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Feasibility of Natural Coagulants to Eliminate Turbidity and TDS from Synthetic Water

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***Abstract*— The study investigated the effectiveness of three natural coagulants—Dolichos lablab, Phyllanthus emblica, and Cicer arietinum—in reducing turbidity and Total Dissolved Solids (TDS) in water treatment. The process involved coagulation-flocculation using various dosages, pH levels, stirring speeds, and contact times. Among the coagulants tested, Phyllanthus emblica performed the best, achieving a 92.7% reduction in turbidity and a 69.2% reduction in TDS under optimal conditions (50 mg/L dosage, pH 7, 200 RPM, and 45 minutes contact time). Dolichos lablab and Cicer arietinum also showed significant but slightly lower removal efficiencies. The study emphasizes the potential of natural coagulants as sustainable alternatives to chemical coagulants, especially in areas where water quality improvement is essential. Further research should focus on the scalability and economic viability of implementing these coagulants on a larger scale and their long-term impact on water treatment infrastructure. These findings contribute to developing environmentally friendly water purification methods that prioritize sustainability and public health.**

***Keywords*— Natural coagulants, water treatment, turbidity reduction, total dissolved solids (TDS), Phyllanthus emblica, Dolichos lablab, Cicer arietinum.**

I. INTRODUCTION

Water is one of the most valuable resources on our planet, yet only three percent of it is fresh, and just a small portion of these reserves is commercially viable. It is estimated that 1.1 billion people currently lack access to safe drinking water, with water shortages impacting over 30 countries [1]. In the modern era, water is considered a critical raw material, and ensuring a secure and sustainable supply is one of the most important global objectives for the future. Water that is easily accessible, sufficient in quantity, free from impurities, safe, and consistently available is essential for human health and well-being. Beyond its vital role in sustaining life, water also plays a significant part in the socio-economic development of human societies [2]. Due to inadequate water treatment, many individuals contract diseases, particularly in countries like India, where there is growing water scarcity. Even groundwater requires purification due to harmful chemicals. Rural communities, in particular, heavily depend on groundwater, assuming it is available in sufficient quantities, but surface water is often contaminated, leading to diseases such as malaria, diarrhea, and cholera, which are among the leading causes of death [4]. Therefore, treating water is essential to improve quality and prevent illness outbreaks. Water treatment aims to remove turbidity and other impurities, including natural organic materials and microorganisms [5]. It has been found that domestic water treatment can enhance water quality in three major aspects: physical, chemical, and microbiological. Techniques such as ceramic and bio-sand filters, fabric filters, coagulation, and flocculation help remove physical impurities, while boiling, solar disinfection, and chlorination improve microbiological purity [2].

As illustrated in Figure 1, coagulation has been primarily used for many years to remove dyes and pigments from various types of contaminated wastewater. The characteristics of the coagulants used play a crucial role in determining the effectiveness of the coagulation process, as they can either enhance or reduce treatment efficiency [6]. In addition to the type of coagulant, other parameters such as coagulant dose, pH, mixing speed, duration, temperature, and settling time must be carefully controlled to optimize the process. Proper control of these factors is essential for reducing execution time and improving the removal of impurities. The advent of coagulants has led to the development of several treatment mechanisms and procedures, such as chemical precipitation, ion exchange, membrane filtration, electrolytic recovery, adsorption, and reverse osmosis, to treat water [8] effectively.

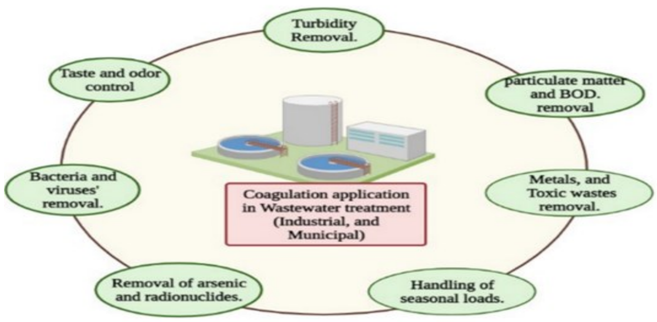

Fig 1: Different applications of coagulation processes in different types of water treatment

