iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** VI **Month of publication:** June 2026

DOI: https://doi.org/10.22214/ijraset.2026.83631

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue VI June 2026- Available at www.ijraset.com

Performance Evaluation of *Moringa Oleifera* Seed Powder and *Citrus Limon* Extract as Natural Coagulants for Turbid Water Treatment

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Abstract: ***This study evaluates the performance of Moringa oleifera seed powder as a natural coagulant for turbid water treatment and investigates the effect of Citrus limon (lemon juice) addition. Jar test experiments identified an optimum Moringa dosage of 150 mg/L, which achieved effective turbidity reduction. Further tests using lemon juice doses of 0.5–3 mL/L in combination with the optimum Moringa dose showed no improvement in coagulation efficiency; instead, turbidity removal performance decreased. The results demonstrate that Moringa oleifera seed powder is an effective, low-cost, biodegradable, and sustainable coagulant, while lemon juice offers no significant advantage under the investigated conditions. The findings support the application of Moringa-based treatment as an environmentally friendly water purification method for rural and low-resource communities.***

Keywords: Moringa oleifera, natural coagulant, turbidity removal, lemon juice, sustainable water treatment, jar test.

I. INTRODUCTION

Access to clean and safe drinking water is essential for public health and sustainable development. However, a large portion of the global population, particularly in developing and rural regions, continues to rely on untreated or inadequately treated water sources. Increasing population growth, urbanization, industrial activities, and environmental pollution have further intensified the demand for effective and affordable water treatment technologies.

Turbidity is one of the most common water quality problems and is caused by the presence of suspended particles such as clay, silt, organic matter, and microorganisms. High turbidity not only affects the appearance of water but also reduces the effectiveness of disinfection processes and may facilitate the transmission of waterborne diseases. Coagulation is therefore an important step in water treatment, where coagulants destabilize suspended particles and promote their aggregation into larger flocs that can be removed through sedimentation and filtration.

Conventional coagulants such as aluminium sulphate (alum) and ferric chloride are widely used because of their high efficiency. However, their application is associated with several limitations, including high operational costs, production of non-biodegradable sludge, and potential environmental and health concerns. These challenges have encouraged the search for sustainable and environmentally friendly alternatives.

Among natural coagulants, *Moringa oleifera* seed powder has attracted considerable attention due to its coagulation properties. The seeds contain water-soluble cationic proteins that neutralize negatively charged suspended particles, resulting in effective turbidity reduction. In addition, *Citrus limon* (lemon) extract contains citric acid and other bioactive compounds that may influence the coagulation process through pH adjustment.

The present study evaluates the performance of *Moringa oleifera* seed powder for the treatment of turbid water and investigates the effect of lemon extract when used in combination with the optimum Moringa dosage. The study aims to assess the potential of these natural materials as low-cost, biodegradable, and sustainable alternatives for water treatment, particularly in rural and resource-limited communities.

II. OBJECTIVE OF THE STUDY

This dissertation has the following main objectives:

1) To determine the optimum dose of *Moringa oleifera* Seed Powder as Natural Coagulant for Turbid Water Treatment.
2) To find out the effect of *Citrus limon* Extract (lemon juice) along with optimum dose of *Moringa oleifera* Seed Powder in turbidity removal.

III.METHODOLOGY

Raw turbid water samples were collected from the River Ganga at Rajnagar, Malda, West Bengal. Initial water quality parameters, including turbidity and pH, were measured prior to treatment.

Moringa oleifera seeds collected from Dakshin Dinajpur, West Bengal, were sun-dried, dehulled, ground into powder, and sieved through a 300 µm sieve to obtain a uniform particle size. The prepared powder was stored in airtight containers until use. Fresh *Citrus limon* fruits were procured locally, and the extracted juice was filtered using Whatman Grade I filter paper.

Jar test experiments were conducted using a six-paddle jar test apparatus with 1000 mL of water in each beaker. To determine the optimum coagulant dosage, Moringa seed powder was applied at concentrations of 50, 100, 150, 200, 250, and 300 mg/L. Samples were subjected to rapid mixing at 120 rpm for 2 min, followed by slow mixing at 30 rpm for 30 min and settling for 30 min. Residual turbidity and pH were then measured.

