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# Effectiveness of alternative natural coagulants in the treatment of industrial wastewater

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**Abstract.** Inorganic coagulants, synthetic organic polymers and alternative natural coagulants are used to treat raw water into drinking water and in wastewater treatment. In this experiment, model dairy water and kaolin water were treated with four alternative coagulants. *Trigonella foenum-graecum* proved to be the best coagulant among the selected alternative coagulants.

## 1. Introduction

Safe drinking water is a basic need for health, and it must be purified before consumption no matter where it comes from. There are only a limited number of available water resources on the Earth. About 75 % of the current population lives in the developing countries. Approximately 1.2 billion of the population do not have access to safe drinking water, and more than 6 million children from developing countries die annually from the complications associated with eating disorders caused by unsafe water [1].

There are many ways to make the water safe for consumers. The chosen method of water treatment depends on the characteristics of the raw water. One of the processes used in water treatment is coagulation followed by sedimentation, filtration, and disinfection. The process of coagulation is important not only because of the removal of colloidal particles, but also for the removal of microorganisms which are often present together with other particles. While removing the turbidity, coagulants also remove pathogens contained in water, thereby improving water quality. There are many coagulants used for the treatment of raw water or wastewater. These are inorganic coagulants, synthetic organic polymers, and alternative natural coagulants.

Coagulation can be achieved using organic and inorganic coagulating reagents. Of these two groups, the organic agents *Strychnos potatorum* Linn, *Moringa oleifera* and *Opuntia ficus* have been long recognized in traditional water treatment, which is evident from historical sources [2]. On the other hand, the global spread of aluminium sulphate as a coagulant in public water treatment occurred only in the 19th century [3].

With the invasion of chemical coagulants on the market, organic coagulants ceased to be widely used. Currently, seeds of *Moringa oleifera* and *Strychnos potatorum* Linn are used primarily in agricultural and developing countries where the access to chemical coagulants is limited [4].

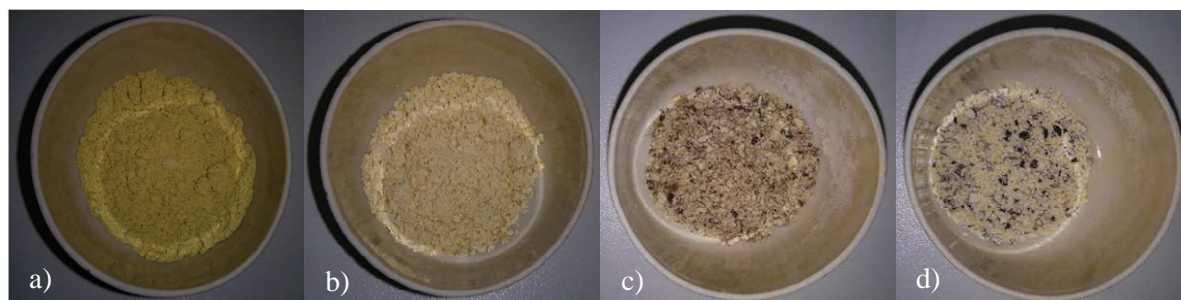
Alternative natural coagulants are today recognized as coagulants safe for human health, whereas aluminium salt-based coagulants are risky due to their neurotoxicity [5].



## 2. Material and Methods

The chosen natural coagulants for this study of the treatment of industrial wastewater are *Trigonella foenum-graecum* (Figure 1a), *Cicer arietinum* (Figure 1b), *Moringa oleifera* (Figure 1c) and *Dolichos lablab* (Figure 1d). These natural coagulants were purchased in local markets.

The dried seeds were ground to fine powder by a household blender. The powders were sieved through 1 mm sieve and stored in resealable plastic bags.



**Figure 1.** a) *Trigonella foenum-graecum*, b) *Cicer arietinum*, c) *Moringa oleifera*, d) *Dolichos lablab*.

Seed suspensions were prepared by mixing the seeds with distilled water. Two grams of ground seeds were placed in a volumetric flask and distilled water was added to make up 100 ml volume. From this stock solution, the given doses were subsequently dosed for coagulation tests [6].

The aluminium sulphate was chosen as an inorganic coagulant to compare the effects of coagulation between natural and inorganic coagulants.

