IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 10, May 2026
Impact Factor: 8.2

Water Coagulation using Natural and Chemical Coagulants

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Abstract: *Water coagulation is a key process in water treatment used to remove suspended and colloidal impurities that cause turbidity and poor water quality. This study focuses on evaluating and comparing the efficiency of natural and chemical coagulants in improving water clarity. Chemical coagulants such as aluminium sulphate (alum) and ferric chloride were tested alongside natural coagulants like Moringa oleifera seed powder and banana peel powder. The experiment involved treating turbid water samples with varying dosages of each coagulant, followed by sedimentation and measurement of turbidity reduction using a nephelometric turbidity unit (NTU) meter. The effects of parameters such as coagulant dosage, pH, and settling time were analysed to determine optimal conditions. Results indicated that both natural and chemical coagulants effectively reduced turbidity, with chemical coagulants showing faster floc formation, while natural coagulants offered a more eco-friendly and bio degradable alternative. The findings highlight that natural coagulants can serve as sustainable substitutes for chemical coagulants, particularly in rural and small-scale water purification systems, providing a cost-effective and environmentally safe method for producing clean water.*

Keywords: *Water coagulation*

I. INTRODUCTION

Water is one of the most essential natural resources on Earth, vital for all forms of life. It covers nearly 71 % of the planet's surface and is found in various forms such as oceans, rivers, lakes, glaciers, and underground sources. Chemically, water is composed of two hydrogen atoms and one oxygen atom (1120), making it a simple yet remarkable compound It plays a crucial role in biological processes, climate regulation, agriculture, industry, and domestic use. Despite its abundance, only a small percentage—about 2.5%—is freshwater, and even less is easily accessible for human consumption. The increasing demand for clean and safe water due to population growth and industrialization has made water conservation and purification vital. Hence, understanding water's properties, sources, and importance is essential for ensuring sustainable development and environmental protection.

water coagulation Water coagulation is one of the most important processes in the treatment of water and wastewater, playing a vital role improving water clarity, colour, and overall quality. Natural water sources such as rivers, lakes, and ponds often contain suspended and colloidal particles like clay, silt, organic matter, and microorganisms that make the water turbid and unsuitable for domestic, industrial, or agricultural use. These tiny particles are often negatively charged, which prevents them from settling naturally because the repulsive forces between them keep them dispersed in the water. Coagulation involves adding specific substances known as coagulants to neutralize these electrical charges, allowing the particles to come together, form larger aggregates known as flocs, and eventually settle out during sedimentation or be removed by filtration

This process significantly reduces turbidity and improves the effectiveness of Subsequent treatment steps such as disinfection. The most commonly used chemical coagulants In conventional water treatment plants are aluminium sulfate (alum), ferric chloride, and ferric sulfate. These chemicals release positively charged ions that counteract the negative charges of the colloidal particles, leading to destabilization and aggregation. Although chemical coagulants

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are highly effective, they may have disadvantages, including high cost, the generation of large quantities of sludge, and the potential for leaving residual metal ions in treated water, which can affect human health and the environment.

1.2 Natural coagulation To address these limitations, researchers and engineers have Increasingly explored the use of natural coagulants as sustainable alternatives. Natural coagulants are typically derived from plants, seeds, and other organic materials such as Moringa oleifera seeds, cactus extract, banana peel powder, and chitosan. These substances are biodegradable, non-toxic, and often available locally at a low cost, making them ideal for small-scale and rural water treatment systems. Studies have shown that natural coagulants can effectively remove up to 90% of turbidity under optimized conditions, though their performance can vary based on water characteristics and dosage. The process of coagulation generally includes three main stages: rapid mixing, flocculation, and sedimentation. During rapid mixing, the coagulant is quickly and evenly distributed throughout the water to ensure that it reacts efficiently with the impurities. The flocculation stage follows, where the water is gently stirred to promote collisions between destabilized particles, forming larger, visible flocs. Finally, during sedimentation, these flocs settle under gravity, allowing the clear water above to be separated and further purified by filtration or disinfection.

.2factors Several factors influence the efficiency of the coagulation process, Including pH, temperature, alkalinity, coagulant type and dosage, and mixing conditions. For example, alum works best within a pH range of 5.5 to 7.5, while iron-based coagulants are more effective in slightly higher pH ranges. Temperature also affects reaction rates, as colder water tends to slow down floc formation, whereas warmer water enhances particle collisions and settling. Optimizing these factors is essential for achieving maximum removal efficiency, which is often determined through laboratory jar tests before full-scale application. Coagulation offers numerous advantages, such as the ability to handle a wide range of impurities and improve the efficiency of filtration systems by reducing clogging 2

