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Article

Degradation Of Congo Red Based On Natural Coagulant (*Moringa Oleifera*)

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Abstract

The release of dyes into the environment can have deleterious effects. therefore, their handling must be done in a conscientious manner. One method that can be employed is coagulation-flocculation. The employment of natural coagulants has been demonstrated to mitigate the deleterious effects of polluting compounds on the ecosystem. *Moringa oleifera*, a plant native to tropical regions, including Indonesia, is a natural source of coagulants. *Moringa oleifera* plants are extracted using sodium chloride to isolate protein active ingredients. The utilization of a natural coagulant derived from *moringa oleifera* was implemented with the objective of ameliorating the deleterious effects of congo red. The effectiveness of the natural coagulant was evaluated based on the effect of initial concentration and coagulant dosage. The initial concentration and dose of coagulant exhibited a direct correlation with the efficiency of reducing congo red. An increase in the initial concentration resulted in a concomitant decrease in efficiency, while an increase in the coagulant dose demonstrated a corresponding increase in efficiency. The highest removal efficiency value was obtained when the coagulant dose was 100 ppm and the initial concentration was also 100 ppm. The consequence of this condition was a 99.46% reduction in efficiency of the congo red.

Keywords: coagulation-flocculation, congo red, moringa oleifera, natural coagulant

1. Introduction

In the contemporary era, the growth of the industrial sector and the increase in production are indicative of the major developments taking place in contemporary society. Dyes have been extensively utilized in a variety of industrial sectors, particularly in the production of paper, plastics, foodstuffs, leather goods, cosmetics, pharmaceuticals, dyes, and textiles [1], [2]. The discharge of dye effluents into water bodies has been demonstrated to induce substantial ecological complications, even when utilized at trace concentrations. This phenomenon can be attributed primarily to the elevated organic composition of the dyes, their associated toxicity profile, and the resultant aesthetic pollution that is concomitant with dye utilization [3]. Congo red is a contaminant that has the potential to exert deleterious effects on ecological systems due to its chromatic properties, which, at low concentrations, can produce carcinogenic and mutagenic effects [4].

The remediation of water bodies that have been contaminated by pollutants necessitates the implementation of suitable treatment methodologies. There exist several methodologies that may be employed in order to minimize the

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presence of congo red in industrial wastewater. Such methodologies include, but are not limited to, membrane filtration [5], adsorption [6], and biological treatment [7]. However, despite the advancements made in other technologies, the chemical coagulation-flocculation process remains the preferred technology due to its simplicity and efficiency [8]. The process entails the utilization of chemicals, including alum, lime, and polyaluminium chloride. These chemicals have been associated with significant environmental issues, including substantial accumulations of sludge and documented detrimental impacts on human health [9]. The utilization of natural coagulants, such as chitosan [10], papaya seed [11], *leucaena leucocephala* [8], *moringa stenopelata* [12], and *moringa oleifera* [13], has been demonstrated to be an effective method for mitigating the adverse effects of dyes in wastewater. Furthermore, natural coagulants possess properties that include biodegradability and environmental friendliness [14], [15].

Natural coagulants can be applied directly from plant parts, such as in the form of seed powder. However, it is important to note that this reaction can be further enhanced by isolating the active ingredients present in the coagulant, one of which is protein. The extraction of protein from the coagulant can be achieved through the use of salts such as NaCl, KNO_3, KCl, NH_4Cl, and $NaNO_3$ [16], [17]. These protein compounds function as polyelectrolytes within the coagulation process [8]. Sodium chloride (NaCl) is a highly viable option due to its abundant availability, low cost, and effective dye-reducing properties [18], [19]. In a recent study, the natural coagulant extracted from *leucaena leucocephala* was utilized in a 3 mol/L NaCl extraction process, resulting in a remarkable reduction of Congo red up to 99.9% [8]. The application of 1 M NaCl to Moringa oleifera extractions resulted in a 77% reduction of congo red [20]. This outcome is consistent with the findings of a study by Ibrahim et al (2021), where it was determined through experimentation that the reduction of dye was effectively diminished by 44.54% through the utilization of moringa oleifera natural coagulant that had undergone extraction [21]. The reduction of reactive black 5 dye was achieved through the use of moringa oleifera natural coagulant, which was extracted using 1M NaCl. The result of the aforementioned study was the removal of reactive black 5 dye, with a 12.5% decrease in the amount of dye remaining after the completion of the experiment [22].

