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Turbidity removal by four plants used as a sustainable green coagulant

Sajad Hatim [1], Asia Fadhile Almansoory[2], Israa Abdulwahab Al-Baldawi [1]
[1] Department of Ecology, College of Science, University of Basrah, Basrah, Iraq
[2] Department of Civil Engineering, College of Engineering, University of Baghdad, Baghdad, Iraq
E-mail: asia.abdullah@uobasrah.edu.iq

Abstract

The utilization of plant-based coagulants in wastewater treatment, coupled with the coagulation-flocculation process, represents a progressive stride towards fostering a green economy and promoting cleaner industrial practices. These plant-derived coagulants, owing to their intrinsic characteristics and biodegradability, demonstrate significant promise as viable substitutes for chemical coagulants that are prevalent in industrial applications. The purpose of this study was to confirm the efficiency of extracting the parts powder of four selected native plants consisting of ***Glycyrrhiza glabra L., Vigna unguiculata L, Prosopis fracta and Alhagi graecorum.*** Different doses of each coagulant powder were added to each flask to meet the doses of 0 g/L (acting as a control), 1000,3000, 5000, and 7000 mg/L. While the operating conditions for the experiment was conducted with a fast-mixing speed of 180 rpm for 5 minutes, and a slow mixing speed of 20 rpm for 20 minutes using the jar test. The results of this research indicate the possibility of using plant parts as a biocoagulant for water treatment.

Keywords: wastewater, plant parts, coagulation-flocculation process

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Introduction

Water is one of the most important things on the Earth. Moreover, challenges related to water scarcity are compounded by various factors, including the impact of climate change and the extensive use of irrigation water in agricultural practices (Zhang, 2012). Industrial activities are a major contributor to water pollution, primarily due to the significant volumes of wastewater generated that contain toxic or recalcitrant species. Improper disposal of effluents from the food industry exacerbates environmental degradation, as these effluents are laden with high levels of organic matter, heavy metals, alkalinity, and hardness. The consequences include water pollution, odor generation, algal blooms, and increased mortality rates among aquatic and terrestrial organisms.

Wastewater treatment typically involves processes such as coagulation, flocculation, sedimentation, along with other physical, chemical, and biological methods (Balbinoti *et al*., 2023). Globally, with a particular emphasis on developing nations, addressing wastewater treatment stands out as a crucial challenge. The extent of distribution coverage is inadequate, and sewer systems often lack robust infrastructure. The discharge of untreated wastewater is prevalent in regions like the Middle East, leading to adverse effects on river water quality and the well-being of local communities (Jing et al., 2008).

With the escalating global population, there is a corresponding rise in the volume of wastewater generated, necessitating treatment without compromising the needs of future generations. Wastewater comprises valuable organic and inorganic components that can be harnessed and recycled back into society, highlighting the potential for sustainable resource management (Vasconcelos et al.,2015). Because existing conventional procedures using chemical coagulants are expensive due to chemical expenses and added sludge, access to clean and safe water at a fair price is a major challenge (Muthuraman and Sasikala 2014; Hamdan et al., 2018). to the use of metal ions as coagulants, it may have an impact on human health (Marsidi et al. 2018; Tetteh and Rathilal, 2020).

Further research into the impact of chemical coagulants on human health and their potential connections to Alzheimer's disease has produced notable findings (Brandt et al., 2017). Consequently, extensive studies have been conducted to develop safer and more environmentally friendly alternatives, such as natural coagulants. These natural coagulants present a promising substitute for the chemical coagulants currently in use, offering benefits for both human health and the environment.

Due to the limitations associated with chemical coagulants, researchers are now focusing on developing and assessing the efficacy of natural coagulants in the coagulation process. Natural coagulants represent a viable alternative to chemical coagulants due to their biodegradability, safety, and cost-effectiveness in wastewater treatment. These natural coagulants can be derived from plant materials and fruit waste, primarily consisting of polysaccharides and proteins. The utilization of natural coagulants not only offers a sustainable approach to environmental technology but also contributes to cost savings, biodegradability, and presumed safety for human health (Seghosime et al.,2017). Natural coagulants can be sourced from a variety of origins, including animals (Vigneshwaran et al. 2020), plants (Ang and Mohammad 2020; Ueda Yamaguchi et al. 2020), and bio-waste (Huzir et al. 2019).

