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EFFICIENT REMOVAL OF MAGENTA DYE FROM WATER BY BOTH NATURAL AND CHEMICAL COAGULANTS

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ABSTRACT

Reactive magenta dye (RMD) has been removed from the aqueous solution by different coagulants such as natural coagulants *Moringaoleifera* (MO), *Strychnos potatotrum* (SP), and Alum chemical coagulants (AC) respectively. All these three coagulants were studied with various parameters to optimize the maximum removal %, like coagulant dosage from 10 ml to 60 ml, RMD concentration range of 100 mg/L to 500 mg/L, contact time between 10 min to 60 min, and pH kept neutral. The maximum percentage removal was achieved by SP coagulant at 60 min contact time, 100 mg/L dye concentration, and 60 ml coagulant dosage whereas MO and Alum achieved the maximum of 93% and 85% respectively. The results showed that MO seeds, SP seeds, and AC coagulants performed well in the removal of suspended solids and dye color. Furthermore, this research validated the preparation of low-cost eco-friendly coagulants and effective jar test methods for treating reactive dyes which are present in real textile water.

Keywords: Natural Coagulant, *Moringaoleifera, Strychno Spotatotrum*, Alum Coagulant, Wastewater, Reactive Magenta Dye.

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INTRODUCTION

Nowadays chemically enriched wastewater discharges have been increasing due to the excessive amount of toxic chemicals used in the industry. Wastewater from various industries like textile, dye synthesis, food, printing, plastic, paper, pulp, and leather industries creates a great cause of environmental pollution.[1] Frequently, dyes are refractory organic compounds that give effluent a vivid hue. They increase the toxicity and organic load of the effluent. Due to limited light penetration and the inclusion of extremely poisonous metal complex dyes, the colored wastewaters of these businesses are detrimental to aquatic life in rivers and lakes.[1,2] The majority of dyes are resistant to oxidizing agents, biodegradation, and UV deterioration.[3] Significant amounts of organic, inorganic, and metal pollutants have been produced concurrently with unprecedented economic growth, which is supported by thriving industries.[4] The migration of these anthropogenic-based toxins makes pollutants have negative effects on human, ecological, and environmental health.[5,6] Cost-effective technologies like coagulation are the best immediate choice because these rural or impoverished towns lack adequate water treatment systems. Coagulation is a crucial step in the treatment of both industrial effluent and surface water.[7] Therefore, coagulation has drawn a lot of interest due to its ability to effectively remove pollutants, particularly colors. Poly aluminum chloride, ferric chloride ($FeCl_3$), and Alum ($AlCl_3$) is the traditional chemical-based coagulants that can be used to remove turbidity and dissolved chemicals from wastewater.[8,9] The main drawbacks of chemical coagulants are including inefficiency in low-temperature, preparation costs, affecting human health, and producing huge amounts of slurry.[10] To address the aforementioned issues, preferable to switch over the plant-based coagulants.[11] The main benefit of employing naturally occurring plant-based coagulants is economically low cost.[12] Plant-based coagulants have been used for treating turbid water for more than a few millennia. Although it is apparent that the coagulants are intended to be a straightforward home POU technology, various studies have concentrated on their application for the treatment of industrial wastewater. The foremost objective of the present study is to examine a novel formulation of coagulation for color removal

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from an aqueous solution using dry MO, SP, and AC coagulants. Various parameters were studied in the current study such as coagulant dosage, RMD concentration, contact time, and pH respectively. In addition, the natural coagulants on dye removal percentage are compared with chemical coagulant results.

EXPERIMENTAL

Coagulant Preparation

MO seeds shell was carefully removed, only the best seeds were chosen, and the kernel was then processed in a typical power blender to a fine powder. Salts like NaCl or KCl solution have been used to activate the coagulants. Following multiple tests, about 4% of concentration (4 g in 100 ml) was utilized for this study. Using a magnetic stirrer, the entire liquid was swirled for 30 minutes at room temperature. The Whatman filter paper was used to filter the suspension. The filtrate solution that was produced was employed as a coagulant. Every day a new solution was devised for consistent outcomes. The MO seeds, MO powder, and coagulant solution can be seen in Fig.-1 (a-c).

