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Phytoremediation Potential of An Azo Dye-Malachite Green

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Abstract
The use of phytoremediation is an eco-friendly and non-destructive method of dye removal from water and soil. On the basis of Tinospora cordifolia ability, it is investigated for phytoremediation. Different experiments were carried out with different concentration of an azo dye malachite green. Degradation of malachite green was confirmed with the help of UV-visible spectroscopy. Parameters like pH and conductivity were also studied before and after treatment with Tinospora cordifolia. The values of these parameters were found to be significantly reduced by Tinospora cordifolia by within 72 hours and it has been observed that Tinospora cordifolia is an efficient plant for degradation of dyes from water resources.
Keywords
Phytoremediation, Non-destructive method.

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INTRODUCTION
Today, more than 100,000 commercial dyes are available in the market and nearly one million tonnes per annum are produced, whereas 10% of dyes are released in the environment and natural resources as dyestuff waste [1]. This production is increased day by day to meet the needs of a growing population, also increases the release of dye effluent. A majority of these dyes are non- biodegradable and toxic to flora and fauna & even carcinogenic or mutagenic in nature [2]. The textile industry is one of the major sources of dye effluent due to the high quantities of water that are used in the dyeing processes. The effluents from these industries are complex, containing a wide variety of dyes and other products, such as dispersants, acids, bases, salts, detergents, humectants, oxidants, high TDS, sodium, chloride, sulphate, hardness, and carcinogenic dye ingredients [3]. Several physical and chemical methods have been suggested for the treatment of dye-contaminated wastewater but are not widely used because of the high cost, low efficiency, and inapplicability to avoid a variety of dyes as well as the formation of toxic by-product and secondary pollution that can be generated by excessive use of chemicals [4]. Alternatively, the approach is shifting towards the use of biological methods to treat such waste water containing dyes [5]. These methods are gaining more importance nowadays because of their lesser cost, effectiveness and eco-friendly nature. Phytoremediation is one of such promising non - destructive and eco-friendly technology that uses green plants for contaminants, degradation or extraction of xenobiotics from water or soil. There are several ways by which plants clean up or remediate contaminated sites like phytoextraction,

rhizofiltration, phytotransformation, phytostabilization, and phytovolatilization. Phytoextraction is the uptake of contaminants by plant roots and translocation within the plants. Contaminants are generally removed by harvesting the plants. It is the best approach to remove contaminants from soil, sediment and sludge. Rhizofiltration is the use of plants, both terrestrial and aquatic, to absorb and concentrate contaminants from polluted aqueous sources in their roots. Terrestrial plants are more preferred because they have a fibrous and much longer root system, an increasing amount of root area that effectively removes the potentially toxic metal [6]. Phytotransformation is a chemical modification of environmental substances as a direct result of plant metabolism often resulting in their inactivation, degradation (phytodegradation). Phytostabilization is the use of plants is to reduce the mobility or bioavailability of pollutants in the environment, thus preventing their migration to groundwater or their entry into the food chain. Phytovolatilization is the use of plants in the uptake of contaminants from soil and waste water, transforming them into the volatilized compound and then transpiring into the atmosphere. A very few studies of phytoremediation have been reported on dye degradation, so it is still in the experimental stage. Plants of *Rheum rabarbarum* reported for the accumulation of sulfonated anthraquinones dyes [7]. Phragmites australis, a reed which is a component of the wetland community has been extensively studied for remediation of textile effluents and mainly with respect to the removal of the dye, Acid Orange 7 [8]. *Typha angustifolia* has been shown potential to remediate synthetic reactive dyes waste water treatment [9]. Tissue culture and plants of *Blumea malcolm* have been found to degrade dyes such as Malachite green, Red HE8B, Methyl orange, Reactive Red 5B [10, 11]. *Typhonium flagelliform* potentially degrade dye Brilliant Blue R and textile dye effluent also [12]. Roots of *Brassica juncea* are able to decolorize methyl orange 92% within 4 days [13]. *Glandularia pulchella* efficiently remediates various textile dyes and a mixture of synthetic dyes into their nontoxic forms [14-16]. *Nopalea cochenillifera* (Cactus) transformed various toxic textile dyes including Red HE7B into less toxic and non-hazardous metabolites [17]. Phytoremediation potential of *Petunia grandiflora* has been explored for disulfonated triphenylmethane textile dye Brilliant Blue G (BBG), dye mixture and textile effluent [18]. So, this research work studied the potential of the Tinospora cordifolia (a macroalga, also called as Brittlewort or stonewort) for phytoremediation against an azo dye Eriochrome Black-T.

