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Turbidity removal by seven plant leaves used as sustainable green coagulant

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Abstract

In the coagulation-flocculation process, the use of plant-based coagulants in wastewater treatment has advanced towards a green economy and cleaner industry. Due to their inherent qualities and natural degradability, plant-based coagulants have the potential to serve as significant alternatives to the chemical coagulants commonly used in industry. The purpose of this study was to evaluate the efficiency of extracting leaf powder from seven selected native plants, namely *Albizia lebbeck* L., *Azadirachta indica*, *Conocarpus lancifolius*, *Dianthus caryophyllus*, *Eucalyptus camaldulensis*, *Nerium oleander*, and *Phoenix dactylifera*. Various doses of each plant-based coagulant powder were added to separate flasks, with doses ranging from 0 g/L (serving as a control), 0.5 g/L, 1 g/L, 3 g/L, 5 g/L, and 10 g/L. The experiment was conducted using a jar test with a fast-mixing speed of 180 rpm for 5 minutes, followed by a slow mixing speed of 50 rpm for 15 minutes. The optimal doses of 0.5 g and 1 g were identified for the removal of turbidity. The results of this study indicate the potential of using plant leaves as biocoagulants for raw water treatment.

Keywords: wastewater, plant leaves, coagulation-flocculation process.

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Introduction

Water is a necessary and irreplaceable ingredient that is commonly referred to as the "elixir of life though lack of access to healthy water is mostly due to water scarcity, when properly addressed, water has the potential to impact innumerable lives by facilitating economic growth and long-term development (Maurya and Daverey, 2018). Large volumes of industrial effluent including refractory organic contaminants are produced in worldwide countries because of fast industrial expansion (Chen *et al*., 2019; Guo *et al*., 2020). As the world's population increased, so did the volume of wastewater generated, which must be treated without imperiling future generations' requirements. Wastewater contains very valuable organic and inorganic components that may be collected and recycled back into society (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). Recent studies have focused on optimizing these chemical-based methods, such as the use of composite polymers like aluminum chloride-polyacrylamide (AlCl3-PAM) for enhanced flocculation efficiency. For instance, Chasib *et al*. (2021) demonstrated the effectiveness of optimizing AlCl3-PAM dosage and pH levels, achieving significant removal rates of turbidity, chemical oxygen demand (COD), and total suspended solids (TSS) in wastewater treatment plants. The use of metal ions as coagulants may have an impact on human health (Marsidi *et al.* 2018; Tetteh and Rathilal 2020). Coagulants/flocculants are utilized in the coagulation-flocculation process, which is one of the procedures in water/wastewater treatment that removes suspended particles during the primary stage. Water and wastewater treatment has typically relied on chemical coagulants such as aluminum and ferric compounds (Yargeau 2012; Barrera-Díaz *et al.* 2018;). Further research into the impact of chemical coagulants on human health and possible linkages to Alzheimer's disease has yielded some interesting results (Brandt *et al.* 2017). As a result, substantial study has been performed in the field to develop answers or alternative methods that are both better for human health and environmentally beneficial, such as the use of natural coagulants, which might be an excellent replacement for chemical coagulants now in use.

Natural coagulants can come from a variety of places, including animals (Vigneshwaran *et al*. 2020), plants (Ang and Mohammad 2020; Ueda Yamaguchi *et al*. 2020) and bio-waste (Huzir *et al*. 2019; Muniz *et al.* 2020). They are thought to be inexpensive and environmentally beneficial (Ahmad *et al.* 2021). Although extensive study has been done on natural coagulants, much of it has been done on seeds from local plants (Saleem and Bachmann 2019), research on leaves from local plants has been restricted (Benalia *et al.* 2018; Maurya and Daverey 2018). The presence of active substances such as carbohydrates and proteins in leaves has been linked to the impact of purification owing to coagulation, making them appropriate for water/ wastewater treatment (choy *et al.* 2014). The quantity of supply, cost effectiveness, biodegradability (Othmani *et al*. 2020).