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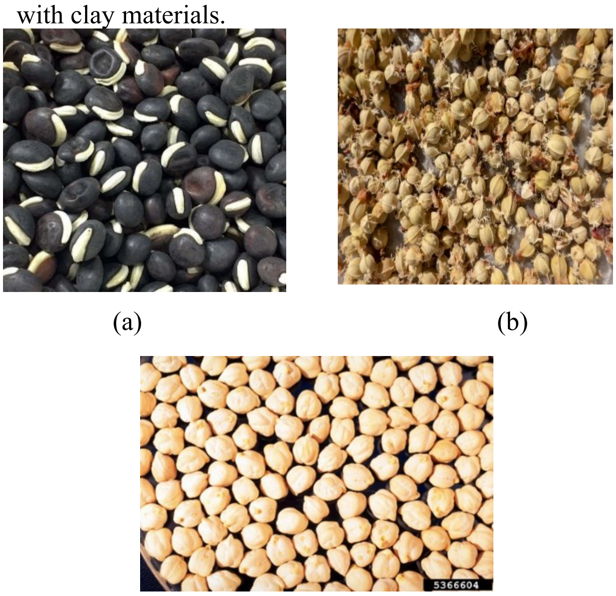
II. MATERIALS AND METHODS

All coagulation experiments were carried out using synthetic artificial turbid water. A conventional jar test apparatus was used in the experiments to coagulate a sample of synthetic turbid water using coagulants.

A. Material

The materials used in this study include water, natural coagulants such as Dolichos lablab seeds, Phyllanthus emblica (Amla seeds), and Cicer arietinum (Chickpea seeds), along with clay materials.



(a) (b)

(c)

Fig 2 : a)Dolichos lablab b)Phyllanthus emblica c)Cicer arientinum

B. Preparations of coagulants

To prepare the natural coagulant, the seeds are first sun-dried or oven-dried. Once thoroughly dried, they are ground into a fine powder using a kitchen blender. Next, 5 grams of this powdered natural coagulant are added to 100 milliliters of distilled water. The mixture is then vigorously shaken for 45 minutes using a stirrer to promote the extraction of the active components from the seed. After shaking, the solution is filtered through filter paper. The filtered extract is then used to prepare different dosages of the natural coagulant, with concentrations of 20, 30, 40, 50, 60, and 70 milligrams per liter, to be tested for their coagulation efficiency.

C. Preparation of Synthetic Water

To prepare artificially turbid water, start by taking 1 kilogram of clay material, which is sieved through a 4.75 mm IS sieve, and add it to 10 liters of tap water. The mixture is then stirred thoroughly and allowed to settle for 1 hour. After this period, the supernatant liquid, which contains the suspended clay particles, is used for further studies.

D. Stock Solution

Distilled water was added to the powder to make 2% suspension of it. The suspension was vigorously shaken for 1 hour using a magnetic stirrer to promote water extraction of the coagulant proteins, and this was then passed through filter paper (Whatman no. 42, 125 mm dia.). The filtrate portions were used for required dose of natural coagulants. Fresh solutions were prepared daily and kept refrigerated to prevent any ageing effects (such as change in viscosity, coagulation activity, and pH). Solutions were shaken before use vigorously

E. Jar test

A series of clean, labeled jars containing a standardized water sample are used in a jar test to assess the efficacy of natural, coagulants in water treatment. To generate solutions of specific quantities, natural coagulants such as Cicer arintinum, Phyllanthus emblica, and Dolichos lablab were dissolved in distilled water. If necessary, the turbidity of the water sample was corrected to a specified level. Individual jar are filled with coagulant solution, which were then mixxed quickly for one to two minutes to distribute the coagulant uniformly. After that, the jars were mixed slowly for twenty to thirty minutes to encourage the productions of floc. To give the flocs time to settle, the jars are kept undisturbed for 30 to 60 minutes after mixing.

Parameters such as turbidity, pH, and Total Dissolved Solids (TDS) were measured before and after treatment using appropriate meters. The effectiveness of each coagulant was assessed by comparing these measurements to those of untreated water, and results were analyzed to determine the most efficient coagulant for reducing turbidity and improving water quality.

Fig 3: jar test

III. RESULTS AND DISCUSSION

A. Initial characteristics

The created synthetic water was used. Under cautious circumstances, the first features of synthetic water were tested as the sample was brought into the lab. Table 1 lists the starting attribute value of synthetic water.

