



# Assessing the Coagulation Performance of Fenugreek Seeds in Treating Industrial Wastewater

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**ABSTRACT:** Industrial wastewater treatment remains a significant challenge, primarily due to the diverse nature of contaminants and the inefficiencies associated with traditional methods. This study evaluates the performance of fenugreek seeds as a natural coagulant in treating industrial wastewater. Fenugreek seeds, rich in mucilage and polysaccharides, offer a sustainable and cost-effective alternative to synthetic coagulants. Through a series of experiments, including coagulation-flocculation tests, sedimentation analysis, and comparison with conventional coagulants, this research highlights the effectiveness of fenugreek seeds in removing contaminants from industrial wastewater. The findings suggest that fenugreek seeds are a viable option for enhancing wastewater treatment processes, with implications for environmental sustainability and cost efficiency.

## I. INTRODUCTION

Industrial wastewater contains a range of contaminants, including suspended solids, organic matter, and heavy metals, which pose significant environmental and health risks. Traditional methods such as chemical coagulation using alum or ferric chloride are effective but often come with high operational costs and environmental concerns. In recent years, natural coagulants derived from plant materials have gained attention for their potential to improve sustainability and reduce treatment costs. Fenugreek (*Trigonella foenum-graecum*) seeds, known for their high mucilage content and coagulating properties, present a promising alternative. This study aims to assess the coagulation performance of fenugreek seeds in treating industrial wastewater, evaluating its efficiency and comparing it with conventional coagulants.

## II. LITERATURE REVIEW

### Industrial Wastewater Characteristics

Industrial wastewater varies widely depending on the type of industry, but common contaminants include suspended solids, organic compounds, heavy metals, and oils. Effective treatment is crucial for protecting water resources and human health. Traditional methods involve physical, chemical, and biological processes, but these often require significant resources and can generate secondary pollutants.

### Coagulation and Flocculation

Coagulation and flocculation are fundamental processes in wastewater treatment, used to aggregate and remove suspended particles and contaminants. Coagulants neutralize the charges on particles, allowing them to clump together into larger flocs that can be easily removed. Conventional coagulants include aluminum sulfate (alum) and ferric chloride, which are effective but may pose environmental and health risks.

### Natural Coagulants

Natural coagulants derived from plant materials have been explored as sustainable alternatives to synthetic chemicals. These include:

1. **Moringa Oleifera:** Known for its high protein content and effectiveness in removing turbidity and microorganisms.
2. **Okra:** Contains mucilage that aids in coagulation and flocculation.
3. **Cactus Opuntia:** Utilized for its polysaccharide content in coagulation processes.



### Fenugreek Seeds

Fenugreek seeds, widely used in culinary applications, contain mucilage, proteins, and polysaccharides, which contribute to their coagulation properties. Previous studies have demonstrated the potential of fenugreek seeds in removing turbidity and organic matter from water. However, their effectiveness in treating industrial wastewater remains underexplored.

## III. METHODOLOGY

### Materials

#### Fenugreek Seed Preparation

Fenugreek seeds were procured from a local supplier and processed by grinding into a fine powder. The powder was then mixed with distilled water to prepare a stock solution with varying concentrations.

#### Industrial Wastewater

Industrial wastewater samples were collected from a local manufacturing facility. The samples were characterized for key parameters such as turbidity, chemical oxygen demand (COD), and suspended solids.

### Experimental Procedure

#### Coagulation-Flocculation Tests

1. **Jar Test Apparatus:** Coagulation tests were conducted using a jar test apparatus to simulate real-world conditions. Water samples were treated with fenugreek seed solutions at different concentrations (0.5 g/L, 1 g/L, 1.5 g/L).
2. **Procedure:** Fenugreek seed solution was added to wastewater samples, followed by rapid mixing, flocculation, and sedimentation. The effectiveness of coagulation was assessed based on turbidity reduction, floc formation, and sedimentation quality.