Materials and methods

Preparation kaolin with Water

The experiment of test plant as green coagulant, turbid water was prepared by mixed 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 L) in beaker and stirred for 30 min to be homogeneous to simulate an initial turbidity concentration of 500 ± 50 NTU (Ahmad *et al*., 2022). Figure (1)

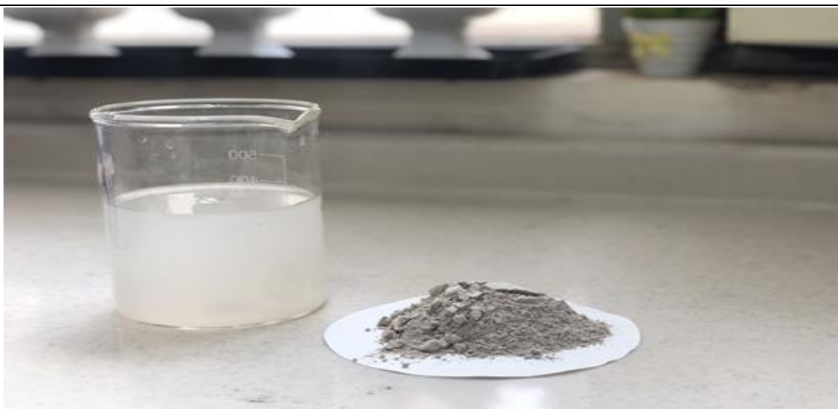


Figure 1: Preparing kaolin with water.

Plant selection and coagulant powder

Seven locally found plants were chosen consisting of *Albizia lebbeck* L., *Azadirachta indica*, *Conocarpus lancifolius, Dianthus caryophyllus*, *Eucalyptus camaldulensis*, *Nerium oleander*, *Phoenix dactylifera.* Firstly, is collected the leaves of plants and washed with distilled water then put in oven under 70 ºC for two days. The dried leaves were ground and sieved to get fine powder with 38 µm then kept in closed container (Ahmad *et al*., 2022) to use for coagulant water extraction and direct used as biosorption.