### 2.1. Coagulation study

For the study of coagulation, a jar apparatus was used. The doses considered for the natural coagulants were taken and modified according to Patil and Hugar [7]. For treatment of synthetic wastewaters, the used dosages were 0.01 g, 0.02 g, 0.05 g, 0.1 g, 0.15 g and 0.2 g of ground seeds per 500 ml of synthetic wastewaters.

To treat synthetic wastewater by an inorganic coagulant, a 20% stock solution of aluminium sulphate was prepared and the used dosages for dairy synthetic wastewater were 6 ml, 12 ml, 17 ml, 26 ml, 29 ml, and 34 ml per 500 ml. For treatment of kaolin synthetic wastewater, the used dosages were 2 ml, 4 ml, 6 ml, 9 ml, 10 ml, and 12 ml per 500 ml.

The jar apparatus has six beakers and six steel paddles which help in the agitation process. The initial speed of agitation was 300 rpm for 2 min, followed by 40 rpm for 30 min. The settling time applied for this coagulation process was 60 min.

### 2.2. Preparation of synthetic wastewaters

In this study, synthetic dairy wastewater was prepared by adding plain yogurt to distilled water; suspension was prepared by mixing 750 ml of plain yogurt in 10 litres of distilled water. The resultant COD (Chemical Oxygen Demand) was 2700 mg/l [8, 9].

Synthetic kaolin wastewater was prepared by adding kaolin to distilled water, the stock kaolin suspension was prepared by adding 5 g of kaolin and 0.05 g hydrogen carbonate sodium into 1 liter of distilled water. This suspension was stirred at 20 rpm for one hour and then the suspension was left to stand for 24 hours so the kaolin completely hydrated. From this stock suspension was prepared working solution by adding 10 ml of stock suspension to 500 ml distilled water. The working solution had a resultant turbidity 14 FNU [10].

## 3. Result and Discussion

The physicochemical characteristics, such as alkalinity, turbidity, conductivity, COD, and dissolved particles were measured in untreated synthetic wastewaters and are given in Table 1. Alkalinity and turbidity were measured by handheld multimeter pH/Cond 340i. Turbidity was measured by HACH Lange DR 2800 spectrophotometer. COD was determined by potassium dichromate (modified

semimicromethod) and dissolved particles according to ČSN 75 7346 - Water quality - Determination of dissolved substances.

**Table 1.** Physical and chemical characteristics of untreated synthetics wastewaters.

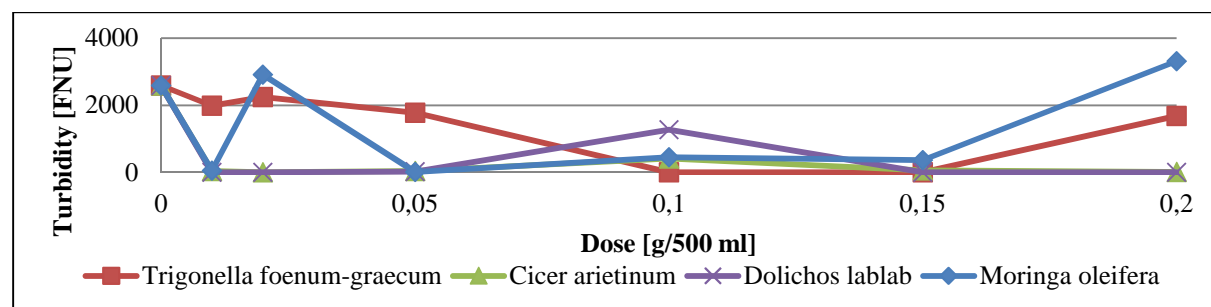
Physicochemical characteristics	Synthetic dairy wastewater	Synthetic kaolin wastewater
pH (-)	6.7	7.1
Turbidity (FNU)	2592	148
Conductivity ( $\mu\text{S}/\text{cm}$ )	298	206
COD (mg/l)	2748	-
Dissolved particles (mg/l)	-	364