Turbidity removal efficiency was calculated as:

$$\text{Turbidity Removal Efficiency (\%)} = \frac{Ti - Tf}{Ti} x100$$

The optimum Moringa dosage was selected and combined with lemon extract doses of 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 mL/L. The coagulation–flocculation procedure was repeated using rapid mixing at 120 rpm for 2 min, slow mixing at 30 rpm for 20 min, and settling for 30 min. Final turbidity and pH were measured, and the results were analyzed using tables, graphs, and percentage turbidity removal calculations.

IV.RESULTS

Turbidity of raw water sample, Ti = 115 NTU

pH of raw water measured 6.9

Following is the table of results when *Moringa Oleifera* seed powder is used as coagulant.

Table 1: Moringa dose and turbidity removal efficiency

Sl No.	Moringa Oleifera dose (mg/L)	Residue turbidity, T_f	pH	Turbidity removal efficiency $\frac{Ti\ \ Tf}{Ti} x100$
1	50	16.4	6.9	85.74
2	100	12.6	6.9	89.04
3	150	10.6	6.9	90.78
4	200	12.2	6.9	89.39
5	250	24.4	6.9	78.78
6	300	35.2	6.9	69.39

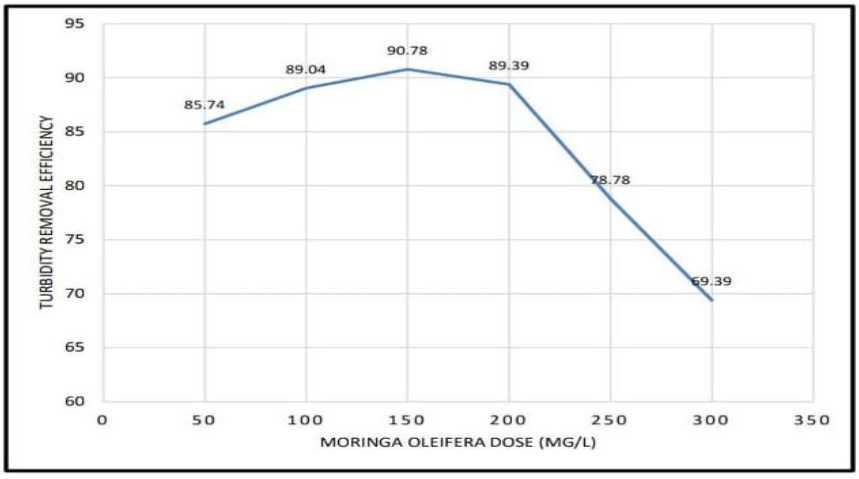

Figure 1: *Moringa Oleifera* dose vs turbidity removal efficiency

From the table and graph, we find moringa dose as 150 mg/L which causes highest turbidity removal of the sample. Now we put this dose along with varied doses of Citrus limon extract (lemon juice) in the raw sample and find out the effect on the turbidity removal efficiency of the *Moringa Oleifera* seed powder.

Table 2: Lemon juice dose and turbidity removal efficiency

Sl No.	Moringa Oleifera dose (mg/L)	Lemon juice dose (ml/L)	Residue turbidity, T_f	pH	Turbidity removal efficiency $\frac{Ti-Tf}{Ti} x100$
1	150	0.5	25.4	6.54	77.91
2	150	1	27.9	6.39	75.74
3	150	1.5	36.5	6.13	68.26
4	150	2	45.5	5.89	60.43
5	150	2.5	58.6	5.64	49.04
6	150	3	76.5	5.35	33.48