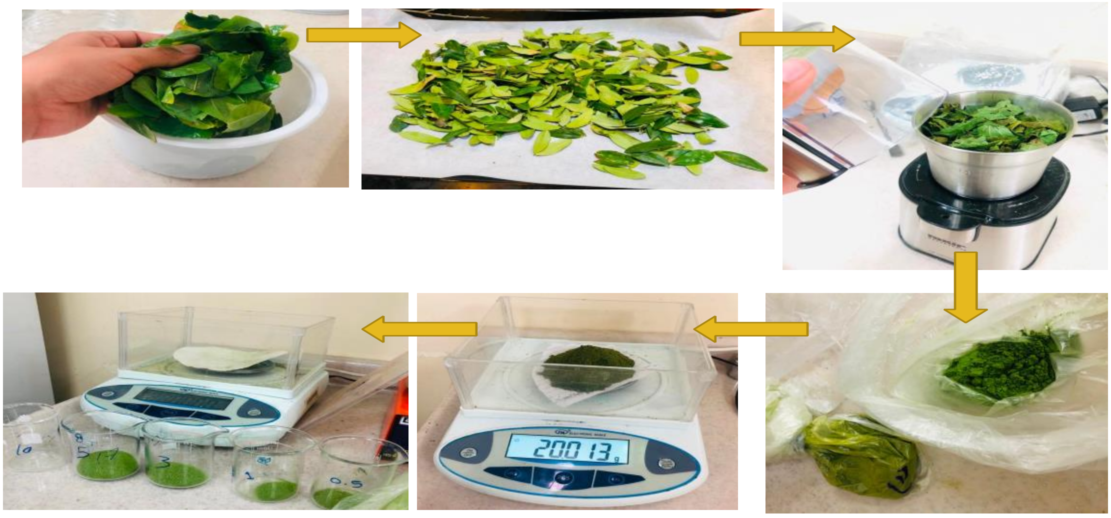


Figure (2) The Preparation of coagulant powder

Procedure to test green coagulant removal efficiency

The experiment was conducted using six 1L beakers which were filled with synthetic water and coagulant to a working volume of 500 mL. Various dosages of each plant coagulant powder were added to each beaker to meet the dosages of 0 g/L (acted as control), 0.5, 3, 5, and10g. While the operation conditions for the. experiment was performed at a rapid mixing speed of 180 rpm for 5 minutes, and a slow mixing speed of 50 rpm for 15 minutes using a jar test (Kakoi *et al*. 2016). After the coagulation-flocculation process, the solids were left to settle for 30 min. The clarified samples from the top of each beaker were collected to measure their turbidity using a turbidity meter in which the measurement is expressed in nephelometric turbidity units (NTU). All these runs were repeated, and the result was finally averaged.

Statistical analysis

Results collected from jar tests were used as input data for each response so that the software could generate the models and perform analysis of variance (ANOVA), standard software and IBM SPSS statistics version 26. To ensure the adequacy of the model.

Results and discussion

coagulant powder

The seven native plants in table (1) were selected for testing to treat kaolin-contaminated water to remove turbidity of these leaves as coagulants are shown in Figures 4,5 and 6 and listed in Table 4 .For *Dianthus caryophyllus* and *Albizia lebbeck* the results showed that the maximum turbidity removal were reached with 0.5g coagulant dosage to 59.6 and 58.5% respectively (Figures 3) .Statistical analysis indicated that there were significant differences in concentrations between plants at $P \leq 0.05$.

Azadirachta indica, and *Nerium oleander*on 0.5g green coagulant concentration have 57.5, and 57.9% *removal* efficiency. (Figures 4) For plant *Moringa oleifera*, another study tests the plant seed as extraction coagulant The experiment was started using a similar dosage of *Moringa* seed powder from 0.1 g/500 l to 0.6 g/500 ml. the removal of the pollutant was increased to 0.4 g/500 ml dosage and the maximum reduction of turbidity and color was attained at this point. After the optimum point, the graph becomes bending down; this is due to the dosage being more than the impurity in the sample water and a more positive ion was developed (Desta and Bote 2021). This means that when the coagulant (Moringa seed powder) was added to the sample followed by rapid string the resulting cationic protein from Moringa seed powder was distributed to all parts of the liquid and interacting with the negatively charged particles that caused disturbed turbidity. When cation was added more than the anion, the cation by itself increases the turbidity of the water, because there is not enough negatively charged particle to interact, As the results obtained in our research for like this research study in terms of the effect of concentrations in relation to the effectiveness of removing turbidity). Statistical analysis indicated that there were significant differences in concentrations between plants at $P \leq 0.05$.

Table1: Show Local selected plants to prepare coagulants

Plant Scientific name	Plant Common name	Full plant Profile	Plant Leaves
Albizia lebbeck (L.)	Silk trees		
Azadirachta indica	Neam		
Conocarpus lancifolius	Buttonwood		
Dianthus caryophyllus	Carnation		
Eucalyptus camaldulensis	Red river gum		
Nerium oleander	Oleander		
Phoenix dactylifera	Date Palm		

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 g/L). Green coagulant of *phoenix dactylifera* reached high removal efficiency (74.9%) on (1g) concentration (Figures 5) The statistical analysis indicated that there were statistically significant differences in the concentrations between plant at P ≤ 0.05, except for a concentration of 0.5 which showed no significant difference between them., In the same concentration of green coagulants *Conocarpus lancifolius* and *Eucalyptus camaldulensis* have the highest removal efficiency 55.3 and 58.3%. Statistical analysis indicated that there were significant differences in concentrations between plants at P ≤ 0.05. Table 2 showed seven plant names and concentrations using sustainable green coagulant to remove turbidity.