The coagulation-flocculation process and the adoption of plant-based coagulants in wastewater treatment have progressed towards promoting a green economy and cleaner industry. Plant-based coagulants, owing to their inherent properties and natural degradability, are emerging as significant substitutes for the chemical coagulants typically employed in industrial applications (Salem *et al*., 2023). The study in this work aims to use local Iraqi plants as a new and promising green coagulant for fish farm wastewater treatment to use environmentally friendly natural green coagulants to treat FFWW in the initial process as a sustainable treatment.

Literature review

Salem *et al*. (2023) study the Iraqi plants to remove turbidity by using kaolin synthetic water. Thirteen selected plants were papered to be powder coagulant. The experiment was run based on coagulant mass varied from 0 to 10,000 mg per liter for each plant with a rapid mixing speed at 180 rpm for 5 min, slow mixing speed at 50 rpm for 15 min, and settling time for 30 min the results shown high removal at 75.5%.

Majeed and Jasim (2015) they studied the ability of some plant in treatment of waste water that contains high levels of turbidity. study involved four different samples of plants for using as natural coagulants that prepared in laboratory, each sample include one part of each plant which was *Cactus* leaves, *Okra* fruit peels, *Okra* seeds and fenugreek seeds. Also, alum was used in this study under same conditions as common traditional coagulant for comparison. The obtained results showed the best efficiency of coagulation process was 78% for cactus leaves with the weight 5 gm for all chemical and physical parameters.

Priyatharishini and Mokhtar (2021) This study investigates the impact of herogenic aces on the coagulation process by employing the peel of cakaya fruit as a clotting agent, prepared through an extraction method utilizing distilled water. Subsequent to the treatment, the wastewater underwent assessment to quantify the reduction rate, and clotting extracts were differentiated utilizing Fourier-transform infrared (FTIR) technology. This approach serves as a primary treatment for drainage water and is recognized as an environmentally friendly alternative.

Materials and methods

Table 1. Instruments and Materials Used in the Study

Instruments	Manufacture
Turbidity meter	Germany
Jar Test	USA
Balance Weight	India
Hot plate with magnetic stirrer	United Kingdom
Oven	Germany
Filtered paper with 0.33 mm	(ZELPA Belgium paper)

Preparation kaolin with Water

Turbid water was prepared by mixing Kaolin powder with water as synthetic turbid water. 500 NTU concentration of synthetic turbid water was prepared by mixing kaolin (1.5 g) with distilled water (3.5 L) in a beaker and stirred for 30 min to be homogeneous to simulate an initial turbidity concentration of 500 ± 50 NTU (Ahmad et al., 202

Figure (1). Preparation of kaolin

Plant selection and coagulant powder

Four locally found plants were chosen consisting of ***Glycyrrhiza glabra L., Vigna unguiculata L, Prosopis fracta and Alhagi graecorum.*** The parts of plants washed with distilled water and were subsequently dried in an oven set at a constant temperature of 40 °C for 72 hours. After drying, the parts were finely ground into a powder with a particle size of 38 µm using a mechanical blender. The resulting fine powders were then stored in a closed container (Ahmad et al., 2022).

coagulant powder

Four locally plants were chosen consisting of ***Glycyrrhiza glabra L., Vigna unguiculata L, Prosopis fracta and Alhagi graecorum.*** Firstly, is collected the parts of plants and washed with distilled water then put in an oven under 70 ºC for two days. The dried leaves were ground and sieved to get fine powder then kept in a container (Ahmad et al., 2022)

