International Research Journal of Plant Science (ISSN: 2141-5447)
Vol. 12(6) pp. 01-5, December, 2021
Available online @ https://www.interesjournals.org/plant-science.html
DOI: http:/dx.doi.org/10.14303/irjps.2021.35

Research Article

Phycoremediation on textile industry based azo dyes of congo red and direct violet

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Abstract

Release of textile effluents into the water bodies have resulted in severe environmental impacts on the living organisms as well as the quality of the water bodies. The presence of organic synthetic dyes has not only deteriorated the aesthetic quality of the ecosystem but has also rendered the water useless for human purpose. Phycoremediation for textile dye degradation is a widely studied method used as an alternative to the expensive, energy consuming physico-chemical processes. This study aims at demonstrating the ability of the microalgae to phycoremediate the textile effluent. It was observed that the five microalgal species, *Chlorella vulgaris, Oscillatoria* Sp., *Scenedesmus dimorphus, Desmococcous* Sp., and *Phormedium* Sp., used for the study were successful in decolourizing the congo red and direct violet azo dye treated water. These results could be promising for the onsite treatment of the textile effluents to decolourize the water bodies.

Keywords: Phycoremediation, microalgae, synthetic azo dyes, textile industry.

INTRODUCTION

Azo dyes are organic synthetic dyes that are predominantly used in the textile industry for dying of garments. Azo dyes are also used in food, pharmaceutical, paper and printing, leather, and cosmetics industries. More than 10,000 dyes are available commercially out of which around 2000 dyes are azo dyes (Chequer et al., 2013). The popularity of the azo dyes are mainly because it is easy to use, relatively cheap and provide clear and strong colours. Approximately 10-15% of the azo dyes is released in the environment by the textile industries during the manufacturing and usage of azo dyes (Srivastav et al., 2019). These industries also release a huge amount of dyes into the environment through the effluents thereby leading to the pollution of water, air and soil. The complex aromatic molecular structures of these dyes moreover make it difficult for it to degrade. The presence of dyes in the ecosystem thus poses a serious threat to the environment and cause several health concerns. The discharge of the textile industries can be carcinogenic and also mutagenic in nature. The azo dyes affect the aesthetic merit, water transparency and gas solubility in lakes, rivers and other water bodies. The release of azo dyes in the water bodies also causes eutrophication, decrease in the photosynthetic activities, alteration of the pH, biochemical oxygen demand (BOD) dissolved oxygen (DO) and chemical oxygen demand (COD) (Wei et al., 2020).

The general processes of decolourization of azo dye containing water involve high costs formation of secondary pollutants. The inevitable need to treat these effluents becomes necessary to promote the environmental sustainability and restoration. Thus, biological treatments involving microorganisms for the remediation of the azo dye to its less toxic forms in water samples are preferred. Among the various bioremediation technologies, decolourization using microalgae has been widely used due to their environmental friendliness and sustainability, cost and low sludge formation. Microalgal species are known to degrade the dyes partially or completely. The microalgae are capable of cleaving the azo bond which is directly associated to the imparting of colour (Ayele et al., 2021).

In this study, the phycoremediation properties of five microalgal species were carried out and its ability to degrade azo dyes were examined.

MATERIALS AND METHODS

Azo dyes used: The synthetic azo dyes Congo Red and Direct Violet were procured from Mehta Dye-Chem Corporation, Chennai, Tamilnadu. Distilled water was used in preparing dye solutions in different concentrations (Srivatsav et al., 2019).

Algae and culture conditions: Five microalgal species; *Chlorella vulgaris, Oscillatoria* Sp., *Scenedesmus dimorphus, Desmococcous* Sp. and *Phormedium* Sp., were used for the study. All the pure cultures were maintained by subculturing in flasks containing 100 ml of sterile Bold's Basal Medium (BBM) and BG11 medium under fluorescent light (4000 lux) at a temperature of 25°C.