Fig.-1:(a) Moringaoleifera Seeds (b) Moringaoleifera Powder (c) Coagulant Solution

Preparation of Dye Solution

Table-1: Properties of Reactive Magenta Dye

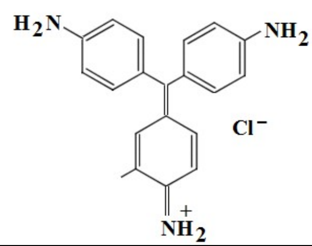
Properties of reactive magenta dye	
RMD structure	
Color index number	42510
CAS Number	632-99-5
Empirical formula	$C_{20}H_{20}ClN_3$
Weight of Molecule	337.86 g/mol
pH	5-6
Max. wavelength (λ_{max})	549 - 552 nm
Application(s)	Diagnostic assay manufacturing, craft color terracotta, dye-tamed wolf collars, haematology, and histology.

Table-1 shows the properties of the reactive magenta dye. Weighed amounts of dye were dissolved in distilled water to create the RMD dye solution stock. For the experiment, a solution with 100 mg/L concentration was used from the mother solution of one-litre prepared solution. The prepared fresh stock solution has been used for the everyday experiment to make consistent results.

Jar Test Apparatus

The coagulation study was conducted in a Jar test device, that has simultaneous agitation capable of six 1.0 L beakers and allowed for variable rotational speeds range of 0 to 100 RPM as shown in Fig.-2 (a) and (b) for jar test experiment and filtrate solution from jar test respectively. The prepared dye sample, 1000 ml, was put into the beakers. A coagulant dose (10 ml to 60 ml) was introduced into each beaker during speedy

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mixing of 100 RPM for two min. This was monitored by a steady mixing state of 40 RPM for 30 min followed by 30 min sedimentation. After sedimentation, Whatman grade No. 42 filter paper was used to purify the supernatant. A UV spectrophotometer was used to measure the absorbance with the 475 nm wavelength of the filtrate. For each solution, readings were taken in triplicate to ensure reproducibility. For the three determinations, the coefficient of variation found was no higher than 4%. The dye removal % was calculated using Eqn.-1.[13-16]

$$\%\ of\ dye\ removal = \frac{C_i - C_f}{C_i} \qquad (1)$$

Where, C_i and C_f denote the concentration of the initial and final solution.

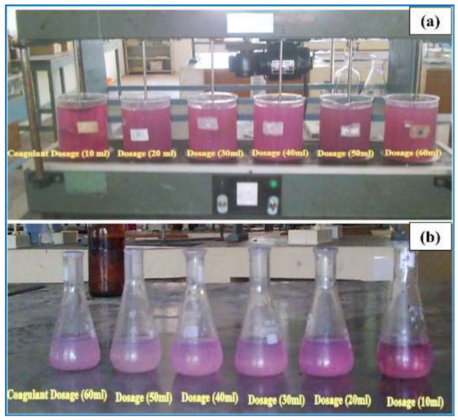

Fig.-2: (a) Jar Test Apparatus, (b) Filtrate Solution from Jar Test

RESULTS AND DISCUSSION

Effect of Coagulant Dosage

One of the most crucial factors taken into account while determining the ideal circumstances for chitosan performance in coagulation and flocculation is the coagulant dosage. Poor flocculation performance would be caused by an inadequate dosage or an overdose. Hence, it is essential to establish the ideal dose of coagulants to reduce dosage costs and get the best possible therapeutic results.

Color Removal

Figure-3 demonstrates the impact of an alum coagulant on the removal of color from a dye solution prepared with an RMD between 100 mg/L and 500 mg/L. The Alum solution varied from 10 ml to 60 ml concerning RMD solution. With increasing RMD concentration it starts to decrease the percentage of dye removal. This phenomenon may occur due to a high dosage of dye concentration. When increased up to 500 mg/L concentration the removal percentage was obtained at 66% only. 60 ml of solution gives a maximum of 85% color removal.