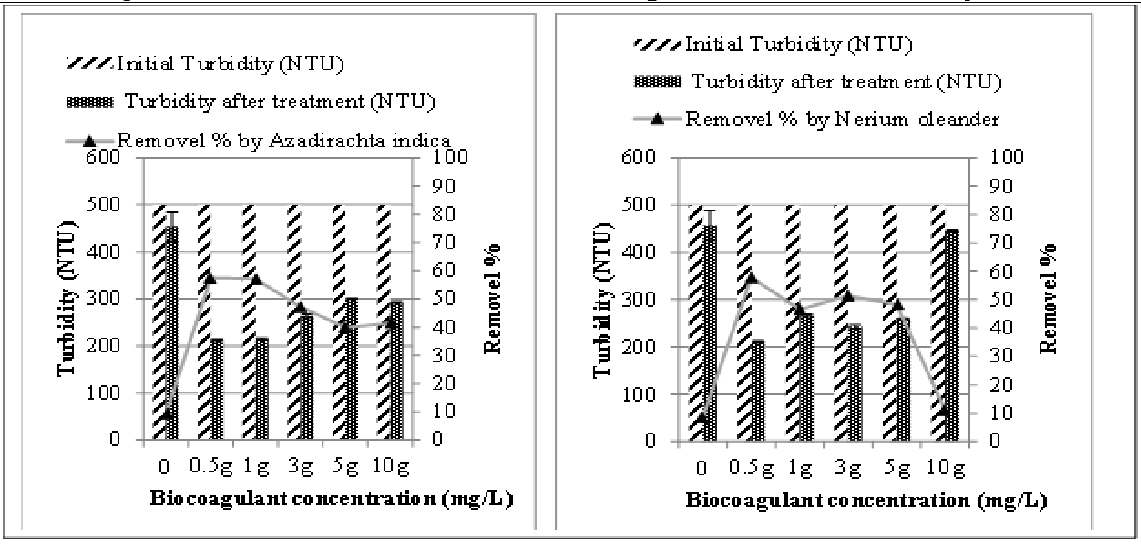
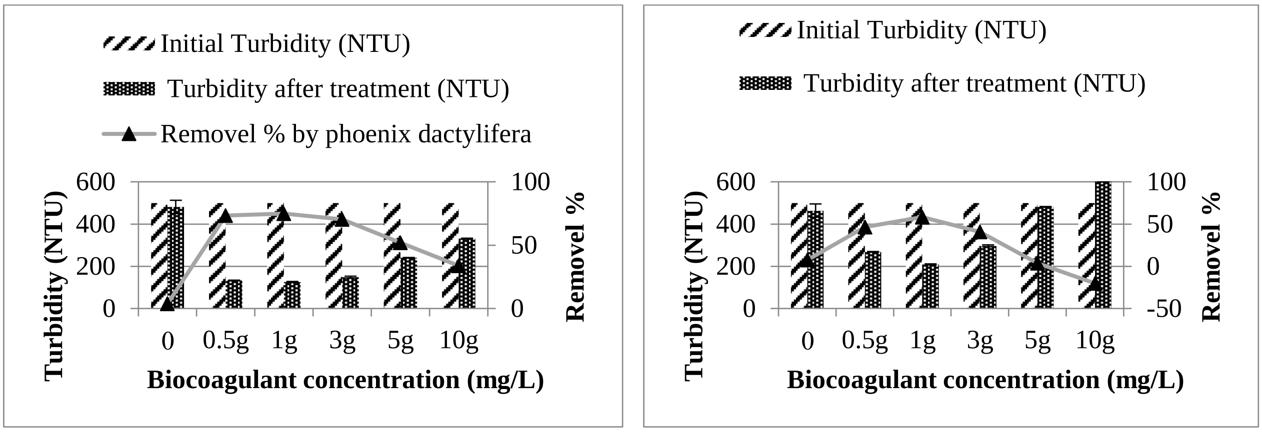


Figure 4: Role of selected plants for turbidity removal with different coagulant dosages compared with the 500 NTU turbidity without green coagulant as control (0 g/L).



