Treatment of Synthetic Turbid Water by using Natural Tamarind Seeds

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Abstract. This study is done to find the alternatives to solve the water pollution problem. The common ways to treat polluted water is by using alum. However, the usage of alum as conventional coagulant had caused the formation of sludge that can pollute the water and also cause illness. Tamarind seed was chosen as the alternative because it is naturals, non-toxic, and 100% biodegradable sources. In this study, the research was done in two parts, there are tamarind seed extraction by using different extraction solutions and the jar test. The extraction solution that was used were sodium chloride, potassium chloride and distilled water. In jar test, synthetic turbid water with turbidity range from 200 to 220 NTU was used to determine the effectiveness of tamarind seed as natural coagulant. Form the results obtained, sodium chloride extract achieved the highest percentage or turbidity removal with the percentage 91.32% with the dosage 25mg/L at pH 6, while the distilled water extract obtained the lowest percentage of turbidity removal with the percentage 56.60 % with the dosage 30mg/L at pH 3. As a conclusion, tamarind seed can be used as a natural coagulant in the treatment of polluted water.

1. Introduction
All human activities and nature are dependent on water. Water is very important because it is needed for life to exist. Water is used in many aspects of life for example, in agricultural, household and environmental activities. Nowadays, water demand already exceeds supply in many parts of world. Water covered almost 70% of the earth. The quality of fresh water that is safe to use is lessen each day. Under the extreme condition, lack of water intake can cause death in a few days, but in comfortable surroundings, human can survive for a week. A human can survive for more than three weeks with food, but human cannot survive that long without water. Water made up the human body for at least 60% of it, and it is very crucial to regularly consumes water to ensure every living cell in the body functioning well. Not only humans who need to consumes water, the animal and ecosystem also need water to survive. Our daily activities like cooking and cleaning, also the industries are using a lot of clean water.

Coagulation is a condition or process where the random motions of particles cause them to collide and coalesce to form larger chain of flocks made up of many particles [1]. The existence of a shear field, the thermal motion of particles and the external forces such as electrical forces and gravity could cause coagulation. Chemical reactions are often imperfect. In wastewater, there are countless side reaction with other substances. Coagulation is the most common and wide method used to treat wastewater. This technique varies with various factors like temperature, dosage and pH [2]. It has been broadly utilized for different field of waste water treatment such as mash factory wastewater, material wastewater, oil plant profluent, sleek wastewater and others. There are four basic mechanisms involved in this process which are double layer compression, charge neutralization, sweep flocculation and adsorption [3].
In this study, tamarind seed (*Tamarindus indica* L.) was used as the naturals coagulants to treat the synthetic turbid water which will reduce the turbidity of the synthetic turbid water. The experimental studies were run by manipulating a single variable or factor while the other factors are fixed. The pH, coagulant dosage of the tamarind seeds and the sedimentation time are the factors that have been chosen to be implemented in this method.

2. **Material and method**

2.1. **Preparation of tamarind seeds powder**

In this experiment, tamarind seeds were used as the natural coagulant. The sources of tamarind seeds were taken from Kampung Padang Benta, Simpang Empat, Perlis. The tamarind seeds that have been collected were cleaned and dried at room temperature. The seeds then were dried in an oven for about 8 hours at 50 °C. The dried seed were ground by using a ball mill for an hour. After that, the grounded seed were sieved through 0.4 mm sieve and stored in air-tight container. For the preparation of the active component extracted from tamarind seeds, the first step done was weighing the amount of tamarind seeds to prepare different dosages of coagulant. 0.5 mg, 1.0 mg, 1.5 mg, 2.0 mg, 2.5 mg, 3.0 mg, and 3.5 mg of the grounded tamarind seed was weighed and each amount was mixed with 100 ml of 1.0 M sodium chloride (NaCl) solution, distilled water, and potassium chloride (KCl) solution accordingly. The mixtures were stirred for an hour at 750 rpm to obtained maximum blending and thorough mixing, and were filtered using Whatman filter paper no-1 [4].

2.2. **Sampling of synthetic turbid water**

Turbid water was prepared in UniCITI Alam Laboratory by mixing kaolin with distilled water. Same amount of kaolin was used to produced same turbidity level which was one milligram (mg) into one liter of distilled water. The solution contains kaolin suspension is then stirred at certain speed for some time to achieve a uniform suspension of the kaolin particles. To ensure the complete hydration of the kaolin, the suspension was permitted to stand for 24 hours.

2.3. **Jar test**

A specific apparatus was used to run the experiments namely the Jar Test apparatus. Jar test is the most commonly used coagulation - flocculation experimental methods. NaOH and HCl was used to adjust the pH the pH sample [5]. To coagulate samples of synthetic turbid water using some coagulants, a conventional jar testing device was set. It was run as a batch test and is suitable for a series of six beakers with six steel spindles. The sample was mixed homogenously before the jar test was performed. The turbidity of all the samples were measured. Beakers will be filled with coagulants of various concentrations. The entire procedures were performed at varying speeds in the jar test.

3. **Results and discussions**

3.1. **Kaolin Water Characteristics**

Kaolin water was prepared in the laboratory as synthetic turbid water used in this study. The level of turbidity of the synthetic water was low, as it was prepared by using 1-gram kaolin into 1000 ml distilled water. The pH of the synthetic water was slightly acidic which is around 6.5. The turbidity of synthetic turbid water used in the study range from 210 NTU to 220 NTU. The synthetic water was stored to completely dehydrated at room temperature for 24 hours before used. Synthetic turbid water was used because it is easier to control the desired turbidity level to be used in the test [4].