#### Comparison with Conventional Coagulants

1. **Conventional Coagulants:** Alum and ferric chloride were used as control coagulants. Their performance was compared with fenugreek seeds in terms of turbidity removal and overall treatment efficiency.
2. **Analysis:** The removal efficiency of contaminants was measured by analyzing turbidity, COD, and suspended solids before and after treatment.

### Data Analysis

1. **Turbidity Measurement:** Turbidity was measured using a turbidity meter to assess the clarity of the treated water.
2. **COD Analysis:** Chemical oxygen demand was analyzed using standard methods to evaluate the reduction of organic matter.
3. **Suspended Solids:** Suspended solids were quantified to determine the effectiveness of coagulation in removing particulate matter.

## IV. RESULTS

### Coagulation Performance of Fenugreek Seeds

#### Turbidity Removal

Fenugreek seeds demonstrated significant turbidity reduction across all tested concentrations. At a concentration of 1 g/L, the turbidity decreased by approximately 60%, compared to 80% with conventional coagulants like alum. The performance improved with increased dosage, but the highest concentration (1.5 g/L) did not show a substantial increase in effectiveness, suggesting an optimal dosage.

#### Chemical Oxygen Demand (COD) Reduction

The COD reduction using fenugreek seeds was notable, with a decrease of around 45% at 1 g/L concentration. This reduction was slightly lower compared to conventional coagulants, which achieved up to 55% COD reduction. The effectiveness in organic matter removal indicated that fenugreek seeds can contribute to improving water quality.



### Suspended Solids Removal

Suspended solids removal was effective with fenugreek seeds, showing a reduction of about 50% at 1 g/L concentration. Conventional coagulants performed slightly better, with a removal efficiency of 65%. The results indicate that fenugreek seeds are capable of removing significant amounts of suspended solids but may be less effective compared to synthetic options.

### Comparison with Conventional Coagulants

#### Alum

Alum was highly effective in turbidity reduction, achieving up to 80% removal. It also demonstrated superior performance in COD and suspended solids removal compared to fenugreek seeds. However, the environmental impact and cost of alum must be considered.

#### Ferric Chloride

Ferric chloride also performed well in removing turbidity, COD, and suspended solids, with efficiencies similar to or slightly better than fenugreek seeds. Its higher cost and potential environmental issues make it less favorable compared to natural alternatives.

## V. DISCUSSION

### Effectiveness of Fenugreek Seeds

Fenugreek seeds proved to be a viable natural coagulant for industrial wastewater treatment. Their ability to reduce turbidity, COD, and suspended solids highlights their potential as a sustainable alternative to conventional coagulants. The coagulation efficiency of fenugreek seeds depends on factors such as dosage and wastewater characteristics. Optimization of these factors is crucial for maximizing performance.

### Environmental and Economic Implications

#### Environmental Benefits

1. **Sustainability:** Fenugreek seeds are biodegradable and derived from agricultural by-products, reducing environmental impact compared to synthetic chemicals.
2. **Resource Utilization:** Using fenugreek seeds promotes resource efficiency and waste reduction, contributing to sustainable water treatment practices.

#### Economic Considerations

1. **Cost-Effectiveness:** Fenugreek seeds are cost-effective, especially when sourced locally. Their use can lower treatment costs and provide an economically viable alternative to expensive chemical coagulants.
2. **Operational Efficiency:** While fenugreek seeds may not match the performance of conventional coagulants in all aspects, their benefits in terms of sustainability and cost make them an attractive option.

### Future Research Directions

Future studies should focus on optimizing the coagulation process using fenugreek seeds, including the development of hybrid systems combining natural and synthetic coagulants. Research into the long-term performance, scalability, and impact on different types of industrial wastewater will further establish the feasibility of fenugreek seeds in various applications.

## VI. CONCLUSION

The study concludes that fenugreek seeds are an effective natural coagulant for treating industrial wastewater, offering a sustainable and cost-effective alternative to conventional chemical coagulants. While their performance in turbidity, COD, and suspended solids removal is promising, further research is needed to optimize their use and explore their application in diverse wastewater treatment scenarios. The environmental and economic benefits of using fenugreek seeds underscore their potential as a valuable addition to water treatment practices.

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