Moringa oleifera, a tropical plant commonly found in Indonesia, has been shown to produce proteins that have the potential to positively impact the coagulation-flocculation process. The objective of the present study is to utilize moringa oleifera as a natural coagulant to achieve the reduction of congo red dye. An evaluation of the coagulation process was conducted by means of the analysis of two parameters: coagulant dosage and initial congo red concentration.

2. Material and Method

2.1. Material

The materials utilized in this study encompass *moringa oleifera* seeds, congo red (Merck), NaOH (Merck), HCl 37% (Merck), and NaCl (Merck). The instrument utilized in this study is a set of jar test tools.

2.2. Preparation of Natural Coagulant

The *moringa oleifera* seeds were subjected to a series of processing steps. They were first peeled and then dried in the sun for a period of 12 hours. Thereafter, they were oven-dried for a duration of 2 hours at a temperature of 105 degrees C. Subsequently, the seeds were fragmented and pulverized to a size of 80 mesh. The *moringa oleifera* seeds were then introduced into a 1 M NaCl solution in a ratio of 1:20 by volume. Moringa oleifera seeds and a sodium chloride (NaCl) solution were stirred for a duration of 30 minutes. The mixture was separated through the use of filter paper in a Buchner funnel at vacuum pressure. The filtered solution was utilized as a natural coagulant, thereby reducing the parameters of congo red [23].

2.3. Coagulation-Flocculation Process

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The coagulation-flocculation process was utilized to reduce the concentration of congo red. The coagulation-flocculation process utilized a volume of 250 milliliters. An evaluation was conducted to ascertain the efficacy of a natural coagulant. The experiment incorporated a range of initial Congo red concentrations, from 100 to 550 parts per million (ppm), and coagulant dosages ranging from 25 to 100 ppm. The subsequent coagulation-flocculation process involved the application of rapid stirring at a rate of 150 revolutions per minute for a duration of three minutes. This was followed by a period of slow stirring at a rate of 15 revolutions per minute for 10 minutes, all under the condition of a pH level set at 3. The sample was then subjected to precipitation for a duration of 10 minutes [23]. UV-Vis spectrophotometry was employed as a analytical tool to evaluate the efficacy of the congo red removal process. The analysis was conducted at a wavelength of 497 nanometers [24].

3. Results and Discussion

3.1. Effect of Natural Coagulant Dosage on Congo Red Concentration Removal Efficiency

The concentration of congo red dye will be reduced through the utilization of a coagulation-flocculation process, employing a natural coagulant derived from *moringa oleifera*. The performance of a natural coagulant derived from *moringa oleifera* was evaluated based on variations in dosage. As demonstrated in Figure 1, the effectiveness of congo red concentration in removal is contingent upon the variability of natural coagulant dosage, with an initial concentration of 100 ppm. It can be posited that an increase in the dosage of natural coagulants would result in a concomitant increase in the removal efficiency of congo red concentration. The highest observed efficiency value, 99.46%, was attained under a condition that involved a dose of 100 ppm. Concurrent research efforts have yielded analogous results, with efficiency levels consistently achieving 98–99% [8], [25]. It has been demonstrated that the coagulation-flocculation process may become ineffective if the quantity of natural coagulant is increased beyond a certain point, thus initiating restabilization [26], [27].