3.2. **Tamarind seeds characterization**

The prepared tamarind seeds powder was analyzed using FTIR spectroscopy to identify the surface functional group present in the tamarind seed particularly, the functional groups that can improve the mechanisms of coagulation process. The observation of spectra for dried tamarind seed is illustrated in Figure 1 shows a range of frequency between 400 cm−1 and 4000 cm−1. The broad absorption band at 3349.17 indicates the presence of -OH functional group. These can prove the theoretical chemical structure of tamarind seed consists of polysaccharide polymers of glucose, xylose and galactose. These
structures are known to be responsible for the presence of -OH functional group in tamarind seeds. The spectrum of carboxylic acid represented by two absorption band. The first band is at the peak 1531.66 cm$^{-1}$ with a C-O stretching vibration and the second band is 1639.03 cm$^{-1}$ with C=O stretching vibrations. A sharp band occurs at peak of 2928.04 cm$^{-1}$ because of the C-H stretching vibrations. These functional groups contain properties that can induced the process of coagulations for tamarind seeds.

![Figure 1. FTIR characterization of tamarind seeds.](image)

3.3. Coagulation Performance Evaluation

3.3.1 Effect of Coagulation Dosage. The dosage used for tamarind seed extraction solutions, sodium chloride, potassium chloride and distilled water range from 5 mg/L to 35 mg/L. In order to determine the optimum dosage, the pH value is kept at constant value at pH 7.48 throughout the experiment. The seed extract is prepared prior to the jar test experimental to avoid the ageing effect. The effect of dosage of the seeds extract of sodium chloride, potassium chloride and distilled water is shown in Figure 2. The percentage removal for turbidity showed fluctuate trend along the experiment. The highest percentage removal for extraction solution sodium chloride (NaCl) was 91.32% at the dosage 20 mg/L. The graph showed a declining pattern afterwards might be based on the amount of dosage applied on. Before reaching the highest percentage removal, the dosage used is not sufficient enough to remove all the contaminants and lead to an incomplete coagulation process [4]. The coagulant need to be added until it reached the optimum dosage. However, the further increased of coagulant dosage can cause the overcrowding of the coagulants [6]. This phenomenon can limit the amount of adsorption sites available for particle bridging.
Based on Figure 2, by using potassium chloride, the highest turbidity removal percentage is at 75.92 % at dosage 25 mg/L. The results also fluctuate along the tests, and after turbidity removal reached the highest percentage, the results keep declining. The reason for the declining results is also due to the amount of dosage applied, where too much coagulant causes the overcrowding. For extraction by using distilled water, the highest percentage removal reached to 54.72 %, where the dosage used is about 30 mg/L. Sodium chloride showed a great ability to remove turbidity at higher percentage [4].

3.3.2 Effect of pH. The analysis was applied again to analyze the effect of pH on coagulation process. In this study, the optimum coagulant dosage was used throughout the experiment. Based on Figure 4.3, the highest percentage for removal turbidity for sodium chloride is at pH 6, which 92.01 %, potassium chloride is at pH 6, where the percentage is 76.89 % and for distilled water, the highest turbidity removal is at pH 3, where the percentage removal is 56.60%. higher value pH (alkaline condition) will decrease the ability of the coagulant dosage to remove turbidity. This is because the nature of coagulant itself is negative surface charge so, efficient turbidity removal can only occur when the opposite surface charges are present to allow the binding between molecules [7].
Figure 3. Comparison graph for the turbidity removal percentage for different pH of sodium chloride, potassium chloride and distilled water.

4. Conclusion
In this study, the treatment of synthetic turbid water using tamarind seeds as coagulant is successfully conducted. Three extraction solutions were used to extract the active component in the tamarind seed that can induce the performance of the coagulant itself. When NaCl was used as the extraction solution, 91.32 % are achieved for the percentage removal of turbidity. The optimum condition achieved is at 25 mg/L at pH 6.0. In comparison, the use of KCl at optimum dosage of 25 mg/L and optimum pH 6.0 resulted as 76.87 % percentage removal. As for distilled water, the best dosage is at 30mg/L, while the best pH for turbidity removal using distilled water is at pH 3 with the percentage about 56.60%. Hence, it can be suggested that tamarind seed using NaCl as extraction solution can be proposed as the effective natural coagulant that are safe to be used as it is safe to be used without causing serious health problem or major effect to the environment.

References
[1] Masliyah J.H, and Bhattacharjee J 2005 Coagulation of Particles, Electrokinet. Colloid Transp. Phenom 1 427–467.
[2] Maurya S, and Davreay A 2018 Evaluation of plant-based natural coagulants for municipal wastewater treatment biotech 8 1–4.
[3] Aboulhassan M.A, Souabi S, Yaacoubi A and Baudu, M 2006 Removal of surfactant from industrial wastewaters by coagulation flocculation process Int. J. Environ. Sci. Technol. 3 327–332.
[4] Emiliah J, Christy J.J, Anantharaj R, Ambedkar B and Dhanalakshmi, J 2017 Treatment of Synthetic Turbid Water using Natural Tamarind Seeds at Atmospheric Condition., Res. J. Pharm. Biol. Chem. Sci. 352–359.
[5] Aziz H.A, Yii Y.C, Syed Z.F.S.S, Ramli S.F and Akinbile C.O 2018 Effects of using tamarindus indica seeds as a natural coagulant aid in landfill leachate treatment Glob. Nest J. 20 373–380.
[6] Jeyakumar P 2014 Purification of pond water by natural seeds and dye water by synthetic coagulant J. Chem. Pharm. Sci. 4 50–51.
[7] Wolf G, Schneider R.M, Bongiovani M.C, Morgan E, Uliana and Garcia Do Amaral A 2015 Application of coagulation/flocculation process of dairy wastewater from conventional treatment using natural coagulant for reuse Chem. Eng. Trans. 43 2041–2046.

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