



PHYCOREMEDIATION OF TEXTILE DYE EFFLUENTS BY FRESH WATER MICROALGAE SPECIES

¹Sani Shuaibu Kafin Hausa*, ¹Rahab Gayus, ²Miqdad Sabo, ³Ibrahim Usman Danladi, ⁴Amina Ibrahim Baiwa, ⁵Abdulbasit Harazimi, ⁵Hauwa Umar Ali, ⁵Sani Ahmad, ⁵Fatima Ibrahim Baiwa, ⁵Kamal Bello, ⁵Mukhtar Adamu, ⁶Ibrahim Ahmad Rabi, ⁶Hussaini Bulakarima Umara

¹Department of Microbiology and Biotechnology, Federal University Dutse, Jigawa State.

²Department of Biological Science, Bauchi State University Gadau.

³Department of Biotechnology, Modibbo Adama University Yola, Adamawa State

⁴School of Basic and Remedial Studies, Kano State Polytechnic, Kano State

⁵Department of Science Laboratory and Technology, Jigawa State Polytechnic Dutse, Jigawa State.

⁶Health Center, Federal University Dutse, Jigawa State

*Corresponding Author

Mr. Sani Shuaibu Kafin Hausa
Department of Microbiology and Biotechnology,
Federal University Dutse, P.M.B 7156, Jigawa
State-
Nigeria.
sasheed200@gmail.com
+2348145999697

potential of microalgae consortia for effective bioremediation of dye-contaminated wastewater.

Key words: Algae, Phycoremediation, Malachite green and Decolorization

ABSTRACT

This study investigates the decolorization of malachite green dye wastewater with a consortium of freshwater microalgae species. Samples were collected in a plastic bottle from the Kasarau area of Dutse metropolis (10.71°N and 10.37°E) and then cultured in a simple photobioreactor. And the contaminated dye sample was collected from Dutse Ultr-modern market and subjected to physio-chemical tests before algal inoculation and after to determine the decolorization potentials of the isolates. The results show that the screened isolates are Scenedesmus spp., Chlorella spp., Synedra spp., and Achnanthydium spp. Decolorization efficiency was tested across different temperatures, revealing that 25 °C was optimal for initiating decolorization, which increased with rising temperatures up to 45 °C before declining due to thermal deactivation of algal enzymes. At 35 °C, the microalgae achieved 78% decolorization of malachite green dye within four days. Physicochemical analysis of wastewater before and after treatment showed significant reductions in BOD₅, COD, and TDS by 91.90%, 91.50%, and 89.10%, respectively, indicating effective remediation. Statistical analysis confirmed that incubation time, temperature, and their interaction significantly influenced decolorization efficiency (P-value < 0.05). This study demonstrates the

INTRODUCTION

Textile dye are an important class of synthetic organic compounds used as coloring agents in textile, paint, ink and plastic industries. Azo-dyes are one of the oldest industrially synthesized organic compounds and represent the major group (60–70%) of more than 10,000 dyes currently manufactured (Bras et al. 2015). However, large amount of these dyes remain in the effluent after the completion of the dyeing process. Consequently, very small amount of dyes in wastewater is highly visible (Wang et al. 2015; Marungueng and Pavasant 2016). A side effect from their negative aesthetic effects, certain azo-dyes and their biotransformation products have been shown to be toxic to aquatic life and mutagenic to humans (Brown and Hamburguer 2017).

Water is an essential resource for life on Earth and human development. The textile industry is one of the anthropogenic activities that most consume water and pollute water bodies. Therefore, the present work aims to undertake a review of the main effects of the release of industrial dyes and the essential bioremediation mechanisms. The textile dyes significantly compromise the aesthetic quality of water bodies, increase biochemical and chemical oxygen demand (BOD and COD), impair photosynthesis, inhibit plant growth, enter the food chain, provide recalcitrance and bioaccumulation, and may promote toxicity, mutagenicity, and carcinogenicity. Despite this, the bioremediation of textile dyes, i.e., the transformation or

mineralization of these contaminants by the enzymatic action of plant, bacteria, extremophiles, and fungi biomasses, is fully possible. Another option is adsorption (Binkley and Kandelbauer 2013). Presently, a wide range of physical and chemical methods are available to decolorize dye-contaminated effluents (Hao et al. 2010), but alternative processes based on biotechnological principles are attracting increasing interest (Kandelbauer and Gübitz 2015) since they often avoid the consumption of high quantities of additional chemicals, energy, and are environmentally friendly. The aim of this study is to determine the effectiveness of algae in remediating textile dye effluent.