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Table -1: Initial characteristics

PARAMETERS	VALUES
pH	8.7
TDS	572 ppm
EC	881ms/cm
Turbidity	45.5NTU

B. Reduction of TDS Using Natural Coagulants

The physical properties turbidity and pH were evaluated after jar test was conducted. Doses started from 20 mg/L to 70 mg/L for corresponding six beakers. Turbidity was measured before and after treatment.

Test-1: Using Dolichos lablab

Dolichos lablab seed powder was first prepared for the jar test trials. It was then well blended and added to water samples in different amounts. The goal of the initial experiments was to find the ideal coagulant concentration, pH, and mixing speed combinations for the removal of TDS. Comprehensive observations of the treatment outcomes are given in the ensuing sections.

Table 2: TDS removal by using Dolichos lablab

pH	Dosage (mg/L)	RPM	Time (min)	Removal Efficiency (%)
5	50	100	45	68.2
5	40	100	60	63.9
5	40	250	60	64.9
7	40	100	45	66.6
7	50	100	45	70.2
7	50	200	30	67.2
7	50	250	45	65
9	50	200	30	65.2
9	50	200	60	66.9
9	50	250	45	63.6

Test-2: Using Phyllanthus emblica

Different quantities of powdered Phyllanthus emblica seed were applied to water samples. By adjusting the coagulant dosage, pH, and mixing speeds, the ideal conditions for lowering TDS were found through the jar experiments.

Table 3: TDS removal by using Phyllanthus emblica

pH	Dosage (mg/L)	RPM	Time (min)	Removal Efficiency (%)
5	50	100	45	69
5	50	250	45	67.4
5	30	200	60	64.6
7	50	100	45	71
7	50	200	30	68
7	50	200	45	66.7
7	40	100	45	66
7	50	250	60	64.9
9	50	200	60	67.7
9	40	250	60	65.2

Test-3: Using Cicer arientinum

After processing, different dosages of Cicer arietinum seed powder were added to the water samples. The purpose of the jar experiments was to determine the ideal turbidity and TDS removal parameters by varying the stirring speeds, pH, and coagulant dosage.

Table 4: TDS removal by using Cicer arientinum

pH	Dosage (mg/L)	RPM	Time (min)	Removal Efficiency (%)
5	50	100	60	67.4
5	50	100	45	65.1
5	30	250	60	63.4
7	50	100	60	66.4
7	40	200	30	65.4
7	50	200	45	64.4
7	40	250	30	63.9
9	50	200	60	66.1
9	50	250	30	64.2
9	50	250	60	63.6

C. Comparison of TDS removal using natural coagulants

Based on neutral pH and moderate agitation speeds, the results show that Dolichos lablab achieves excellent Total Dissolved Solids (TDS) removal under moderate circumstances, with a decrease of 65.6% at a dosage of 50 mg/L. Because Phyllanthus emblica contains bioactive components that improve coagulation, it demonstrated greater TDS reduction, attaining 69.2% elimination under identical conditions. On the other hand, Cicer arietinum demonstrated efficient TDS removal over a wider pH range, especially in alkaline circumstances, attaining a maximum TDS removal of 67.4% at a dosage of 50 mg/L. Its susceptibility to environmental changes was evident from its poor performance in highly agitated or acidic environments.

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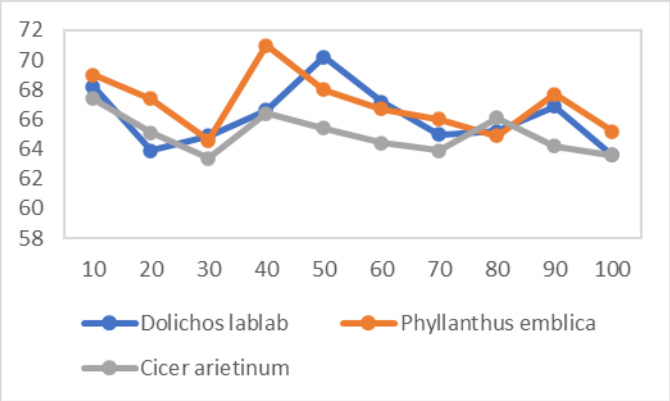

Chart-1: Comparison of TDS removal using natural coagulants

D. Reduction of Turbidity Using Natural Coagulants

The Turbidity Removal Efficiency For Contact Times 30, 45, And 60 is Observed in Experimental Trials.

