Decolorization of Malachite green dye using seaweed

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Abstract
The potential use of seaweed Sargassum crassifolium to decolorize Malachite Green dye (MG) in a batch process has been investigated in the current study. Adsorbent dosage, contact duration, initial dye concentration, as well as temperature were examined as influencing factors for adsorption. Optimizing the initial pH (2 – 12), temperature (20 – 38°C), initial concentration of dye (10 – 30 mg/L) as well as adsorbent dose (0.4 – 2.4 g) at varying time intervals led to an increase in the decolorization efficiency. The percentage of dye adsorption was calculated using standardized colorimetric procedures.

The highest degree of decolorization was observed at an initial pH of 8, dye concentration of 10 mg/L, a biosorbent dosing of 2 g, contact temperature of 35°C, at a contact period of 150 min. The findings have indicated that the research is a useful alternative technique in minimizing damage to the ecosystem.

Keywords: Malachite green, decolorization, seaweed, adsorption.

Introduction
Treatment of pollutant-contaminated wastewater remains a major challenge in modern society. Today, there is still a lot of concern on treating wastewater contaminated with toxins. Concerns include the intake of contaminated water, especially in developing nations, which can result in a range of diseases and ailments[5]. Furthermore, as the world's population continues to rise, there is an exponential increase in the demand for textiles and coloring products. Consequently, there has been a surge in both the production volume and the utilization of colored materials including synthetic dyes. As synthetic dyes are inexpensive, widely accessible and used in a variety of ways, this cannot be avoided[3].

The dyes easily pollute the water when they are released into waterways. The majority of synthetic dyes could be extremely hazardous to the environment and to living organisms. Prior to being disposed of into water systems, contaminated wastewater needs to be treated to minimize this problem[11].

Although dye concentrations exceeding 1 mg/L are normally noticeable in water, the usual textile wastewater dye concentration is 300 mg/L[14]. An enormous amount of dyeing wastewater is produced as a result of the increased water consumption that occurs in textile processing procedures like dyeing, cleaning, de-sizing as well as finishing[15]. Owing to the existence of toxic aromatics, heavy metals, chlorides and other contaminants, ineffective treatment of such a dyeing effluent results in soil as well as natural water body pollution[12].

One of the widely used dyes throughout the textile industry is malachite green (MG)[6,9,10]. Humans experience teratogenic, mutagenic, as well as carcinogenic impacts from MG exposure[16]. Different treatment options have been developed and utilized for this purpose. Adsorption has been reported to be one of the most efficient processes for removing color from dye wastewaters among all of the treatment options.

Research on biosorption based approach that takes advantage of the sorption ability of biological substances for removal of various pollutants has been sparked by growing demands for efficient and affordable color removal technologies. Dried and nonliving biomass could serve as a desirable biosorbent for color removal from dye effluents. Metabolically functional Aspergillus terreus culture was utilized to remove synthetic dyes[4].

Triphenyl methane dye called malachite green is used to color materials including cotton, silk, wool, paper and leather. It is additionally useful as antiprotozoan, fungicide, antibacterial and parasiticide agent[13]. The dye is exclusively recommended for external application because it contains nitrogen, which is hazardous, toxic and carcinogenic when consumed orally[2]. It is well recognized to be extremely harmful to mammalian cells and to promote tumour growth. Additionally, it impairs the ability to eat, develop and reproduce, damages the major organs and results in lesions on the body. Therefore, it is crucial to remove them from the effluents.

A marine algae species that is abundant in sulfated polysaccharides and has a wide range of biological characteristics, including free radical scavenging as well as antioxidant effects, is the brown *Sargassum crassifolium* algae. The goal of this research is to use the seaweed *Sargassum crassifolium* to effectively remove the triphenylmethane dye (MG) and to optimize the process parameters.

Material and Methods
Preparation of seaweed sample (adsorbent): *Sargassum crassifolium*, a type of seaweed, was rinsed with water

several times to get rid of contaminants. For seven days, the washed seaweed was completely air dried. Then it was pulverized and sieved to yield particles of 150µm in size.

Preparation of dye (adsorbate): One gram per litre of water was used to dissolve precisely weighed colors to create dye stock. In order to prevent color decolorization from light, the bottle was shielded with aluminium foil and stored at room temperature in a dark place.

Batch adsorption study: The effects of different variables on the discharge of MG color by fluid arrangement upon the *S. crassifolium* were taken into consideration. 100 mL of dye solution and the required level of adsorbent were placed inside 250 ml Erlenmeyer flask for the experimental studies. The experiment was performed with various dye concentrations (10-30 mg/L), adsorbent doses (0.4–2.4 g), pH (2-12) and at various temperatures (20-38° C) to assess the impact of diverse environmental conditions on decolorization. 0.1 N Sodium hydroxide and 0.1 N hydrochloric acid were added to the solution to adjust the pH. The color removal efficiency and adsorption capacity were assessed at different intervals of time (0, 30, 60, 90, 120, 150 min) at the optimized conditions. The final dye concentration was calculated based on absorbance of a supernatant arrangement as measured by a colorimeter operating at 625 nm.