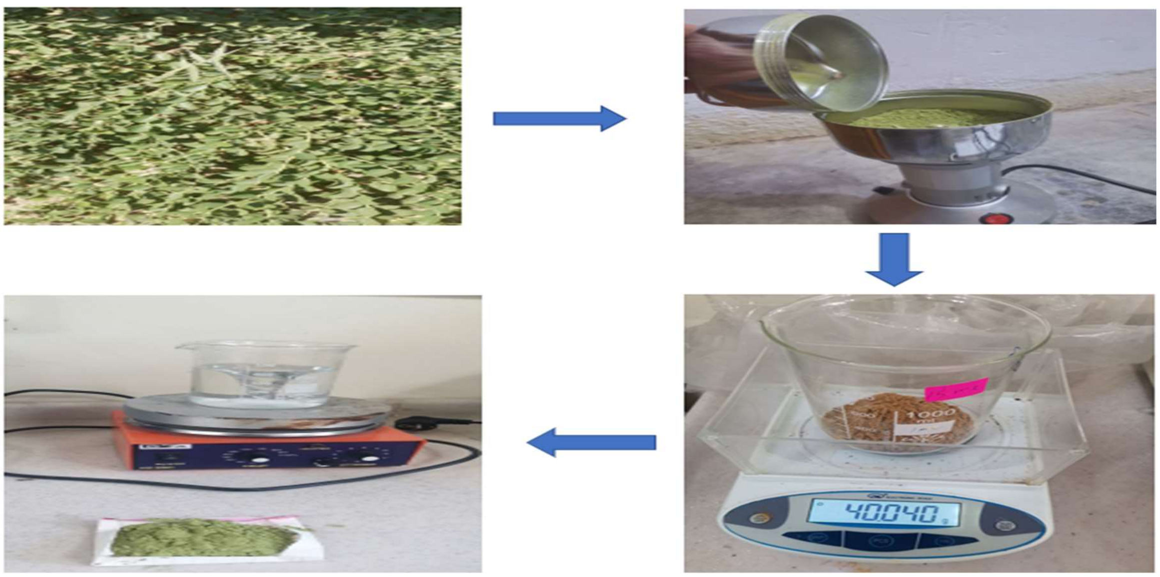


Figure (2) Preparation of coagulant powder

Procedure to test green coagulant removal efficiency

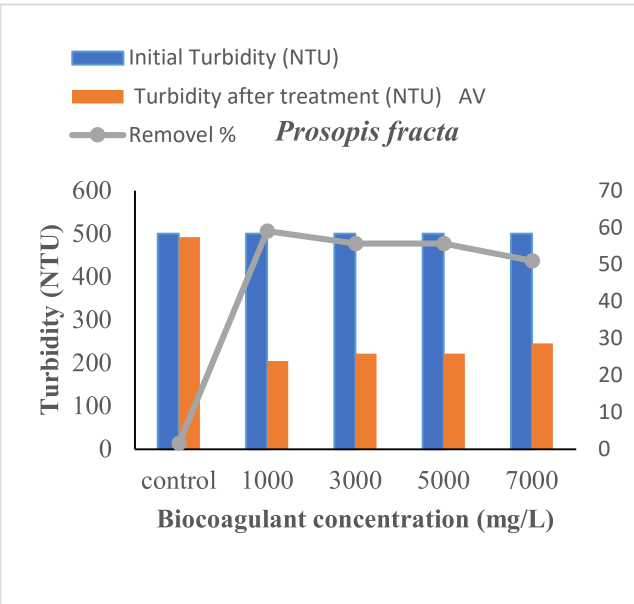
The experiment utilized six 1-liter beakers, each filled with synthetic water and coagulant to achieve a working volume of 500 mL. Different dosages of each plant coagulant powder were introduced into the beakers, including 0 mg/L (acted as control), 1000,3000,5000 and 7000 mg/L. The operation conditions for the experiment were performed at a rapid mixing speed of 180 rpm for 5 minutes, and a slow mixing speed of 20 rpm for 20 minutes using a jar test (Kakoi et al. 2016). Following the coagulation-flocculation procedure, the solids were allowed to settle for 30 minutes. The clear samples from the surface of each beaker were gathered for turbidity measurement using a turbidity meter, with values expressed in nephelometric turbidity units (NTU). This process was repeated multiple times, and the outcomes were then averaged for accuracy.

Statistical analysis

The results used as input data for each response so that the software could generate the models and perform analysis of variance (ANOVA) and IBM SPSS statistics version 26. To ensure the adequacy of the model.