MATERIALS AND METHODS

Sample collection and Preservation

Samples were collected in a plastic bottle from Kasarau area of Dutse metropolis (10.71⁰N and 10.37⁰E), before collecting, it was thoroughly clean with hydrochloric acid and wash with tap water to render free of acid and preserved below 4°C. All the glassware, burette and pipettes were first clean with tap water thoroughly and finally with deionized water. The chemicals and reagents used for analysis is analytical reagent grade. PH, Total Dissolved Solids (TDS), Biological Oxygen Demand (BOD), and Chemical Oxygen Demand (COD) were analyzing base on water and wastewater quality analysis ASTM standard methods before and after bioremediation.

Experimental setup

Method of Aragaw and Asmare (2017) was adopted with little modification. 250 ml, 500 ml and 1,000 ml conical flasks as photobioreactor (PBR) were used in a batch process in temperature incubation chamber and seal with cap stoppers and glass tubes through which air is fed at flow rate of 2.0L/min (Figure 1). The air feed tube was immerse at the bottom of the reactor to allow mixing, prevent sedimentations of the algae, and to ensure that all cell of the populations are equally expose to light and nutrients, and improve gas exchange between the culture medium and the air.

Two red, two blue and one white fluorescent lamps were employed as the light source for growth with an average light intensity of 1,450 Lux and with 12 D:12 L hour photoperiod with negligible external light interference. The PBR temperature was monitored 25 ±2°C. The batch experiments was conducted using bold basal medium (BBM). Algae was cultured first with 250 ml conical flask PBR in BBM media without inoculums and the culture from the freshwater sample were grown in a continuous air bubble feeding chamber with several times a day CO₂

flashing (this keeping the pH below 10) until the medium turns green, signaling adequate algae growth. Once maximum density is attained the predominant species was identified according to its morphology and microscopic observations as prominent genera using digital camera equipped microscopy (Olympus DP 73).



Figure 1: Photobioreactor constructed for phycoremediation

Dye wastewater decolorization study

Wavelength of maximum absorbance (λ_{max})

The primary step in this study is to determine the dye wastewater's maximum absorbance (λ). Thus, the range of wavelengths was scanned with a diluted solution based on the characteristic intensities of color and sensitivity of the instrument. The maximum wavelength absorbance (λ_{max}) was determined.

Spectrophotometric determination

The dye wastewater containing 10% cultured microalgae from freshwater was taken for incubation. Decolorization of dye wastewater was used to determine spectrophotometrically with a 5-day interval up to optimum decolorizations. Treated waste was drawn at regular intervals and centrifuged at 3,500 rpm for 10 minutes in order to precipitate the cell mass, and the supernatants were evaluated at the respective maximum absorbance (λ_{max}) of the tested dye wastewater, and analyses were done in triplicate. The percentage decolorization or color removal efficiency achieved will be determined by monitoring the decrease in absorbance at 592 nm, the λ_{max} . The percentage of decolorization will be calculated as shown by APHA (1995).

$$\text{Percentage decolorization (\%)} = \frac{\text{Initial Absorbance} - \text{final Absorbance}}{\text{Initial Absorbance}} \times 100$$

Effect of temperature on Decolorization

The effects of temperature on decolorization were investigated by setting the reaction volumes at 20°C, 30°C, 40°C, 50°C and 60°C with 10% inoculums concentration.

Statistical data Analysis

Obtained data were presented as mean representation of the replicates value and subjected to statistical analysis using SPSS software (version 20). Statistical significance was established at $p \leq 0.05$.

RESULTS

Identifications of the Predominant Fresh Water Co-Cultured Species

Alga cells cultivated on nutrient medium gave different species. The size and shapes of the microalgal species which identified was different with circular shapes, rod shapes and spherical shapes. The observation by light microscopy confirmed the predominant species was dominantly green algae. The identification of the species was done on the basis of microalgal morphology. As a result, the Predominant consortium of microalgal species identified in this study was: *Scenedesmus spp.*, *Chlorella spp.*, *Synedra spp.*, *Achnanthydium spp.*

As can be seen from Figure 2 *chlorella spp.* dominantly grown but *Synedra spp.* and *Achnanthydium spp.* was found in small amount. This revealed that, mostly the freshwater microalgal species sample where taken from the study, are green algae.

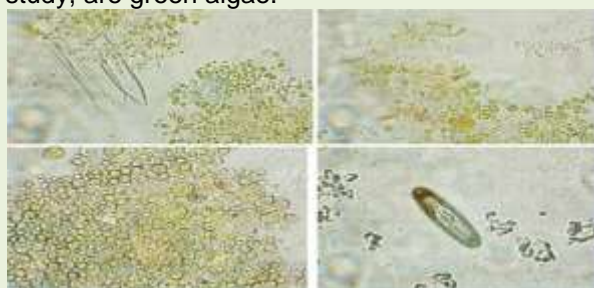


Figure 2: Microscopic photograph of mixed culture microalgal species.