Results and Discussion

Adsorbent dose effect: The maximum colour removal was observed at 2g (95.7%) biosorbent concentration (Figure 1). Biosorption potential of the biosorbent decreased when the adsorbent dose was increased from 2 to 2.4. The percentage of colour removal was 95.7% for the 2g adsorbent dose.

Effect of pH: The effect of pH was investigated by increasing the pH values from 2 to 12 (Figure 2). The minimum adsorption rate of 40% was observed at pH 2. Adsorption was found to increase slowly as pH was increased; at pH 4, it increased by 60%; at pH 6, by 90%; and at pH 8, it increased by a maximum of 95.5%. The adsorption rate gradually decreased above pH 8 and was observed to be 65% when the pH was 12. Similar findings were reported for the adsorption studies of malachite green dye employing rambutan seed derived activated carbon[1].

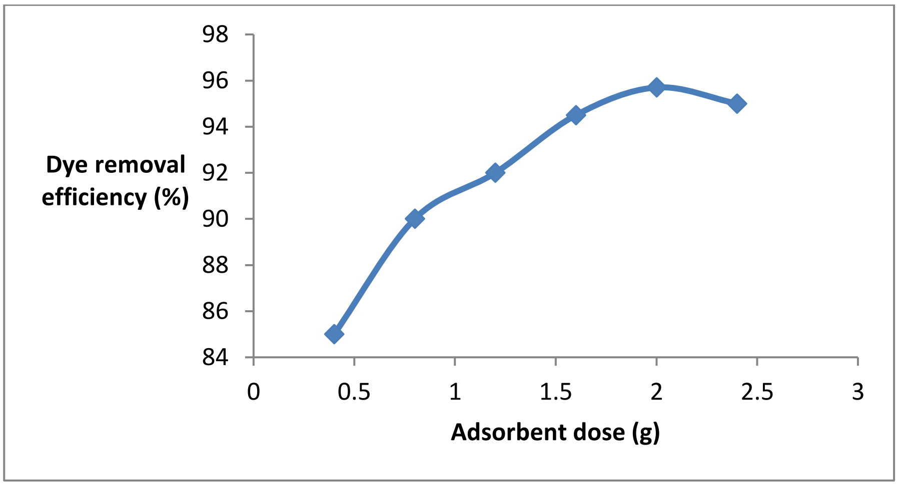

Fig. 1: Effect of adsorbent dose on the removal of MG dye

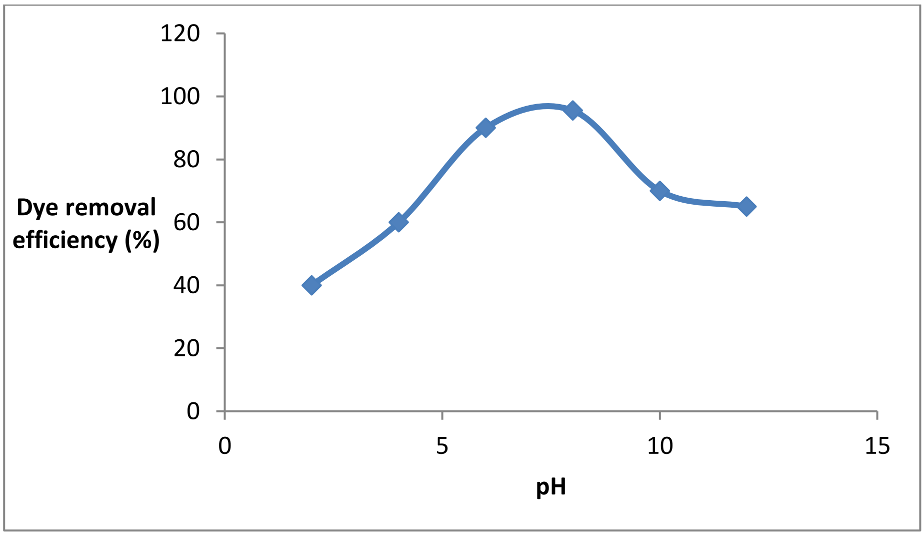

Fig. 2: Effect of pH on removal of MG dye

Effect of temperature: Within the range of 20°C to 38°C, the effect of temperature was taken into consideration (Figure 3). With the increase in temperature from 20°C to 35°C, the color removal was increased from 80% to 96%. When the temperature was raised from 35°C to 38°C, there was either no noticeable increase in color loss or a decrease from 96% to 95%. The maximum removal of color was subsequently achieved at 35°C.

The reduced ability of colors to be bioadsorbed at extremely high temperatures may be attributed to the deterioration of the adsorptive properties necessary for adsorption of color compounds onto the surface layer of biosorbents. This may also be due to the deactivation of energetic areas which occurs at higher temperatures and reduces biosorption[8]. The adsorption was therefore moderate at high temperatures.

Effect of initial dye concentration and contact time: Figure 4 illustrates that the color was quickly absorbed in the first 30 minutes and thereafter, the total color removal was relatively constant. Malachite green dye adsorption on polyaniline and formaldehyde on chitosan composite yielded similar results[7]. The exterior surface of adsorbent initially absorbs the colour and the adsorption rate is rapid.