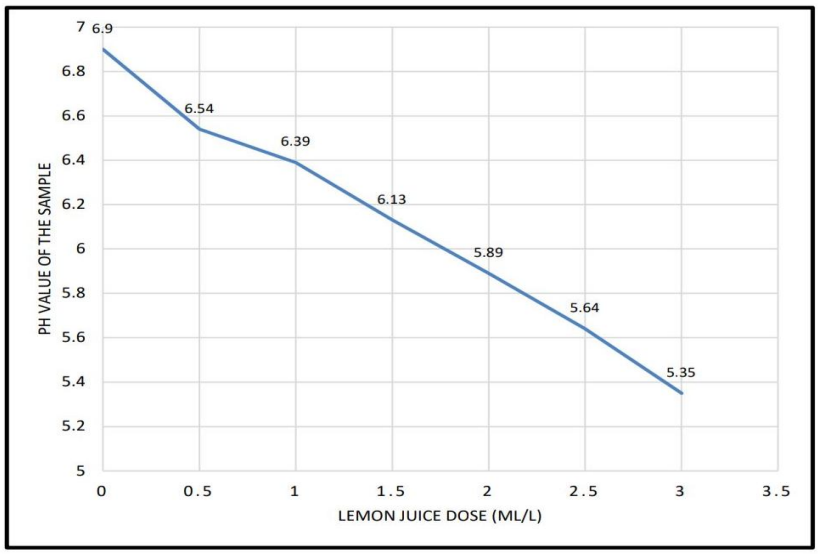

Figure 2: Lemon juice dose vs pH value of sample

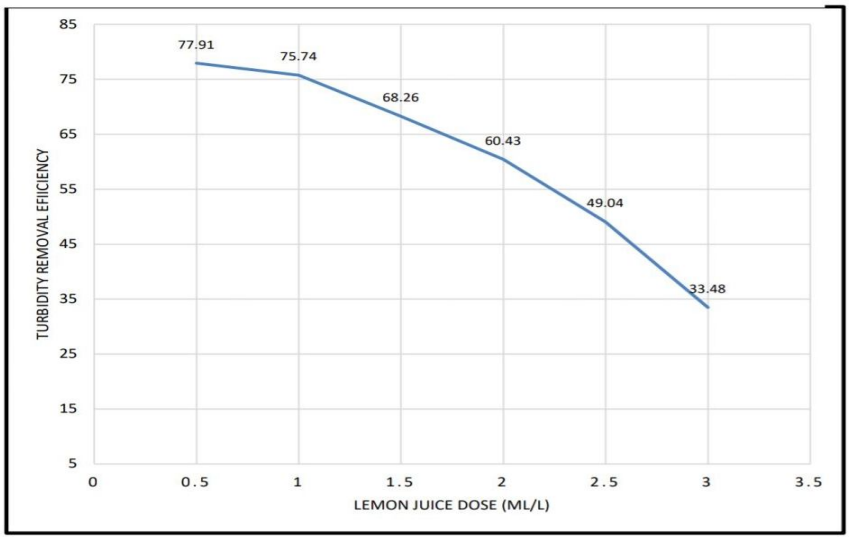

Figure 3: Lemon juice dose vs turbidity removal efficiency with moringa dose

V. DISCUSSIONS

The study demonstrated that *Moringa oleifera* seed powder is an effective natural coagulant for turbidity removal, with an optimum dosage of 150 mg/L achieving the highest treatment efficiency. The coagulation performance is attributed to the cationic proteins present in Moringa seeds, which promote particle destabilization, floc formation, and sedimentation.

The addition of *Citrus limon* extract (0.5–3.0 mL/L) to the optimum Moringa dosage did not enhance treatment performance. Instead, turbidity removal efficiency decreased from 77.91% to 33.48% with increasing lemon dosage, while pH declined from 6.54 to 5.35. The reduced efficiency may be attributed to the acidic nature of lemon juice, which can alter the optimum conditions required for protein-based coagulation. Furthermore, colloidal materials and organic compounds naturally present in lemon juice may contribute additional turbidity and interfere with floc formation and settling.

The results indicate that the combined Moringa–lemon treatment system is less effective than Moringa seed powder alone. These findings highlight the importance of experimentally validating natural coagulant combinations before their practical application in water treatment systems.

VI. CONCLUSIONS

This study demonstrated that *Moringa oleifera* seed powder is an effective natural coagulant for turbid water treatment, with an optimum dosage of 150 mg/L. The addition of *Citrus limon* extract (0.5–3.0 mL/L) did not enhance coagulation performance; instead, turbidity removal efficiency decreased while pH was reduced. The adverse effect is likely due to pH changes and the presence of colloidal and organic constituents in lemon juice. No synergistic effect was observed between Moringa seed powder and lemon extract. Therefore, *Moringa oleifera* seed powder alone is recommended as a low-cost, biodegradable, and sustainable coagulant for water treatment, particularly in rural and resource-limited areas. findings highlight

VII. FUTURE ENHANCEMENT

As the pH reducing substance like lemon juice did not enhance the turbidity removal efficiency of *Moringa Oleifera* seed powder for the treatment of turbid water in our experimental set up, pH increasing natural substances may be investigated along with moringa dose.