### 3.1. Efficiency of natural coagulants

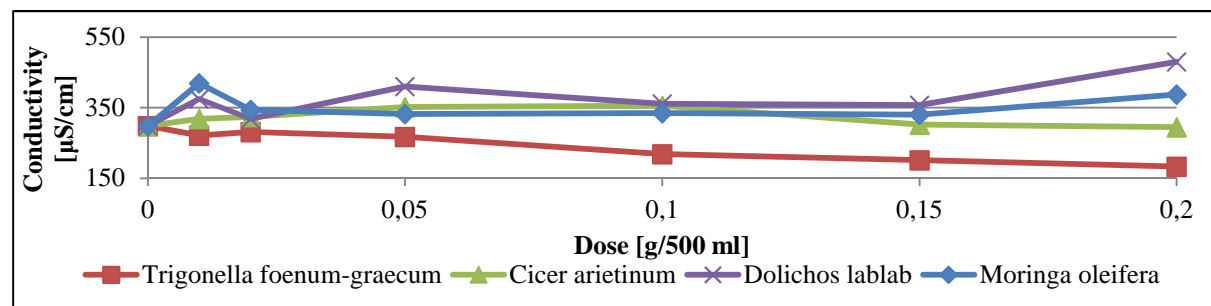
The efficiency was evaluated based on the ability of coagulants to remove physical and chemical characteristics from synthetics wastewaters. The values shown in the following tables are the average values of triple measurements.

The most effective alternative coagulant agent proved to be *Trigonella foenum-graecum*, which at its optimal dose 0.1 g/500 ml in synthetic dairy wastewater reduced the turbidity value by 99 % (Figure 2), the conductivity value by 86 % (Figure 3) and at the same time the COD value dropped by 26 % (Figure 4).

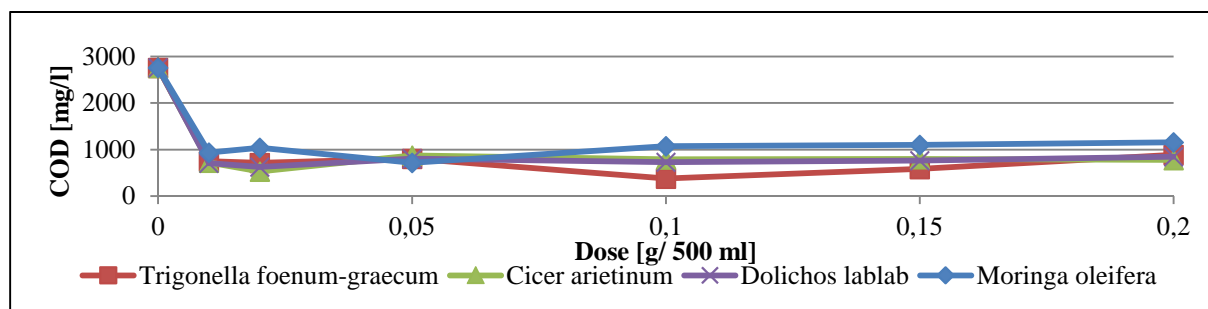
As can be seen in Figure 2, with dose 0,2 g/ 500 ml of *Moringa oleifera*, turbidity value raised. We think this occurred because there are too many solids non-settable by gravity. This is supported by the raised conductivity value (Figure 3) at the same dose of *Moringa oleifera*.