Determination of absorption maxima (λmax) and plotting of standard curve: The absorption of light by the dyes within the visible range (400-700 nm) was determined to calculate the adsorption maxima (λmax) using UV-Vis spectrophotometer. Known concentrations (10, 20, 30, 40, 50, 60, 70, 80, 90, 100 ppm) of each dye were prepared to plot the standard curve.

Phycoremediation and spectroscopic analysis: The decolourization experiments were performed in 250 mL erlenmeyer flasks containing the algal culture and different concentrations of the azo dyes. All the treated flasks were incubated at 30°C with constant fluorescent illumination. The samples were withdrawn after every 5 days interval for a period of 45 days and the decolourization of the dye was monitored by spectrophotometrically (SHIMADZU 1800 UV VIS model with diode array detector). The decrease in the absorbance readings correspond to the decolourizing activity and were expressed in terms of percentage decolourization using the equation according to (Telke et al., 2014).

$$\text{Decolourization \%} = \frac{\text{Initial absorbance} - \text{Final absorbance}}{\text{Initial absorbance}} \times 100$$

Azo dyes of Congo red and direct violet samples were used as a control.

Statistical analysis

Anova was used to determine the significance of concentration in dye decolourization. Statistics were calculated using GraphPad Prism.

RESULTS AND DISCUSSION

Standardization of the azo dyes

The standard graph for congo red and direct violet was plotted to determine the maximum adsorption wavelength. The wavelength for congo red and direct violet was determined as 488 nm and 520 nm respectively.

Phycoremediation

Decolourization experiments were carried out using different concentrations of the azo dyes for a period of 45 days. Figures 1 shows the decolourization percentage of different dye concentrations by the microalgal species. The maximum decolourization was observed with 30 ppm of congo red and 40 ppm of direct violet for all the five microalgal species. The results obtained revealed that the amount of colour removal depended on the time duration of the algal interaction with the azo dyes. The decolourization percentage gradually decreased with an increase in the concentration of the dye.

As evident from the Figure 1 *Oscillatoria* Sp., *Scenedesmus dimorphus* and *Phormedium* Sp. showed the highest percentage of decolourization activity (96%, 95% and 95% respectivly) for congo red. In *Oscillatoria* Sp., the maximum decolourization for congo red was 96% at 20 ppm respectively. The decolourization percentage showed a steady increase with the increasing concentrations of the dye at the end of 45 days.

Figure 2 represents percentage decolourization in Congo red by *Scenedesmus dimorphus* with a minimum and maximum decolourization percentage of 57% and 95% respectively. Further the algae exhibited decreased percentage of decolourization for the increasing concentrations.

Similarly *Phormedium* Sp. also showed Figure 3 a maximum of 95% decolourization at 30ppm. Whereas, the results for *Chlorella vulgaris* revealed that the congo red dye at the concentration of 20 ppm was decolourized after 30 days with a decolourization percentage of 96%. *Desmococcous* sp., showed a maximum decolurization of 96% at 40 ppm at the end of 35 days.

Representative pictographs Figure 4 of congo red phycoremediated with (a) *Phormedium* Sp.,-30 ppm (b) *Chlorella vulgaris*-20ppm (c) *Desmococcus sp* – 10ppm (d) *Desmococcus sp*– 40ppm

Rapid decolourization of Congo red after 5 days of treatment with the algae could be attributed to the strong attractive force between the azo dye molecule and the algae resulting in the fast diffusion of the dye onto the external surface and the further diffusion into the algae cells (Daneshvar et al., 2007).

The degree of decolourization for Direct violet were studied at different concentrations of 10ppm, 20ppm, 30ppm, 40ppm and 50ppm. Figure shows the decolourization (%) of different Direct violet concentrations by the microalgal species.

The extent of colour removal of direct violet ranged Figure 5 from 65% to 95% in *Oscillatoria* Sp., the maximum decolourization was observed with 30 ppm and the end of 30 days and further decreased with the increasing concentrations upto 50ppm.