.3Drinking water is a vital resource for all human bungs, and the access to safe and clean drinking water is a major concern throughout the world (WHO). Producing potable water from surface or ground water usually involves one or several treatment steps for removing unwanted substances. When surface water IS used as raw water the removal of organic and inorganic material from raw water is essential before it can be supplied to human for consumption. This is being carried out by chemical coagulation. In developing countries like India, this system is Inappropriate because of the expensive and low and non availability of chemical coagulants. The high cost of treated water makes more people in the rural communities to resort to readily available sources which are normally of low quality exposing them to waterborne diseases. 1.14 primary method Among various water treatment methods, coagulation and flocculation are considered highly effective primary steps for removing suspended and colloidal particles. These processes enhance the efficiency of subsequent treatment stages such as sedimentation, filtration, and disinfection. In conventional systems, chemical coagulants like aluminium sulfate (alum) and chloride are commonly used due to their high effectiveness and ease of application. However, their continuous use raises concerns such as the formation of large volumes of chemical sludge, high operational costs, and potential health impacts associated with residual metal ions in treated water. Furthermore, the efficiency of coagulation depends on several operational parameters, including pH, dosage of coagulant, mixing intensity, temperature, and contact time. Optimizing these parameters ensures maximum turbidity removal and improves water clarity Various studies have demonstrated that natural coagulants can remove turbidity up to 80—95% under optimized conditions, comparable to or even better than chemical coagulants in some cases, 2Drinking water is avital resource for all human beings, and the access to safe and clean drinking water is a major concern throughout the world (WHO). Producing potable water from surface or ground water usually involves one or several treatment steps for removing unwanted substances. When surface water is used as raw water the removal of organic and inorganic material from raw water is essential before it can be supplied to human for consumption. This is being carried out by chemical coagulation. In developing countries like India, this system is inappropriate because of the expensive and low and non availability of chemical coagulants. The high cost of treated water makes more people in the rural communities to resort to readily available sources which are normally of low quality exposing them to waterborne diseases.

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.5 Alum Coagulation is a primary process in water treatment used to remove suspended particles, turbidity, and impurities from water. Alum (Aluminium Sulphate 181120) is the most commonly used chemical coagulant because of its high efficiency, low cost, and easy availability. When alum is added to raw water, it reacts with the natural alkalinity to form gel-like flocs of aluminium hydroxide $(Al(OH)_3$

These flocs trap fine particles, organic matter, colour-causing substances, and microorganisms, allowing them to settle easily during sedimentation. The overall result is a significant reduction in turbidity and improved water clarity. Alum coagulation is widely used in drinking water plants, laboratories, and smallscale purification systems due to its simplicity and effectiveness

OBJECTIVE

The main objective of the coagulation process is to remove suspended, colloidal, and fine impurities from water by forming flocs that can easily settle, thereby reducing turbidity and improving overall water quality.

- To study the effectiveness of both natural and chemical coagulants in removing turbidity and suspended impurities from water.
- To compare the performance of natural coagulants (such as Moringa oleifera, banana peel powder, or cactus extract) with conventional chemical coagulants (such as alum or ferric chloride).
- To determine the optimum dosage of each coagulant required to achieve maximum turbidity removal under controlled conditions.
- To evaluate the environmental and economic benefits of using natural coagulants as sustainable alternatives to chemical coagulants.
- To assess the quality of treated water In terms of turbidity, clarity, and suitability for domestic or industrial use.
- To promote eco-friendly water treatment methods that reduce chemical usage, sludge production, and environmental pollution

PREPARATION OF BANANA PEEL POWDER:

I. Collection of Banana Peels

Collect fresh, ripe banana peels.

Avoid spoiled or overripe peels (they introduce extra organic matter

2.Washing

Rinse the banana peels thoroughly under tap water to remove dirt, dust, and pesticides.

Follow with a final wash using distilled water

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3 .Cutting
Cut the peels into small pieces (2—3 cm size).
Smaller pieces dry faster and more uniformly
Drying
Choose either method
A. Sun Drying (Low-Cost Method)
Spread peel pieces on a clean tray.
Dry under direct sunlight for 2—3 days.
•Ensure no moisture remains
B. Oven Drying (Recommended for Lab Use)
Spread peel pieces on a tray.
•Dry in a hot air oven at 60—70^{0}C for 6—8 hours.
Continue drying until peels become crisp and easily breakable.
Note: Complete drying is important to avoid mould growth.
Grinding
Transfer the dried peels to a grinder/mixer. •Grind into fine powder.
Sieving
Pass the powder through a 150—300 gm sieve.
This ensures uniform particle size and better coagulation performance.
SOLUTION:
10 g/L stock (moderate strength — convenient) • Weigh 10.0 g banana peel powder.
Add to 1.0 L distilled water (use glass or PET).
Stir vigorously for 30 minutes (magnetic stirrer or shaking).
•Let settle 10—15 min, then filter through double-layer muslin/coffee filter (or centrifuge at 3000— 4000 rpm for 10 min) to remove coarse solids.