**Figure 2.** Comparison of turbidity in the model dairy wastewater filtrate using alternative coagulants.

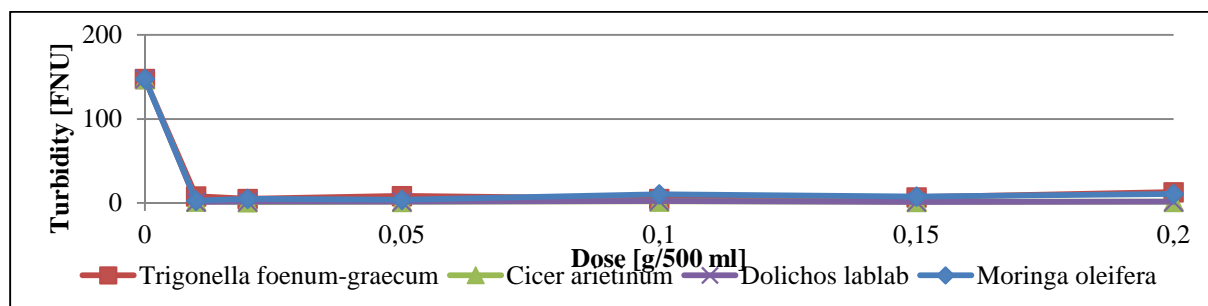


**Figure 3.** Comparison of conductivity in the model dairy wastewater filtrate using alternative coagulants.

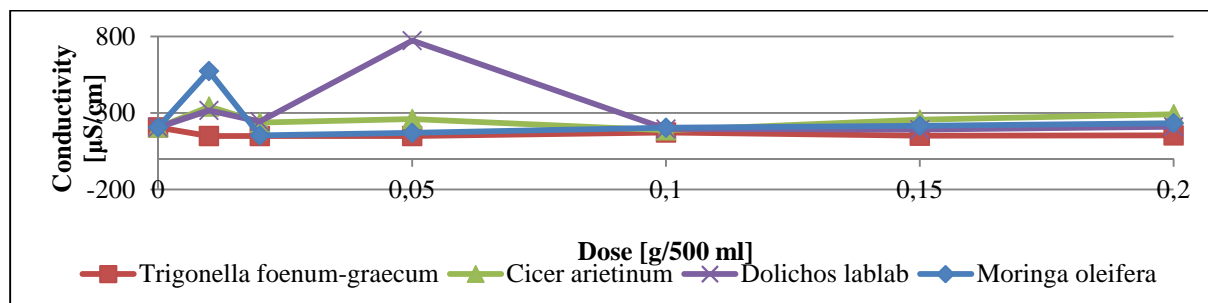


**Figure 4.** Comparison of COD value in the model dairy wastewater filtrate using alternative coagulants.

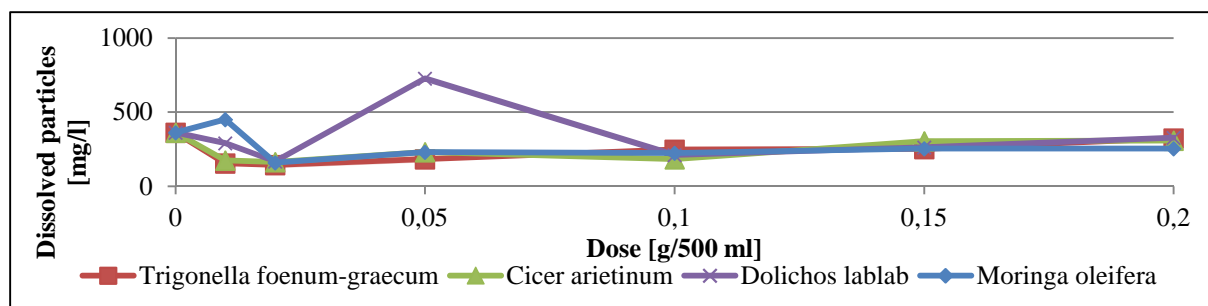
The most effective alternative coagulant agent proved to be *Trigonella foenum-graecum*, which at its optimal dose 0.02 g/500 ml in synthetic kaolin wastewater reduced the turbidity by 96 % (Figure 5), the conductivity dropped by 60 % (Figure 6), and this coagulant also reduced the conductivity by 28 % (Figure 8).



**Figure 5.** Comparison of turbidity in the model kaolin wastewater filtrate using alternative coagulants.



**Figure 6.** Comparison of conductivity in the model kaolin wastewater filtrate using alternative coagulants.



**Figure 7.** Comparison of dissolved particles in the model kaolin wastewater filtrate using alternative coagulants.

### 3.2. Efficiency of inorganic coagulant

During the clarifying process with model dairy water, the coagulant aluminium sulphate was able to remove 98 % of turbidity value and decreased COD by 81 %. In the process with model kaolin water, the inorganic coagulant reduced turbidity by 99 % but increased the number of particles in the solution by 15 %.

### 4. Conclusion

The most effective alternative coagulant was *Trigonella foenum-graecum*, which, at its optimal dose 0.02 g/500 ml in synthetic kaolin wastewater, reduced the initial values of the turbidity, dissolved particles, and conductivity by 96 %, 60 %, and 28 % respectively.

In synthetic dairy wastewater, the optimal dose of this natural coagulant (0.1 g/500 ml) reduced the turbidity, COD, and conductivity by 99 %, 86 %, and 26 % respectively.

The experiments showed that the alternative coagulants can reduce the value of turbidity, dissolved particles, COD, and conductivity in the selected model waters to at least same levels as those reached by commonly used inorganic coagulants.

Subsequent research can be focused on the use of alternative coagulants on samples of real industrial wastewater.

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