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ECO FRIENDLY BIO- COAGULANTS FOR INDUSTRIAL AND KITCHEN WASTE WATER TREATMENT

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Abstract - *Rapid urbanization and industrial growth have increased wastewater generation, creating a need for effective and sustainable treatment methods. Textile dye wastewater is difficult to treat due to its high color and complex composition, while kitchen wastewater contains organic matter, oils and grease that increase pollution levels if not properly treated. This study evaluates natural bio-coagulants Neem leaves (Azadirachta indica), Moringa (Moringa oleifera), and Date seeds (Phoenix dactylifera) for wastewater treatment using jar test experiments. The results showed improvement in key parameters such as turbidity, pH, TDS and BOD with best performance at 0.6 mg/l. The study concludes that these materials are cost-effective, eco-friend and suitable alternatives to chemical coagulants.*

Key Words: **Textile dye waste water, Kitchen waste water, Neem leaves, Moringa leaves & seeds, Date seeds, turbidity, pH, Total hardness,EC, TDS and BOD**

1. INTRODUCTION

Water is an essential resource for human survival, environmental balance, and economic development. However, rapid industrialization, urbanization, and population growth have significantly increased wastewater generation from both industrial and domestic sources. Textile dye wastewater is difficult to treat due to its high color, turbidity, and presence of non-biodegradable chemicals, which affect aquatic life and reduce water quality. Kitchen wastewater also contributes to pollution as it contains organic matter, oils, grease, and microorganisms that increase biochemical oxygen demand (BOD) and cause environmental and health problems if discharged without proper treatment.

This study focuses on the use of natural bio-coagulants Neem leaves (Azadirachta indica), Moringa seeds and leaves (Moringa oleifera), and Date seeds (Phoenix dactylifera) as eco-friendly alternatives to chemical coagulants. These materials help in removing impurities through coagulation, adsorption, and antimicrobial action. Moringa improves floc formation, Neem reduces microbial content, and Date seeds enhance the removal of dissolved pollutants. The combined use of these materials increases overall treatment efficiency, making them a cost-effective, sustainable and environmentally friendly solution for treating textile dye and kitchen wastewater.

2. MATERIALS AND METHODS

2.1 Materials

A. Neem leaves

Neem (*Azadirachta indica*) leaves can be used as a natural coagulant to help treat water and wastewater. They are eco-friendly, biodegradable, and non-toxic. Neem leaves contain natural compounds like tannins, flavonoids, saponins and alkaloids that help remove impurities by binding particles together and allowing them to settle. In practice, the leaves are dried, ground into powder and mixed with wastewater, then left to settle so the impurities can separate from the water. Studies show that Neem can remove up to 80–90% of turbidity and reduce some heavy metals, making water cleaner. Although it may be slightly less effective than chemical coagulants for very fine particles, Neem is low-cost, sustainable and especially useful for rural or low-resource areas.

Fig 1: Neem leaves

B. Moringa leaves and seeds

Moringa oleifera seeds and leaves are commonly used as natural coagulants for water treatment because they are eco-friendly, biodegradable and low-cost. The seeds contain natural proteins that help bind suspended particles so they can settle out of the water, while the leaves contain bioactive compounds that help remove impurities through adsorption and particle bridging. This process helps reduce turbidity, remove pollutants and control some bacteria, improving water quality. Although slightly higher amounts may be needed for very polluted water, Moringa is a safe,

sustainable, and effective green alternative for water purification.

Fig 2: Moringa seeds and leaves

C. Date seeds

Date seeds (Phoenix dactylifera) can be used as a natural and eco-friendly coagulant for treating water and wastewater. They contain compounds such as proteins, polysaccharides, tannins and polyphenols that help remove impurities by binding particles together and allowing them to settle. Date seed powder can reduce turbidity, suspended solids, and some heavy metals in water. Compared to chemical coagulants, it is biodegradable, non-toxic, low-cost and easily available. It also produces less harmful sludge, making it a sustainable option for water treatment, especially in rural and low-resource areas.

Fig 3: Date seeds

2.2 Methods

A. Preparation of coagulant

Neem leaves were collected, washed with distilled water to remove impurities and air-dried under shade for four days to preserve their bioactive properties. The dried leaves were then ground into a fine powder and sieved through a 75-micron mesh for uniform size. Finally, the powder was stored in an airtight container to maintain its quality and prevent contamination.

Fig 4: Neem leaves powder

Moringa seeds and leaves were collected, washed with distilled water and air-dried under shade for four days to preserve their bioactive compounds. The dried material was ground into a fine powder and sieved through a 75-micron mesh for uniform size. Finally, the powder was stored in an airtight container to maintain quality and prevent contamination.

Fig 5: Moringa seeds and leaves powder

Date fruits were obtained from the local market and the seeds were separated, washed thoroughly with distilled water, and sun-dried for five days. They were then oven-dried at 105°C for 8 hours to remove moisture completely. The dried seeds were crushed into smaller particles and stored in an airtight container to maintain quality and prevent contamination.