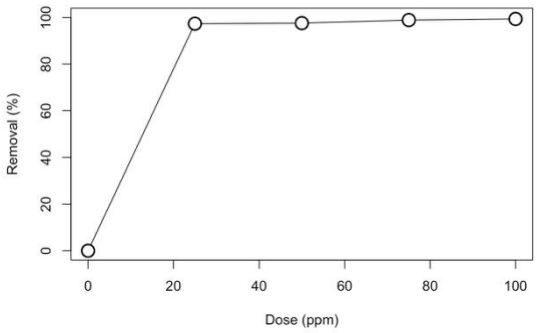

Fig 1. Impact of natural coagulant dosage on congo red reduction

3.2. Effect of Congo Red Initial Concentration on the Removal Efficiency of Congo Red Concentration

An analysis was conducted to assess the efficacy of *moringa oleifera*-based natural coagulant in reducing the concentration of congo red. This analysis incorporated a change in the initial concentration of congo red to investigate the relationship between concentration and the effectiveness of the coagulant. As demonstrated in Figure 2, the efficacy of congo red removal is contingent upon alterations in its initial concentration. The lowest recorded process efficiency, which is defined as the ratio of product output to initial input, was obtained when the initial concentration was set at 550 parts per million, with an efficiency value of 95.209%. The efficacy of congo red concentration removal exhibited an inverse relationship when the initial congo red concentration was elevated under conditions involving a natural coagulant dosage of 100 ppm. The scarcity of coagulant, compounded by the rise in congo red concentration, led to a decline in the efficacy of the coagulation-flocculation process [28]. Concurrent findings of a similar nature have been documented by other researchers [27], [28].

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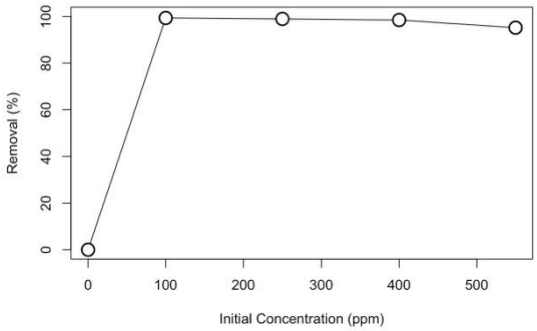

Fig 2. Impact of initial congo red concentration on congo red removal efficiency

3.3. Coagulation-Flocculation Process Mechanism

As demonstrated in Figure 3, the utilization of a natural coagulant derived from *moringa oleifera* results in a notable decrease in the concentration of congo red. The process of congo red dye reduction is facilitated by the application of moringa oleifera-based natural coagulants, leading to the capture and neutralization of both unstable colloids and particles and colloidal charges during the adsorption phase [29]. Congo red dye, which possesses a negative charge, will bind to proteins that have a positive charge. This phenomenon is particularly evident in the context of *moringa oleifera*-based natural coagulants. This process initiates particle collisions caused by charge differences, thereby facilitating the formation of larger solids. These solids possess the properties of water-insoluble substances and can be separated through a process of sedimentation [30]. Furthermore, the coagulation-flocculation process is influenced by acidic pH conditions. In this condition, *moringa oleifera* seeds, a source of protein, are expected to play a pivotal role in maintaining the adsorption process of congo red dye [31]. The presence of a substantial positive charge on the protein is the underlying cause of its magnetic-like behavior, which enables the molecule to attract negative charges, a phenomenon exemplified by the attraction between congo red dye and a magnetic field [32].

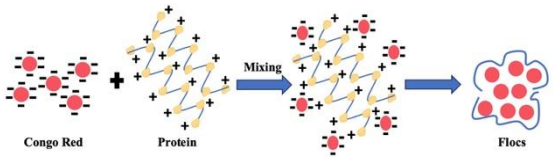

Fig 3. Mechanism of coagulation-flocculation process between congo red and natural coagulant

4. Conclusions

The preparation of a natural coagulant derived from *moringa oleifera* through salt extraction has been successfully achieved. This coagulant has been effectively utilized to mitigate the impact of congo red during the coagulation-flocculation process. The impact of initial concentration and coagulant dosage was employed to assess the performance of a natural coagulant derived from moringa oleifera. An increase in initial concentration was observed to be associated with a decrease in congo red removal efficiency. An elevated dosage of coagulant proved effective in enhancing the efficiency of congo Red removal. The study found a removal efficiency of 99.46%, which is considered the highest removal efficiency. Congo red dye was reduced through a two-step process: first, through adsorption, and second, through colloidal charge neutralization.

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