Phormedium Sp, was able to decolourize 95% of the dye Figure 6 at a concentration of 30 ppm after 30 days. With the increasing dye concentrations, the decolourizaing ability of the algae was also reduced. *Chlorella vulgaris* and *Scenedesmus dimorphus* showed 82%, 93% decolourizing of the dye after 35 days at 30 ppm. *Desmococcous* Sp., exhibited a maximum decolourization of the dye at 20ppm at the end of 30 days.

Representative pictographs (Figure 7) of direct violet phycoremediated with (a) *Phormedium* Sp.,-30 ppm (b)

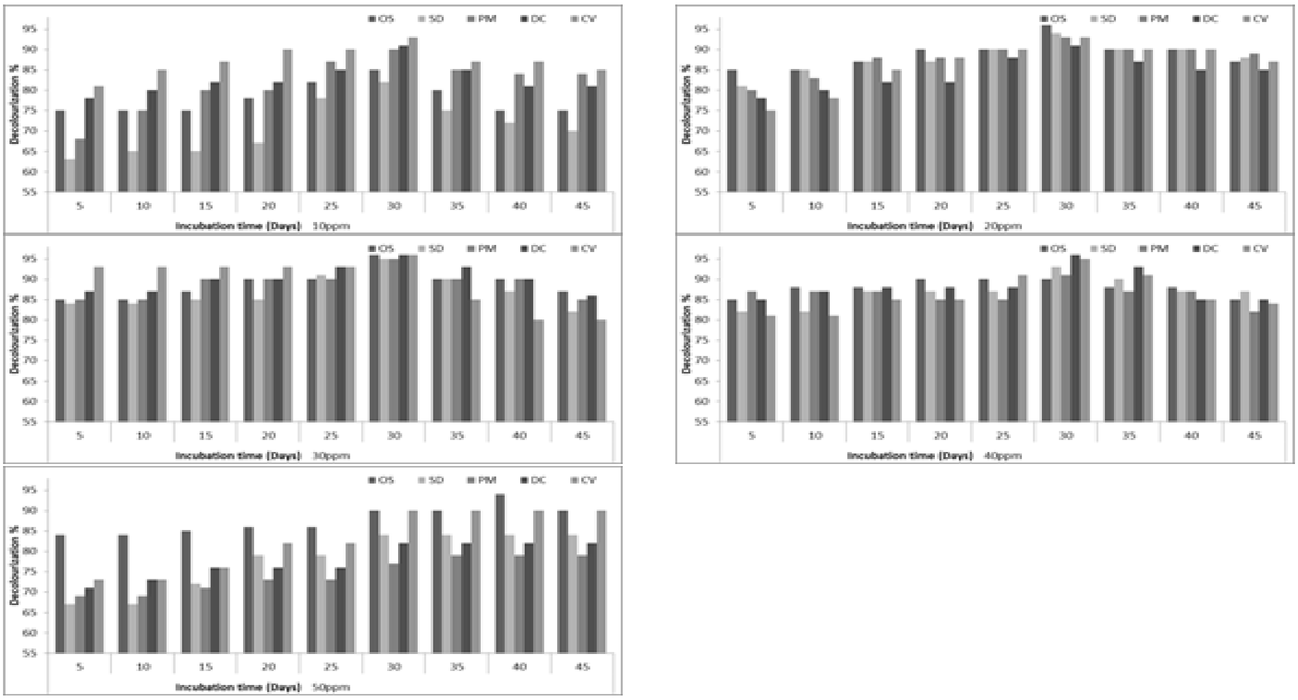
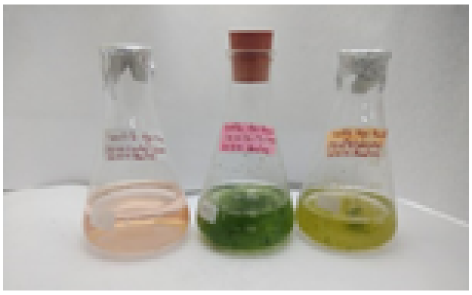
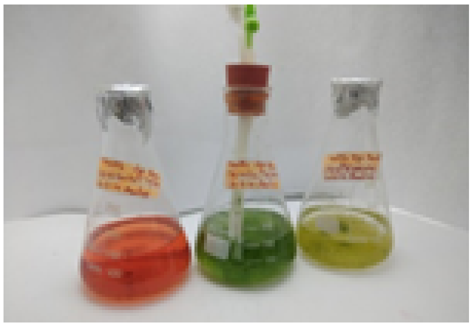


Figure 1: Percentage of decolourization activity.