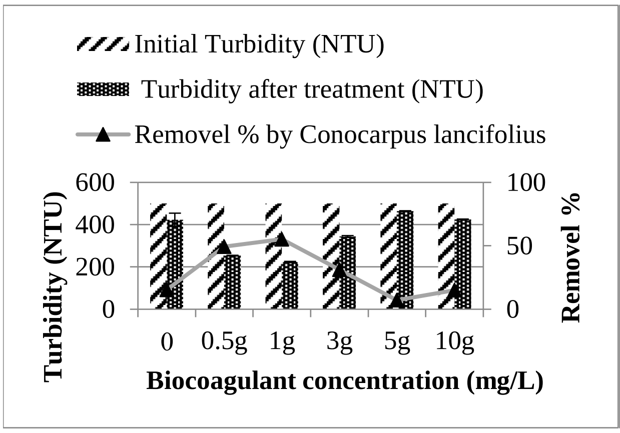


Figure 5 : Role of selected plants for turbidity removal with different coagulant dosages compared with the 500 NTU turbidity without green coagulant as control (0 g/L).

Table 2: Plant names and concentrations using sustainable green coagulant to remove turbidity.

Plant	Concentrations (g)	Removal %
Albizia lebbeck(L.)	0.5	58.5
Azadirachta indica	0.5	57.5
Conocarpus lancifolius	1	55.3
Eucalyptus camaldulensis	1	58.3
Dianthus caryophyllus	0.5	59.6
Nerium oleander	0.5	57.9
Phoenix dactylifera	1	74.9

Conclusion

The studies proved that the use of plant leaf powder to remove turbidity is very effective. Maximum turbidity removal achieved at 0.5 and 1 g per 500 ml of water sample but increase the dose Leaf powder above 0.5 and 1 g led to a decrease in removal turbidity this is due to the dosage being more than the impurity in the sample water and a more positive ion was developed.

Acknowledgement

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ازالة العكارة باستخدام اوراق سبعة نباتات كمخثر اخضر للاستدامة

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المستخلص

تقدمت عملية التخثر والتلبد ، واستخدام مواد التخثر النباتية في معالجة مياه الصرف الصحي في اتجاه نحو اقتصاد أخضر وصناعة أنظف. نظرًا لصفاتها المتأصلة وقدرتها على التحلل بشكل طبيعي ، فإن مواد التخثر النباتية لديها القدرة على العمل كبدائل مهمة لمخثرات المواد الكيميائية التي يشيع استخدامها في الصناعة. الغرض من هذه الدراسة هو تأكيد كفاءة استخراج مسحوق الأوراق لسبعة نباتات محلية مختارة تتكون من *Albizia libeck* L. ، *Azadirachta indica*، *Conocarpus lancifolius*، *Dianthus caryophyllus*، *Eucalyptus camaldulensis*، *Nerium oleander*، *Phoenix dactylifera.* تمت إضافة جرعات مختلفة من كل مسحوق تخثر نباتي إلى كل دورق لتلبية الجرعات من 0 جم / لتر (تعمل كعنصر تحكم) ، 0.5 ، 1 ، 3 ، 5 ، 10 جم. بينما ظروف التشغيل ل. تم إجراء التجربة بسرعة خلط سريعة تبلغ 180 دورة في الدقيقة لمدة 5 دقائق ، وبسرعة خلط بطيئة تبلغ 50 دورة في الدقيقة لمدة 15 دقيقة باستخدام اختبار الجرة. الجرعة المثلى للنباتات (0.5 جرام) (1 جرام) في إزالة العكارة. بشكل عام ، تشير نتائج هذا البحث إلى إمكانية استخدام أوراق النبات كمخثر حيوي لمعالجة المياه الخام.

الكلمات المفتاحية: مياه عادمة، أوراق نبات، عملية تخثر-تلبيد.