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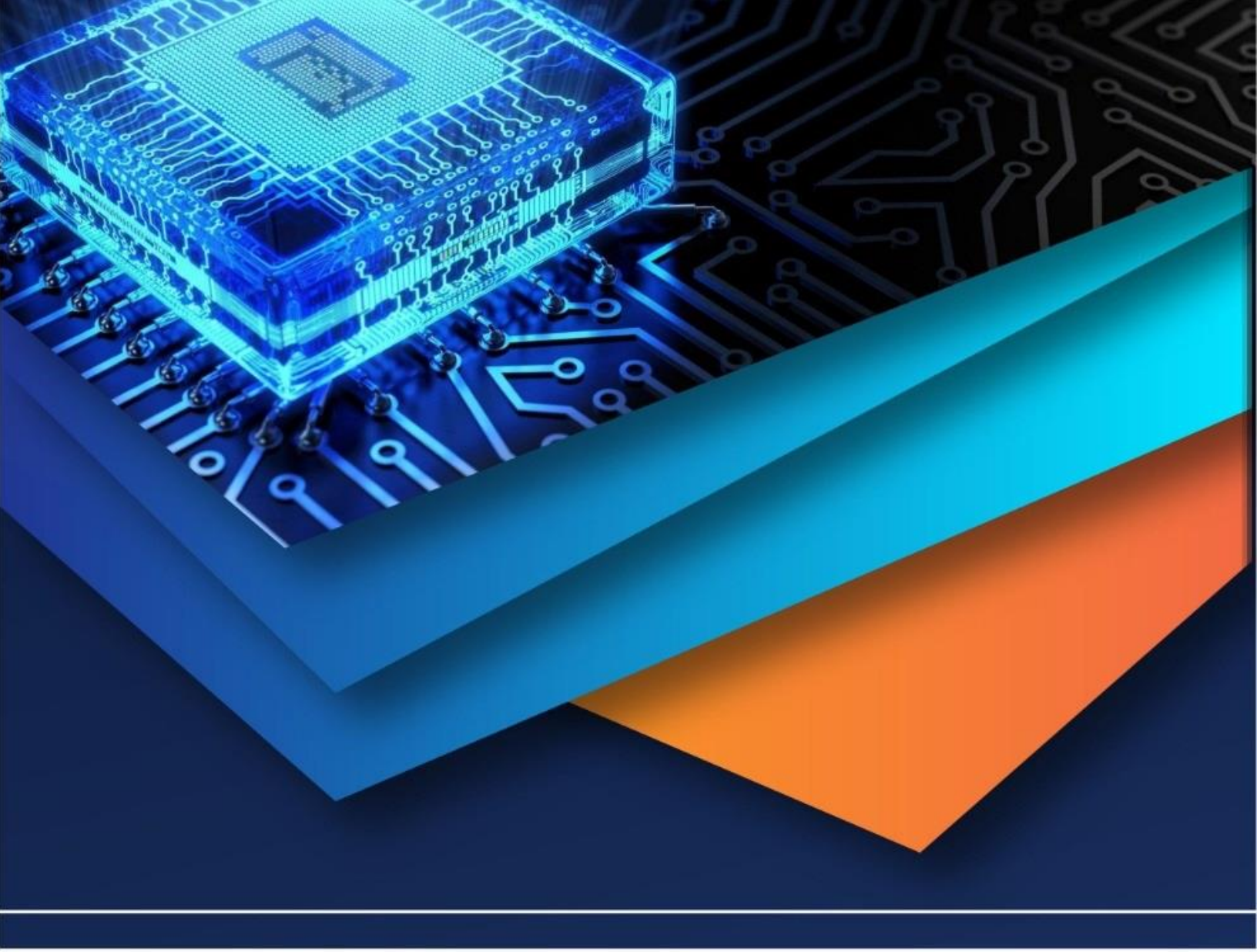

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