(a)



(b)

Figure 2: Representative pictographs of *Oscillatoria* Sp. incubated with congo red at (a) 20 ppm and (b) 50ppm.

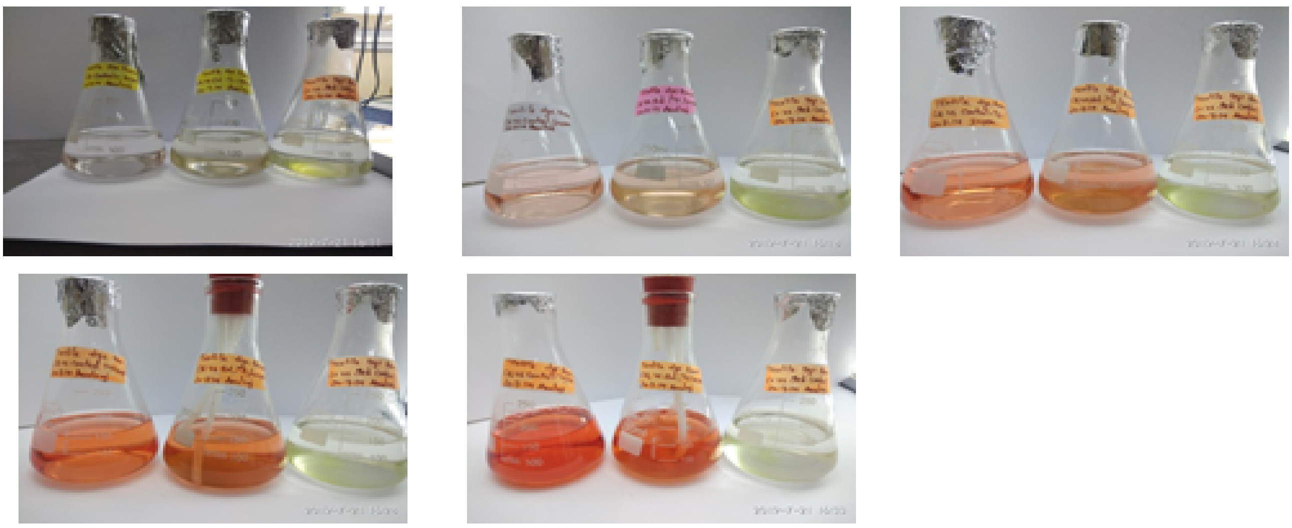


Figure 3: 95% decolourization at 30ppm.