Results and discussion

The four native plants (table1) were selected for testing to treat kaolin contaminated water to remove turbidity of these plants as coagulants are shown in Figures 3,4 and 5 and listed in Table 2. The results of the study showed that four native plants can be used as coagulants to remove turbidity from water. For *Prosopis fracta* the results showed that the maximum turbidity removal was reached with 1000 mg/L coagulant dosage to 59% and *Vigna unguiculata L.* reached with 7000 mg/L coagulant dosage to 58.2 % (Figures 3). Statistical analysis indicated that there were significant differences in concentrations between plants at $P \leq 0.05$.



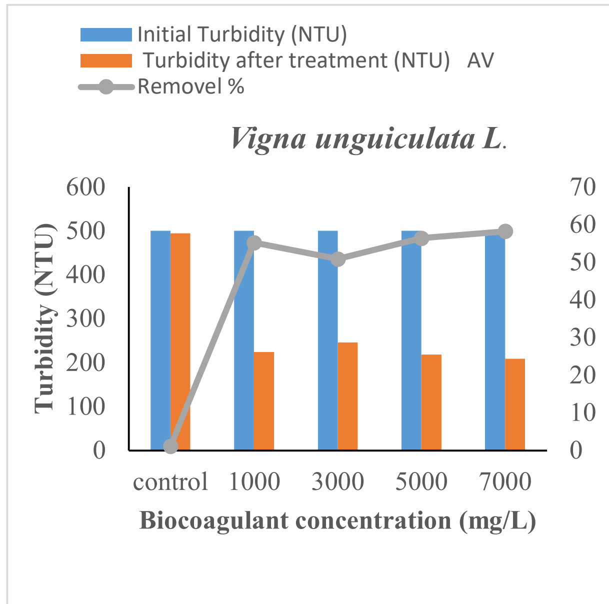


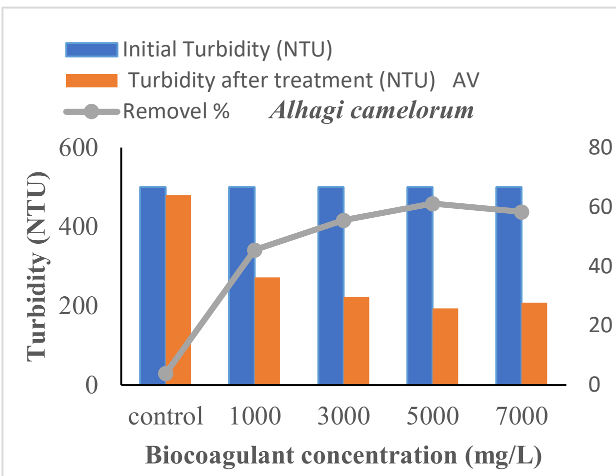
Figure 3 Role of selected plants for turbidity removal with different coagulant dosages compared with the 500 NTU turbidity without green coagulant as control (0 mg/L).

Table2 Show locally selected plants to prepare coagulants

Plant scientific name	Plant common name	*Full plant profile*	Plant leaves or seeds
Glycyrrhiza glabra L.	Sus		
Vigna unguiculata L.	southern pea		

Prosopis fracta	syrian mesquite		
Alhagi graecorum	Camelthorn		

For *Glycyrrhiza glabra L.* and *Alhagi camelorum (*roots) the results showed that the maximum turbidity removal was reached with 5000 mg/L coagulant dosage to 57.4 and 57.6% respectively (Figures 4).