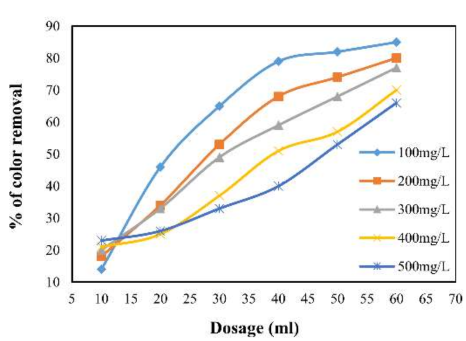

Fig.-3: The Effect of Alum Coagulant Dosage for Dye Removal using RMD from 100 to 500 mg/L

It can be seen in Fig.-4, the impact of MO coagulant dose on prepared dye solution color removal using RMD. In this experiment, the parameters of MO dosage and RMD concentration varied from 10-60 ml and 100-500 mg/L respectively. With increasing RMD concentration the dye removal % begins to decrease up

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to 62 % for 500 mg/L. The drastic removal % was observed when increased RMD concentration from 100 to 200 mg/L (13% difference). Same time the 300 mg/L obtained 74% dye removal. The maximum % of RMD removal was achieved at 60 ml coagulant dosage, and 100 mg/L concentration was 93%. Figure-5 shows the effect of SP coagulant dosage on the removal of color using an aqueous RMD solution. Here the operating conditions of 60 ml of coagulant dosage and 100 mg/L concentration yield the maximum 95% dye removal. Later, increasing the dye concentration the removal % starts to decline. From this experiment moving from 200 to 300 mg/L concentration, we noticed around a 12% increment in dye removal. Least % elimination was noticed at 500 mg/L dye concentration for 61% RMD removal. The comparative study of three coagulants such as MO, SP, and AC was analyzed and tabulated in Table-2. This study confirms the SP coagulant performed well and yielded up to 95% removal than other coagulants.

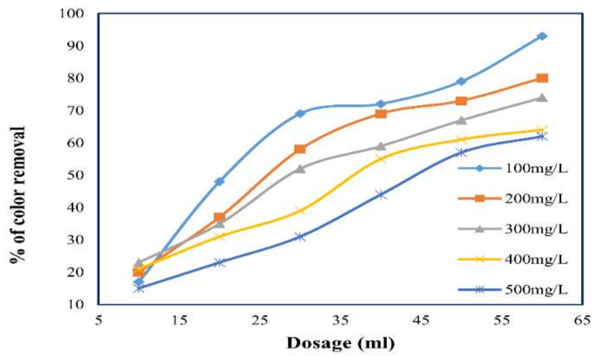

Fig.-4: The Effect of MO Coagulant Dose for Dye Removal using RMD

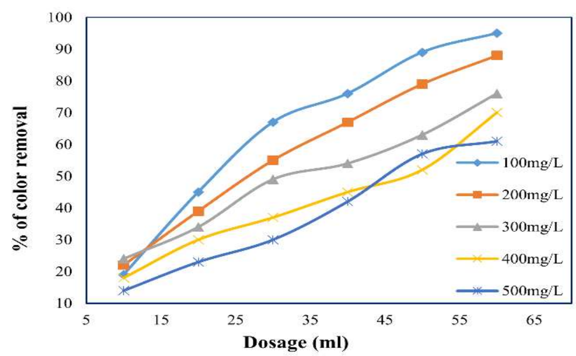

Fig.-5: The Effect of SP Coagulant Dose for Dye using RMD

Table-2: Comparison of Various Coagulants with their % Removal and Contact Time of Reactive Magenta Dye

Coagulant	Contact time (min)	% Removal	References
Algal alginate	60	92.5	9
Alum	60	85	This work
Moringa oleifera	60	93	This work
Strychnos potatorum	60	95	This work

CONCLUSION

The natural coagulants were developed for RMD removal and obtained results compared with the Alum chemical coagulant. The natural coagulants such as MO and SP achieved 93% and 95% respectively the maximum dye removal percentage whereas AC coagulant obtained a maximum of 85% at 60 min contact time, 100 mg/L dye concentration, and 60 ml coagulant dosage. Therefore, the current study confirmed that natural coagulants perform better than chemical coagulants. So, these results demonstrate the existence of natural coagulants is a better choice to treat reactive toxic dyes that are more often present in the effluent.

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CONFLICT OF INTERESTS

The authors hereby declare that they do not have any conflict of interest.

AUTHOR CONTRIBUTIONS

All the authors contributed significantly to this manuscript, participated in reviewing/editing and approved the final draft for publication. The research profile of the authors can be verified from their ORCID ids, given below:

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