MATERIALS AND METHODS

Plant Material and extractions:

Tinospora cordifolia is commonly found in the local area of Ahmedabad. It is a garden tree as well. So it was used for the phytoremediation process. The *Tinospora cordifolia* shoot was collected from Gujarat university campus and in and around Ahmedabad, Gujarat. Samples of plant material were authenticated by the botany department, Gujarat University, Ahmedabad, India. The powder defatted dry plant material (20 gm.) was extracted with 200 ml of solvent for 72 hrs., refluxed at a temperature below the solvent boiling point using Soxhlet extractor. The crude solvent collected in the flask was concentrated at reduced pressure. The yield collected after drying was kept at -4^{o}C until further use.

Chemicals and dyes

All chemicals used were of the highest purity available and of analytical grade. Eriochrome black-T (Fig 1) was obtained from Merck.

Decolourization Experiments

All decolorization experiments were performed in three sets and average values were determined. First, a screening test was done with *Tinospora cordifolia* for phytoremediation. In the screening test, plant (2 g) was suspended in 100 ml malachite green solution of 20 mg/l. After 24 hours, plant showed the very good visible result with an accumulation of blue coloration in reproductive parts of the plant as well as nodal and intermodal portions. With this indication, further experiments were carried out with different concentration of malachite green dye 50, 100, 200, 500 mg/L and control sample to measure the decolorization. The analysis was done by using different analytical methods such as UV/ VIS spectroscopy, pH meters, conductivity. The supernatant of various dye solutions was analyzed to measure absorbance at their respective absorption maxim λ_{max} (malachite green-623nm) using a Systronic-2202 UV-visible double beam spectrophotometer. The pH of the samples was determined by using a glass electrode pH meter (E.I. Model111) calibrated at pH 4.0 and 9.0. The conductivity was determined with the help of conductivity-meter.

Experimental Setup

The plants were taken of same growth stage and almost of equivalent dry weights approx. 5g (weight is taken after keeping the plant on filter paper) for all experiments carried out in 1-liter beakers.

Table 1: Experiment Set up

Experimental set up (500 ml)	(Malachite green) Concentration
Set a	50 mg/L
Set b	100 mg/L
Set c	200 mg/L
Set d	500 mg/L
Sete	Control (without dye)

After 72 hours, the absorbance of the clear solution was measured at the respective absorption maxima. Decolorization percentage was calculated as follows:

Decolorization % = Initial Absorbance-Observed absorbance /Initial Absorbance x 100

RESULTS AND DISCUSSION

In this present work, the excellent response of Tinospora cordifolia plant is observed for phytoremediation of dye waste water. Tinospora cordifolia is well known for its strong nutrient absorption power. On basis of this ability, it is investigated for phytoremediation. After the 1st day of experimentation, blue-violet pigmentation of reproductive parts starts appearing in malachite green concentrated water. Blue-violet patches observed in case of malachite green concentrated water. This results also point toward strong phytoextraction ability of plant.

Plant show effective decolorization results with both malachite green concentrated water. UV-visible spectrophotometric, conductometric and pH analysis (400-800nm) of different experimental sets were carried out after 72 hours which indicated maximum decolorization in set b (100 mg malachite green dye per liter). UV-visible spectra of different sets of malachite green concentrated water provide evidence of decolorization. A malachite green solution of 200 mg per liter showed maximum decolorization percentage 73% and minimum decolorization occurs in 500mg/l dye waste water as shown in figure 3. In 500mg/L malachite green concentrated water, plant enzyme became almost law after 1week and showed only 5% decolorization. As far as conductivity is concerned, *Tinospora cordifolia* decreases the conductivity of different concentration of the malachite green solution and textile dye waste water. Maximum decreases found in 200mg/L malachite green concentrated water as shown in figure 4. Also, the results obtained from the pH study of malachite green concentrated water gave confirmation about the extraction of dyes from the water by the plant. After treatment, different malachite green concentrated water shows the significant increase in pH which indicates the concentration of malachite green decreased in different solutions to a different extent as shown in figure 5. Minimum pH change observed in 50mg/L malachite green concentrated water in after 1 week.