Fig 6:Date seeds powder

B. Jar test

A jar test apparatus was used to carry out the coagulation experiments. It included three 1000 ml beakers placed on magnetic stirrers, which allowed different samples to be tested at the same time. Measured amounts of coagulants (0.4–0.8 mg/l per 100 ml of water) were added to the raw water in each beaker. The process started with slow mixing at 50 rpm for 15 minutes, followed by faster mixing at 150 rpm for 10 minutes to ensure proper dispersion. After that, slow stirring was continued again at 50 rpm for another 15 minutes to help floc formation. The samples were then left undisturbed for 30 minutes to allow the particles to settle. Finally, the clear upper layer (supernatant) was filtered and tested for various parameters such as pH, total dissolved solids (TDS), electrical conductivity (EC), turbidity, total hardness and (BOD).

3. RESULT AND DISCUSSIONS

Neem leaves, moringa leaves and seeds, and date seed powder play an important role in improving water quality by helping to remove different physicochemical parameters. These natural materials help reduce pH, total dissolved solids (TDS), electrical conductivity (EC), turbidity, total hardness and biological oxygen demand (BOD) making the wastewater cleaner and safer after treatment.

Table -1: Result of textile dye waste water before treatment

SI No.	Parameters	Before treatment results
1	pH	9.9
2	Turbidity	227 NTU
3	Total Hardness	250 mg/l
4	Electrical conductivity	2403 µS/cm
5	Total dissolved solids	950 mg/l
6	BOD	38.25 mg/l

The table 1 shows the characteristics of textile dye wastewater before treatment, indicating that the water is highly polluted and not suitable for direct discharge. The pH value of 9.9 shows that the water is strongly alkaline due to the chemicals used in textile processing, which can harm aquatic life. The turbidity of 227 NTU indicates a high amount of suspended particles and color in the water. The total hardness of 250 mg/l suggests the presence of dissolved minerals like calcium and magnesium. The electrical conductivity of 2403 µS/cm and total dissolved solids of 950 mg/l show that the water contains a large amount of dissolved ions and chemicals. In addition, the BOD value of 38.25 mg/l indicates a high level of organic pollution, which can reduce oxygen in water bodies and affect aquatic organisms.

Table -2: Result of Total hardness in textile dye waste water after treated with Neem leaves stock solution

SI No.	Concentration of stock solutions (mg/l)	Neem leaves stock solution
1	0.4	240 mg/l
2	0.6	220 mg/l
3	0.8	235 mg/l

Table -3: Result of Total hardness in textile dye waste water after treated with Moringa leaves & seeds stock solution

SI No.	Concentration of stock solutions (mg/l)	Moringa leaves & seeds stock solution
1	0.4	190 mg/l
2	0.6	120 mg/l
3	0.8	115 mg/l

Table -4: Result of Total hardness in textile dye waste water after treated with Date seeds stock solution

SI No.	Concentration of stock solutions (mg/l)	Date seeds stock solution
1	0.4	175 mg/l
2	0.6	155 mg/l
3	0.8	163 mg/l

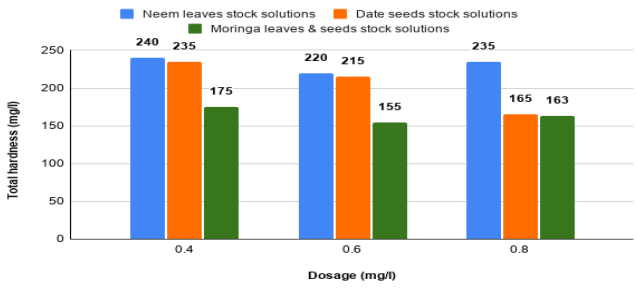

Fig 7: Graph showing Total hardness of textile dye waste water after treatment

Fig 7 shows how Neem leaves, Date seeds, and a mixture of Moringa leaves and seeds affect total water hardness at different dosages (0.4, 0.6 and 0.8 mg/l). The mixture of Moringa leaves and seeds showed the best result, with the lowest hardness value of 155 mg/l at 0.6 mg/l dosage, which means it removed more hardness-causing minerals from the water. This may be because Moringa contains natural proteins that help bind and remove calcium and magnesium ions. Date seeds also improved hardness removal as the dosage increased, reaching 165 mg/l at 0.8 mg/l. Neem leaves showed only small changes in hardness compared to the other treatments. The results indicate that Moringa works more effectively, especially at a moderate dosage.

4. CONCLUSIONS

The results show that bio-coagulant efficiency depends on the parameter considered. Moringa seeds and leaves were most effective in reducing pH (9.1%), turbidity (60%), and total hardness (35.4%), indicating strong coagulation ability.Date seed coagulant performed better in reducing electrical conductivity (17.5%) and TDS (34.3%), highlighting its effectiveness in removing dissolved substances. Moringa is more suitable for suspended impurities, while date seeds are better for dissolved contaminants. These natural coagulants are low-cost, eco-friendly, and suitable for irrigation reuse, making them sustainable alternatives to chemical coagulants like alum.

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