Test-1: Using Dolichos lablab

Table 5: Turbidity removal by using Dolichos lablab

pH	Dosage (mg/L)	RPM	Time (min)	Turbidity Removal Efficiency (%)
5	40	100	45	80.1
5	50	100	45	89.3
5	40	250	60	84
5	50	100	30	85
7	50	200	30	82.7
7	50	100	45	89.5
7	50	250	45	87.8
9	50	200	60	79.5
9	50	250	30	81.7
9	40	200	60	80.5

Test-2: Using Phyllanthus emblica

Table 6: Turbidity removal by using Phyllanthus emblica

pH	Dosage (mg/L)	RPM	Time (min)	Turbidity Removal Efficiency (%)
5	40	100	45	83.7
5	50	100	45	92
7	50	100	45	88.5
7	50	200	30	86
7	50	250	45	85.2
7	50	200	45	86.7
7	40	100	30	90
9	50	200	60	84.5
9	40	250	60	80
9	50	100	30	78.9

Test-3: Using Cicer arientinum

Table 7: Turbidity removal by using Cicer arientinum

pH	Dosage (mg/L)	RPM	Time (min)	Turbidity Removal Efficiency (%)
5	50	100	60	87
5	50	100	45	90
5	30	250	60	84.3
7	50	100	60	87.5
7	40	200	30	85
7	50	200	45	81
7	40	250	30	83.8
9	50	200	60	80
9	50	250	30	85.5
9	50	250	60	80.9

E. Comparison of TDS removal using natural coagulants

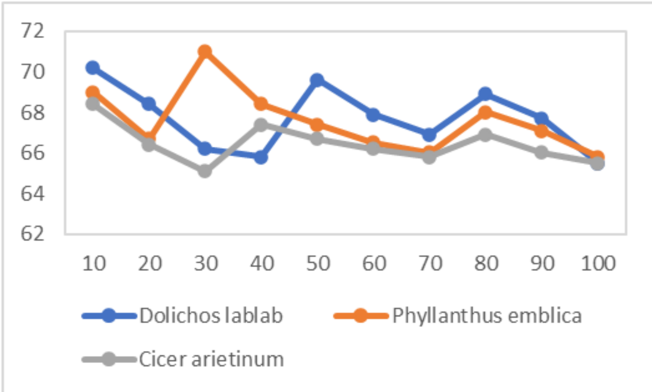

Chart-2: Comparison of Turbidity removal using natural coagulants

Among the three seeds tested—Phyllanthus emblica, Cicer arietinum, and Dolichos lablab—Phyllanthus emblica demonstrated the highest turbidity reduction, reaching up to 92.7% under optimal conditions (50 mg/L dosage, pH 7, 1 plate, 45 minutes). It consistently outperformed the other two seeds, particularly in neutral pH environments, making it the most efficient coagulant across a range of conditions. Dolichos lablab closely followed with 89.1% turbidity reduction at a similar dosage and pH level but with a shorter contact time (30 minutes). This indicates that Dolichos lablab is a strong alternative in situations where faster coagulation is required with neutral pH, though it slightly lags behind Phyllanthus emblica in overall effectiveness.

IV.CONCLUSIONS

Based on jar test experiments comparing Dolichos lablab, Phyllanthus emblica (Indian gooseberry), and Cicer arietinum (chickpea), Phyllanthus emblica emerged as the most effective natural coagulant for water treatment. Under optimal conditions (dosage of 50 mg/L, pH 7, plate number 1, and contact time of 45 minutes), it achieved a turbidity reduction of 92.7% and a TDS reduction of 69.2%.

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Dolichos lablab showed good performance at neutral pH with a higher dosage (60 mg/L), a stirring time of 45 minutes, and an Rpm of 200, achieving turbidity and TDS reductions of 82.5% and 65.6%, respectively. Cicer arietinum was effective at a higher pH (9) with a dosage of 40 mg/L, a stirring time of 60 minutes, and an Rpm of 250, achieving a turbidity reduction of 75.4% and a TDS reduction of 59.5%. Phyllanthus emblica's superior performance in reducing turbidity and TDS suggests its potential as a sustainable alternative in water treatment processes. Future research should explore its scalability, cost-effectiveness, and long-term stability in large-scale applications, as well as compare it with other natural and synthetic coagulants to optimize water treatment efficiency

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