlorella sp*	11.71	9.66
11	*Chlorococcum vitiosum*	11.74	9.63
12	*Palmellococcus sp*	11.72	9.63

The TDS was reduced significantly by *Chlamydomonas sp* in comparison to the others which is given in the Table 4.

Table 4. TDS of dyeing effluent treated with microalgae

SI.No	ORGANISM NAME	Initial TDS	Final TDS
1	Control	8.6	7.5
2	*Chlorococcum humicola*	8.4	7.5
3	*Desmococcus sp*	8.5	7.4
4	*Chroococcus sp*	8.5	7.5
5	*Chlorela vulgaris*	8.4	7.5
6	*Chlamydomonas sp*	8.8	7.5
7	*Scenedesmus sp*	8.6	7.5
8	*Dactylococapsis sp*	8.5	7.5
9	*Scenedesmus incrasantulus*	8.6	7.5
10	*Chlorella sp*	8.9	7.5
11	*Chlorococcum vitiosum*	8.6	7.5
12	*Palmellococcus sp*	8.5	7.5

Table 5. Colour reduction in dyeing effluent by microalgae

S.No	ORGANISM NAME	*A X 10*	*B X 10*	C = (A+B)/2	Colour removal	% of colour removal
1	Control	4.73	6.88	5.393	5.393	0
2	*Chlorococcum humicola*	4.96	4.94	4.95	0.443	8.214
3	*Chlamydomonas* sp	4.88	4.70	4.79	0.603	11.181
4	*Dactylococapsis sp*	4.68	4.43	4.56	0.833	15.445
5	*Chlorococcum vitiosum*	4.43	4.28	4.36	1.033	19.154

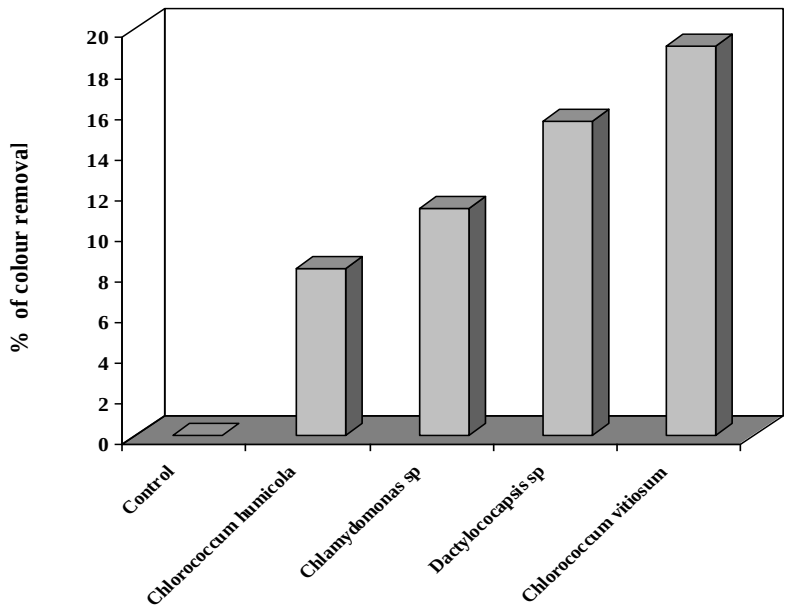

Figure 1. Colour reduction in dyeing effluent by microalgae

Table 6. Sludge reduction in dyeing effluent by microalgae

S.No	ORGANISM NAME	Weight of sludge + algae mg/ml	(Dry weight/cell count) X final cell count	Sludge reduction	% of sludge reduction
1	Control	0.6	0.6	0.6	0
2	*Chlorococcum humicola*	0.73	0.229	0.50	16.66
3	*Chlamydomonas sp*	0.53	0.0064	0.52	13.33
4	*Dactylococapsis sp*	0.56	0.091	0.54	10
5	*Chlorococcum vitiosum*	0.60	0.0117	0.5883	1.95

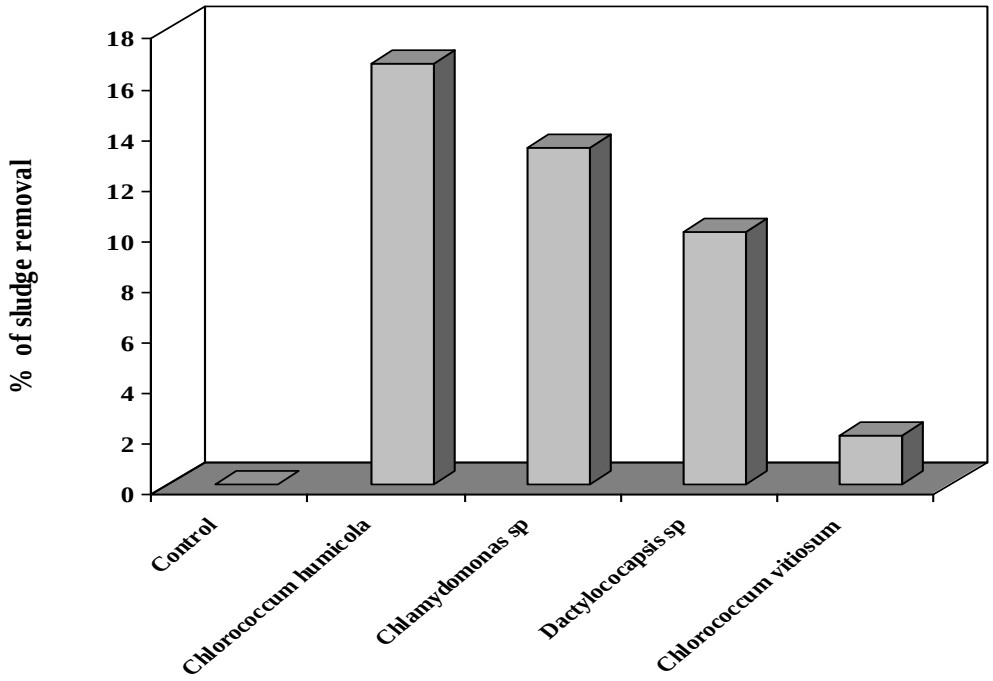

Figure 2. Sludge reduction in dyeing effluent by microalgae

The four micro algae which showed an increased growth rate were used to study the sludge reduction and colour removal in dyeing effluent. The colour removal was very high in the effluent treated with *Chlorococcum vitiosum* and *Dactylococapsis*. The sludge reduction was high in dyeing effluent treated with *Chlorococcum humicola* and *Chlamydomonas* (Tables 5 & 6, Fig 1 & 2).

CONCLUSION

1. pH and TDS were recorded in the effluent treated with microalgae. *Chlorococcum vitiosum*, *Chlorococcum humicola*, *Chlamydomonas* and *Dactylococapsis sp* tolerated and grew.
2. *Chlorococcum humicola* and *Chlamydomonas* sp reduced sludge to 16.66% and 13.33% respectively.
3. *Chlorococcum vitiosum* has shown 19.15% and *Dactylococapsis* sp 15.45% followed by the other two.

Further investigations using these four micro algae are needed both at the laboratory level and large scale level for checking the feasibility of micro algae to treat dye effluent in industries.

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