- Collect the clear/partly cloudy filtrate — this is your 10 g/L stock. Label with date.
- B. 50 g/L stock (strong, for small dosing volumes

Preparation of alum solution I. Take 5 g of alum.
Add to a beaker containing 400 mL distilled water.
Stir until fully dissolved. 4. Transfer to a 500 mL measuring flask
5. Make the volume up to 500 mL with distilled water and mix.
preparation of moringa oleifera solution
I Seed Cleaning & Drying
Remove husk and collect kernels.
Wash if necessary.
Dry in shade or oven at 40—50^{0}C until constant weight.
Grinding
Grind dried kernels into fine powder.
Sieve to remove large particles (S250 um).
Making Stock Solution
Weigh 1.25 g of moringa powder.
Add to a beaker with —400 mL distilled water.
Stir vigorously for 20--30 minutes.
Filtration
Filter through cheesecloth to remove coarse solids.
Optionally filter through filter paper or centrifuge for a clear solution

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Sample Collection
location : Pattanam
Appearance: The liquid appears light yellow to pale white.
It is cloudy/turbid, indicating suspended particles are still present.
There is no clear settling layer visible yet; the turbidity IS spread throughout the liquid,
The sample looks non-transparent and uniformly mixed

sample 2 location . Chinniyampalayam
Appearance: A light yellow, translucent liquid
Slightly cloudy, not fully clear
With small floating particles or fine suspended solids visible near the top surfac

sample 3 location : Periyanaickenpalayam Appearance: The liquid appears opaque and white

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It is not clear, indicating the presence of high turbidity or suspended particles.
The sample looks uniformly cloudy throughout, with no visible settling at the bottom

Sample 4 location - Vellalore Appearance:
The sample is bright orange in colour.
It appears opaque and highly turbid, indicating a large amount of suspended matter.
Some dark solid particles are visible at the bottom of the container.
The liquid is not transparent, and the colour is uniformly distributed.

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RESULT AND TESTING

INITIAL TURBIDITY

S.NO	SAMPLE	INITIAL TURBIDITY
1	SAMPLE 1	265(NTU)
2	SAMPLE 2	540(NTU)
3	SAMPLE 3	355(NTU)
4	SAMPLE 4	610(NTU)

TREATING WITH ALUM SOLUTION

S.NO	SAMPLE (NTU)	5ML(NTU)	IOML(NTU)	15M L(NTU)
1	SAMPLE 1 (265)	97	51	33
2	SAMPLE 2 (540)	180	70	35
3	SAMPLE 3 (355)	140	66	34
4	SAMPLE 4 (610)	267	113	63

TREATING WITH MORINGA OLEIFERA SOLUTION

s.N0	SAMPLE (NTU)	5ML(NTU)	IOML(NTU)	15ML(NTU)
1	SAMPLE 1 (265)	120	66	41

DOI: 10.48175/568

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2	SAMPLE 2 (540)	331	215	145
3	SAMPLE 3 (355)	171	106	70
4	SAMPLE 4 (610)	344		113

TREATING WITH BANANA PEEL POWDER SOLUTION

S.NO	SAMPLE (NTU)	5ML(NTU)	IOML(NTU)	15ML(NTU)
1	SAMPLE 1 (265)	174	146	101
2	SAMPLE 2 (540)	381	280	210
3	SAMPLE 3 (355)	255	192	145
4	SAMPLE 4 (610)	420	312	233

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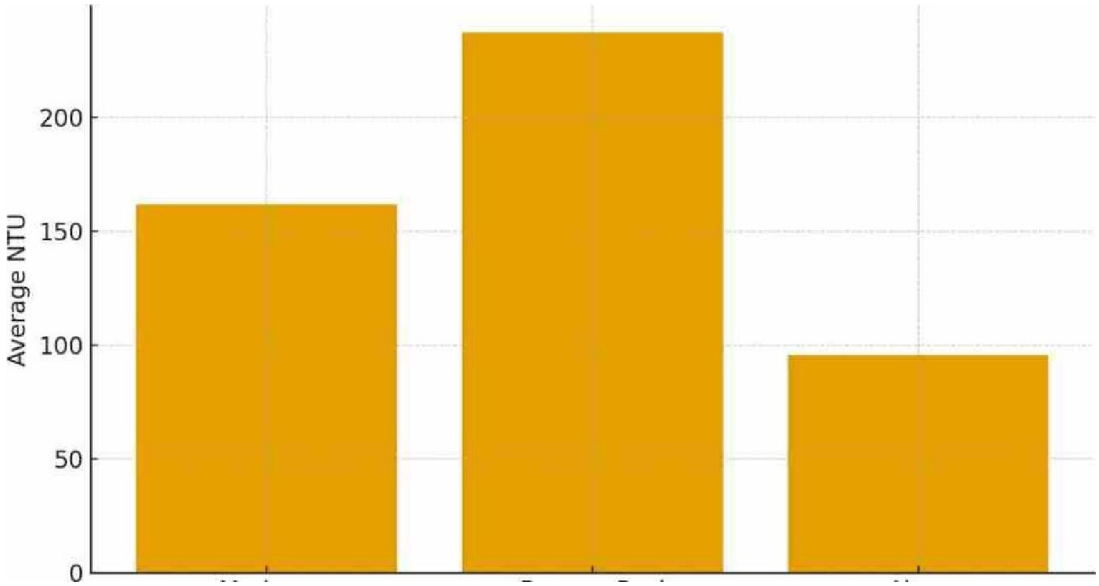
RESULTS