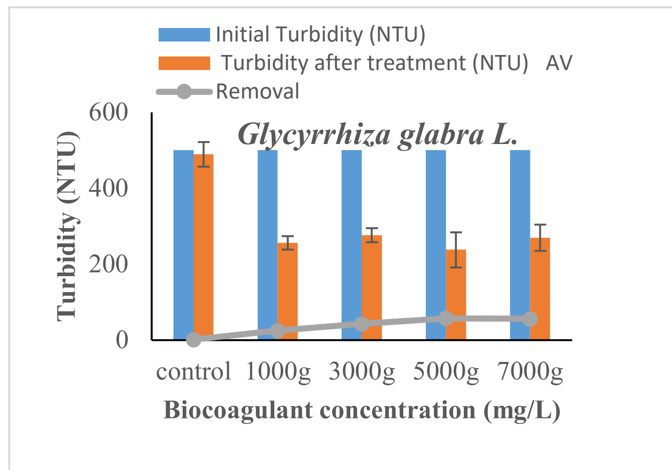


Figure 4 Role of selected plants for turbidity removal with different coagulant dosages compared with the 500 NTU turbidity without green coagulant as control (0 mg/L).

The study also found that the optimal coagulant dosage for each plant varied. For example, the optimal dosage for *Prosopis fracta* was 1000 mg/L, while the optimal dosage for *Vigna unguiculata L.* was 7000 mg/L. Statistical analysis indicated that there were significant differences in concentrations between plants at $P \leq 0.05$.

The findings of this investigation propose that indigenous plants can serve as sustainable and efficient coagulants for eliminating turbidity from water. However, further exploration is necessary to ascertain the enduring impacts of employing these plants as coagulants and to pinpoint the specific compounds within these plants responsible for their coagulation capabilities. Leveraging native plants as coagulants offers several advantages over synthetic alternatives. Native plants are environmentally friendly and sustainable since they obviate the need for chemicals or synthetic substances. Moreover, these plants are often readily available in abundance, rendering them a cost-effective choice. In sum, utilizing native plants as coagulants presents a promising avenue for addressing high-turbidity water treatment needs.

Table 2 Turbidity removal of four locally selected plants

Plant	Concentrations (mg/L)	Removal %
Prosopis fracta	1000	59
Vigna unguiculata	7000	58.2
Alhagi camelorum	5000	57.6
Glycyrrhiza glabra L.	5000	57.4

Conclusion

Based on the study, the application of plant leaf powder is highly effective in removing turbidity from water. The maximum turbidity removal was observed at 1000 mg/L coagulant dosage. Nevertheless, surpassing this dosage led to a decrease in turbidity removal. This occurred as the quantity of leaf powder exceeded the impurity level in the water sample, resulting in the generation of more positively charged ions.

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إزالة العكارة بواسطة أربعة أجزاء نباتية تستخدم كمخثر أخضر مستدام

سجاد حاتم [1]، آسيا فاضل المنصوري [2]، إسراء عبد الوهاب البلداوي [1]
[1] قسم البيئة، كلية العلوم، جامعة البصرة، البصرة، العراق
[2] قسم الهندسة المدنية، كلية الهندسة، جامعة بغداد، بغداد، العراق

الملخص:
ويمثل استخدام مواد التخثر النباتية في معالجة مياه الصرف الصحي، إلى جانب عملية التخثر والتلبد، خطوة تدريجية نحو تعزيز الاقتصاد الأخضر وتشجيع الممارسات الصناعية الأنظف. تُظهر مواد التخثر المشتقة من النباتات، نظرًا لخصائصها الجوهرية وقابليتها للتحلل الحيوي، وعدًا كبيرًا كبدائل قابلة للتطبيق لمواد التخثر الكيميائية السائدة في التطبيقات الصناعية. الغرض من هذه الدراسة هو التأكد من كفاءة استخلاص مسحوق أجزاء أربعة نباتات محلية مختارة تتكون من

Glycyrrhiza glabra L., Vigna unguiculata L, Prosopis fracta and Alhagi graecorum

تمت إضافة جرعات مختلفة من كل مسحوق تخثر إلى كل دورق لتلبية الجرعات البالغة 0 جم/لتر (كعنصر تحكم)، و1000، 3000، و5000، و7000 ملجم/لتر. بينما أجريت ظروف التشغيل للتجربة بسرعة خلط سريعة 180 دورة في الدقيقة لمدة 5 دقائق، وسرعة خلط بطيئة 20 دورة في الدقيقة لمدة 20 دقيقة باستخدام اختبار الجرة. وتشير نتائج هذا البحث إلى إمكانية استخدام أجزاء النبات كمخثر حيوي لمعالجة المياه.