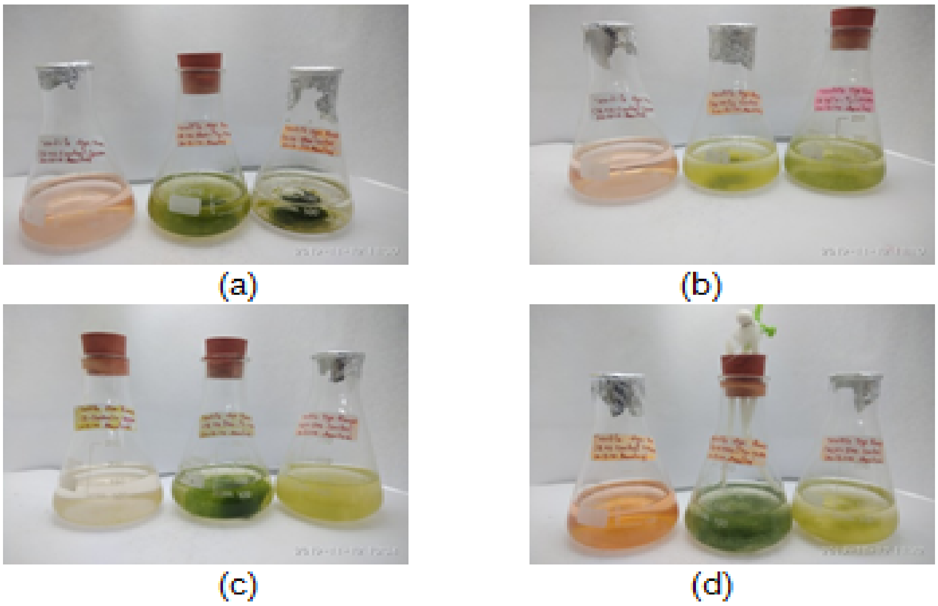


Figure 4: Representative pictographs of congo red phycoremediated.