The color is adsorbed by the interior particle surface when the exterior adsorption surface becomes immersed in it. The first rapid adsorption can be explained by the instant binding of colors towards the adsorbent surface or by the enormous number of empty spaces present in the initial arrangement. *S. crassifolium* was able to fully adsorb MG dye out of an aqueous solution under the aforementioned optimal conditions as presented in table 1.

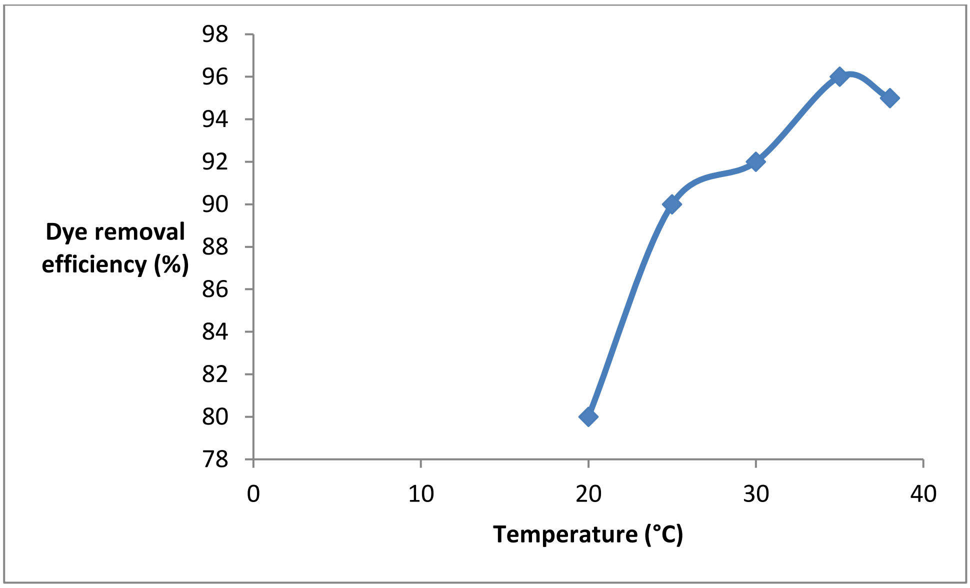

Fig. 3: Effect of temperature on removal of MG dye

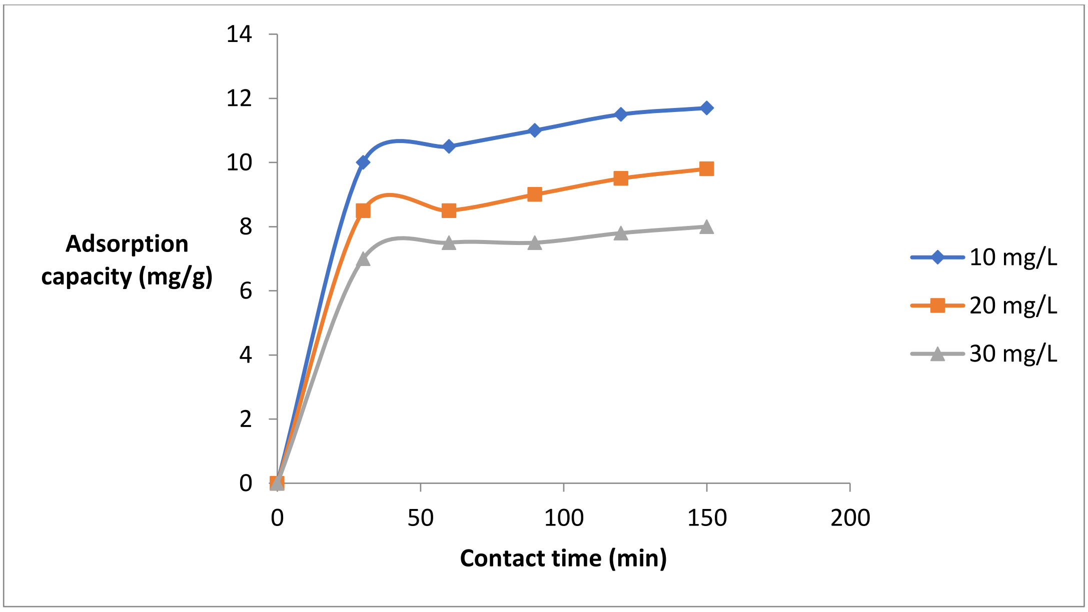

Fig. 4: Effect of dye concentration and time on the removal of MG dye

Table 1
Optimum conditions of MG dye removal using *S. crassifolium*

S.N.	Parameters	Treatment conditions	Dye removal efficiency (%)
1	Adsorbent dose	2g	95.7
2	pH	8	95.5
3	Temperature	35°C	96
4	Contact time	150 min	96

Conclusion

The findings of this investigation clearly demonstrated that seaweed *S. crassifolium* is an effective adsorbent for the removal of MG from aqueous solutions. *S. crassifolium* was effectively used to identify the optimal conditions for the removal of the maximum proportion of MG dye. The optimum conditions for *S. crassifolium* to remove MG are determined.

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