Table 1 Effect of temperature on phycoremediation at varying time

Temperature (°C)	Decolorization time (hrs)				
	24	48	72	96	120
25	3.85	3.78	3.08	2.92	2.12
30	3.79	3.15	2.55	2.00	1.75
35	3.53	3.01	2.16	1.56	1.01
40	3.76	3.45	3.19	2.97	2.14

Table 2 Physico-chemical properties textile wastewater samples before and after remediation

Parameters	Before treatment	After treatment	Percentage removal	Guide line limit
Color	Blue black	Light blue	-	Offensive colors not accepted
TDS	1210 ± 2.7	220 ± 2.7	81.81%	250 mg/L
PH	10.5 ± 0.2	8.3 ± 0.2	-	6-9
COD	361 ± 2.0	157 ± 2.0	56.51%	160 mg/L
BOD	401 ± 5.0	32.5 ± 3.0	91.89%	160 mg/L

Keys: BOD: biological oxygen demand, COD: Chemical oxygen demand, TDS: Total dissolve solid

Discussion

The results obtained from this study show that the predominant consortium of microalgal species identified in this study was *Scenedesmus spp.*, *Chlorella spp.*, *Synedra spp.*, and *Achnanthydium spp.*, as seen in Figure 1, in which *chlorella spp.* was dominantly grown but *Synedra spp.* and *Achnanthydium spp.* were found in small amounts. This revealed that most of the freshwater microalgal species samples taken from the study are green algae; this species was also identified by Missoum (2018) in his research conducted in Gambia.

The temperature and pH of the cultures were within the optimum microalgal growth range suggested for most strains of algae, as were the wastewater temperature values (Borowitzka 2010). Those ranges are mostly 20–60 °C to understand the effect of low temperature, room temperature, and high temperature on the decolorization. Among the different temperatures tested in this study, 25 °C was found to be the optimum for decolorization. It is noted that the percentage of decolorization increased with an increase in temperature from 25°C to 45°C. The percentage of decolorization decreased with a further increase in temperature up to 45 °C. An increase in the temperature from 25 to 45 °C had a positive impact on the decolorization of dye (malachite green) wastewater (Figure 1).

Decolourization of dye (Malachite green) wastewater was found optimal at a temperature 35 °C, as the species were able to decolorize by 78% for a 4-day cultivation time. High temperatures probably caused the thermal deactivation of the algal enzyme(s) responsible for decolorization. Previously, Guo et al. (2010) reported that 28 to 35 °C may be an optimal temperature for the decolorization of dye (Malachite green) wastewater.

The determination of physicochemical parameters of the wastewater before and after treatment in this study is presented in Table 2. BOD₅, COD, and TDS values have decreased dramatically from 5 to 15 remediation times. Also, it can be seen from Table 2 that the color is not offensive; TDS, COD, and BOD have 89.10%, 91.50%, and 91.90% percentage removal, respectively. This much of the removal COD, BOD, and TDS conforms to acceptable ranges of the guideline limit.

About 100% of the variability in the percent decolorization is explained by the incubation time, temperature, and temperature-incubation time interaction, as shown in Table 2. For each, the P-value is 0.05; this shows that there is a significant

effect both on the main effect and their interaction on the percentage decolorization. And this is in line with the research conducted in Libia by Bras et al. (2015).

Conclusion

Microalgae have the capability of biotransforming and biodegrading dye contaminants commonly found in natural sources and wastewaters. Furthermore, microalgae have the ability to enhance the biodegradation potential of the microbiota present and therefore contribute to the elimination of pollutants from the respective ecosystem. Most of the green microalgae from freshwater were used to treat the dyed (malachite green) wastewater. Biodegradation activity is significantly suppressed at high temperatures in the basic and acidic PH ranges. This can be due to cell viability loss or the deactivation of biodegradation enzymes. Generally, it can be concluded that algae undoubtedly have the potential to rapidly, efficiently, and effectively remove dye wastewater to acceptable ranges of guideline limits at environmental temperature and neutral PH range. Moreover, the biosorption process could be adopted as a cost-effective and efficient approach for decolorizing effluents, and it may be an alternative to more costly materials.

Recommendations

- i. It was recommended that an industrial dye effluent can be remediated using algae species at an optimum temperature in a specific time.
- ii. Also more research should be done on which algal species degrade effluent dye

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