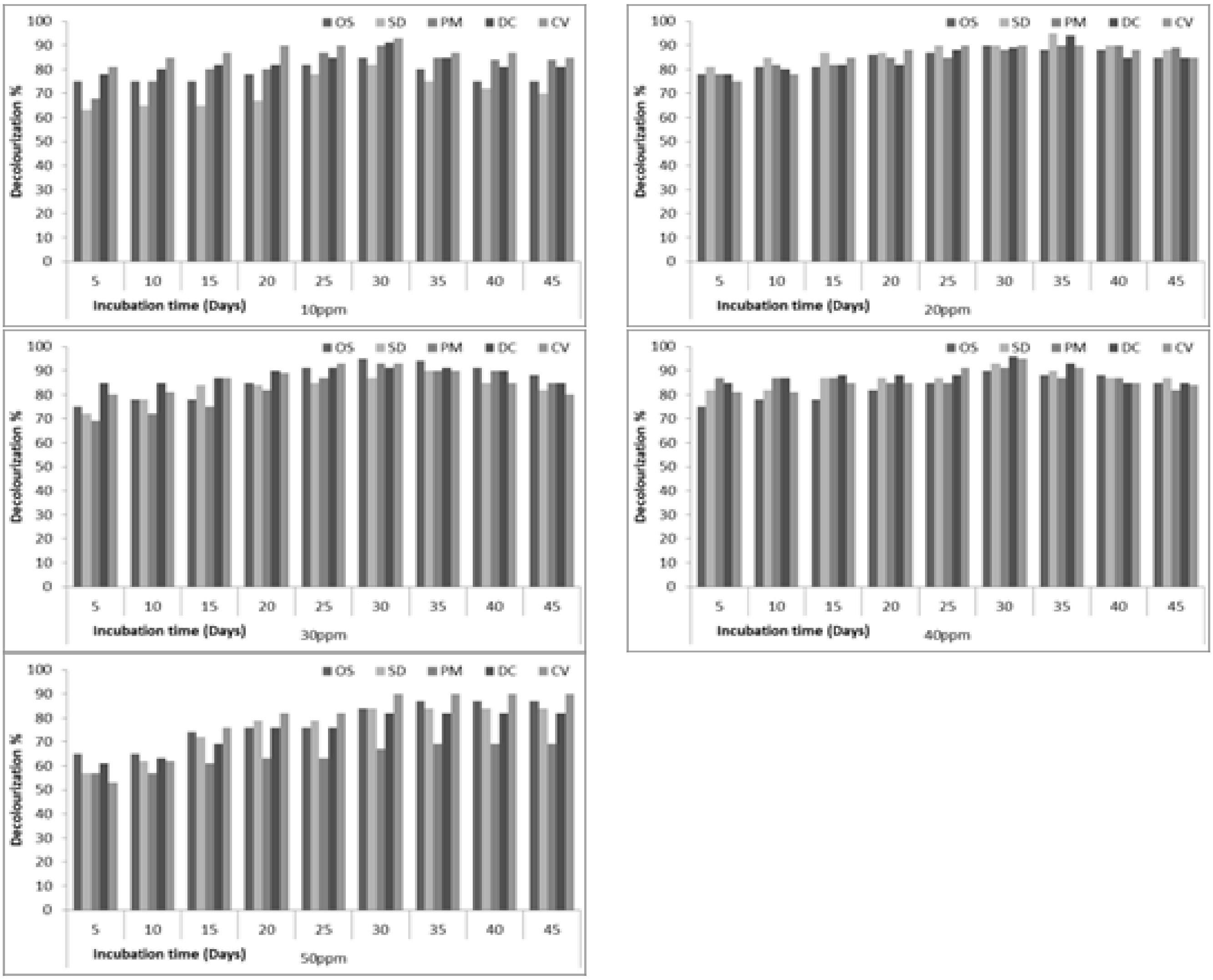


Figure 5: Extent of colour removal of direct violet.


(a) (b) (c)

Figure 6: Decolourize of the dye.


(a) (b) (c) (d)

Figure 7: Representative pictographs of direct violet.

Phormedium Sp.,-50 ppm (c) *Desmococcus* Sp., – 20ppm (d) *Chlorella vulgaris* – 30ppm. The decolourization of the dye is also dependent on the molecular structure of the dye (Urushigawa & Yonezawa, 1977). From the obtained results, it could be concluded that Congo red was decolourized more efficiently than direct violet. This difference in decolourization could be due to the presence of the amino group in the Congo red which facilitates the ability of the algae to decolourize the dye. The methyl, methoxy and sulfo derivatives in direct violet might be the reason for its lower decolourizing rate.

CONCLUSION

The presence of azo dyes in the industry effluents affect the ecosystem by imparting a distinct colour to the water bodies and also lead to environmental problems. The remediation and decolourization procedures using microalgae have been extensively studies for its potential to rapidly, efficiently and effectively degrade dyes to its lower concentration thereby helping in the restoration of the aesthetic effects of the water ecosystem. The present study revealed the ability of the microalgae, to decolourize the two azo dyes, Congo red and direct violet. Results obtained from the study showed that this algal species possessed high decolorization efficiency which is dependent on the dye concentration as well as the time of interaction between the dye and the algae. This degrading potential of the algae could be useful in treating the textile industry effluents.

REFERENCES

1. Ayele A, Deribe GM, & Kamaraj AS(2021). Phycoremediation of Synthetic Dyes: An Effective and Eco-Friendly Algal Technology for the Dye Abatement. Trends in Dye Removal from Aqueous Systems.
2. Chequer FMD, de Oliveira GAR, Ferraz ERA, Cardoso JC, Zanoni MVB, & de Oliveira DP(J2013). Textile Dyes: Dyeing Process and Environmental Impact, Eco-Friendly Textile Dyeing and Finishing, Melih Günay, IntechOpen,
3. Daneshvar N, Khataee A, Rasoulifard M, & Pourhassan M(2007). Biodegradation of Dye Solution Containing Malachite Green: Optimization of Effective Parameters Using Taguchi Method. *J of hazard materials, 143*: 214-9.
4. Srivatsav DP, Devi VS, Reddy PSV, Venkat MS, & Shammari HTA(2019). Microbial Degradation of Azo Dyes From Textile Industry – Review, *Int J of Engine Res & Tech (IJERT) 08*(11).
5. Telke A, Kadam A, & Govindwar S(2014). Bacterial Enzymes and Their Role in Decolorization of Azo Dyes.
6. Urushigawa Y, & Yonezawa Y(1977). Chemo-biological interactions in biological purification system II- Biodegradation of azo compound by activated sludge. *Bull. Environ. Contam. Toxicol., 17*: 214-218.
7. Wei F, Shahid MJ, Alnusairi GSH, Afzal M, Khan A, El-Esawi MA, Abbas Z, Wei K, Zaheer IE, Rizwan M, & Ali, S(2020). Implementation of Floating Treatment Wetlands for Textile Wastewater Management: A Review. Sustainability, 12: 5801.