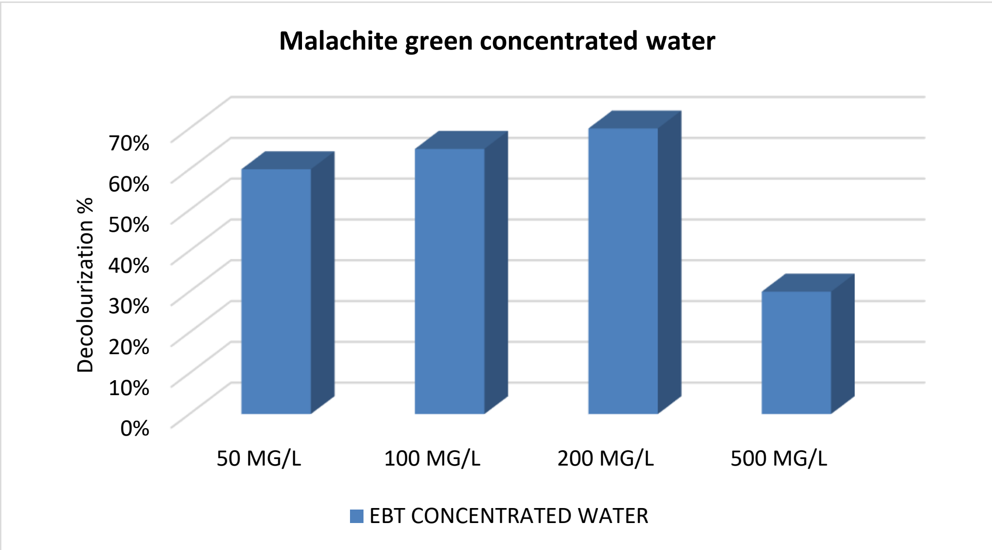

Fig 3. Decolourization % in malachite green concentrated water

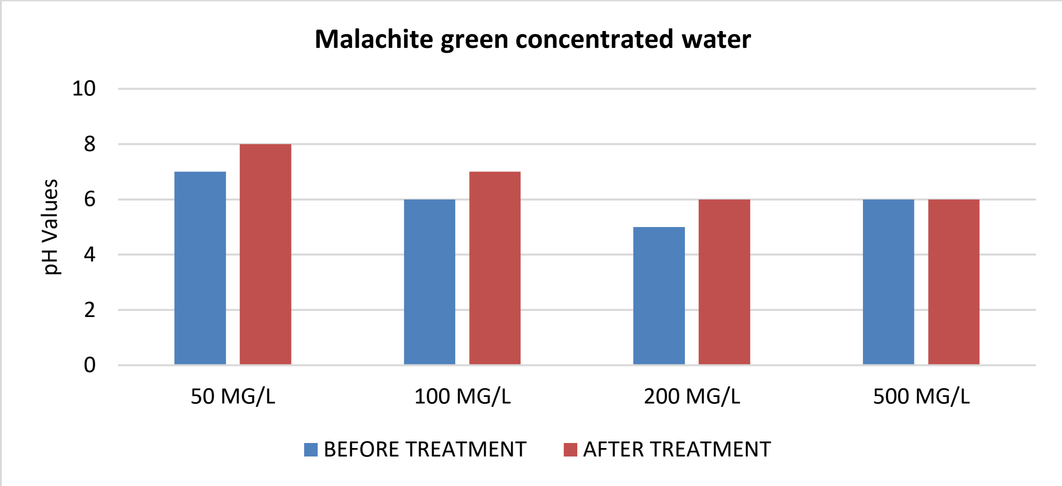

Fig 4. pH Change in malachite green concentrated water

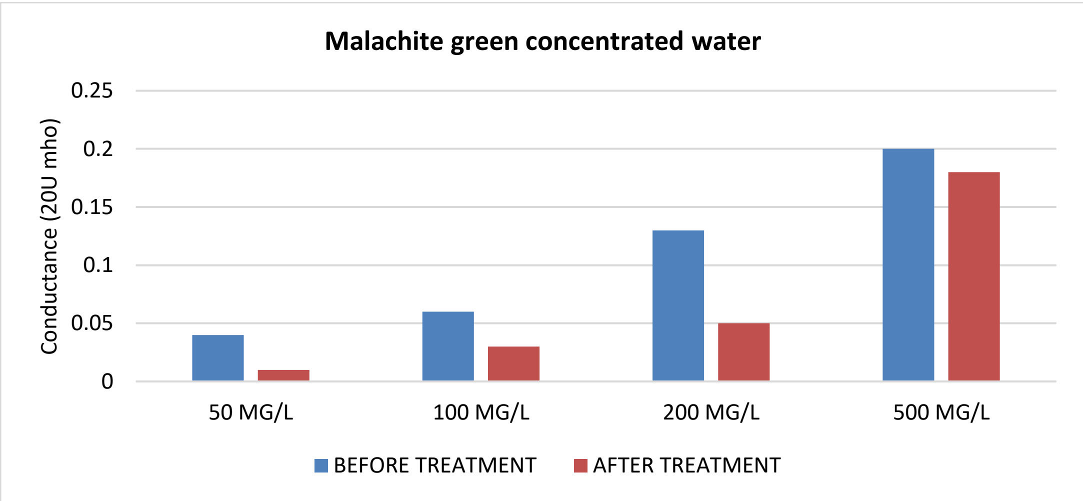

Fig 5. Conductance change in malachite green concentrated water

CONCLUSION

From our study, it was concluded that Tinospora cordifolia plant has sufficient potential for removing dyes from polluted water. Tinospora cordifolia plant efficiently removes dyes through phytoextraction process. It extracts dyes from water through its fine rhizoids and stem. Overall, Tinospora cordifolia plant was found to be most tolerant plant in 70-75 % concentrated water. However, highly concentrated water has negative effect on plant and dye shows its toxic effect on plant. So Tinospora cordifolia is made more efficient by dilution of waste water.

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