Average NTU Comparison (Bar Graph)



Coagulants

The bar graph compares the average turbidity (NTU) values obtained after treating water samples with Moringa oleifera solution, banana peel powder solution, and alum solution. From the graph, nit is evident that alum produced the lowest average NTU, indicating the highest turbidity removal efficiency among the three coagulants. This is because alum is a conventional chemical coagulant known for its fast floc formation and strong settling characteristics.

Moringa oleifera shows the second-best performance. The average NTU value is higher than alum but significantly lower than banana peel. This suggests that Moringa contains natural cationic proteins that effectively neutralize suspended particles and promote flocculation. Although not as strong as alum, Moringa offers the advantage of being a natural, biodegradable, and non-toxic alternative.

Banana peel powder exhibits the highest average NTU among the three coagulants, This indicates that its turbidity reduction ability is comparatively lower. However, banana peel is still effective to some extent due to the presence of natural polysaccharides and active functional groups that aid coagulation, although its performance is not as pronounced as that of Moringa or alum

Overall, the bar graph demonstrates that alum > Monga > banana peel in terms of turbidity removal. While alum is the most efficient, natural coagulants like Moringa and banana peel offer safer, eco-friendly alternatives suitable for sustainable water treatment applications.

II. CONCLUSION

The study successfully evaluated the effectiveness of both natural and chemical coagulants in reducing turbidity and suspended impurities from water. The experimental results showed that all coagulants—Moringa oleifera seed powder, banana peel powder, and alum—were capable of improving water clarity, but their performance varied depending on dosage and sample turbidity. Alum, being a conventional chemical coagulant, produced rapid floc formation and high turbidity removal; however, the natural coagulants demonstrated comparable efficiency at optimum doses.

Moringa oleifera showed the highest turbidity reduction among the natural coagulants due to its strong coagulating proteins, while banana peel powder also showed significant improvement as an Inexpensive and biodegradable

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alternative. Natural coagulants were found to generate less sludge, pose minimal environmental risk, and offer cost-effective treatment options, especially for rural or low-resource settings.

The results indicate that natural coagulants can serve as sustainable substitutes for chemical coagulants, particularly where eco-friendly and low-toxicity treatment methods are preferred. Therefore, the study supports the adoption of natural coagulants for small-scale -water purification, contributing to reduced chemical usage, lower environmental pollution, and enhanced sustainability in water treatment practices.

REFERENCES

[1]. L Babu & Chaudhuri (2005) reported that natural coagulants like moringa oleifera effectively reduce turbidity while being eco-friendly and biodegradable.
[2]. Sanchez-Martin et al. (2010) showed that plant-based coagulants produce less sludge than alum and are safer for drinking water treatment
[3]. Okuda et al. (2013) found that natural coagulants can remove up to 90% turbidity in low-cost rural water purification systems.
[4]. Jahn (2014) observed that moringa proteins act as cationic polyelectrolytes, helping particles to aggregate rapidly.
[5]. Farooq et al. (2017) compared chemical alum with natural coagulants and reported higher pH stability and lower toxicity for natural options.
[6]. Abidin et al. (2018) found that chemical coagulants give higher initial turbidity removal but natural ones are more sustainable and cost-effective.
[7]. Ghebremichael (2018) highlighted that natural coagulants significantly reduce residual aluminium levels left by chemical coagulants.
[8]. Saleem & Bachmann (2019) reviewed coagulation mechanisms and concluded that natural coagulants Improve water quality without altering water chemistry drastically.
[9]. Reyhani et al. (2020) demonstrated that chemical coagulants like alum and ferric chloride are effective even for high-turbidity industrial wastewater.
[10]. Al-Zoubie et al. (2021) showed that hybrid treatment (natural + chemical) provides maximum turbidity removal and reduces chemical dosage,