

The Potential of Natural Coagulants for Turbidity Removal

(Potensi Koagulan Semulajadi dalam Penyingkiran Kekeruhan)

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Abstract

The use of potassium alum as a synthetic coagulant to clarify turbid water in the water treatment plant is widely recognized. However, the dirtier the water, the more volume of alum is needed in the water treatment plants. The large volumes of alum or other chemical substances to treat water may pose a potential risk to human health and high processing cost in water treatment plants. Therefore, this study aims to investigate the potential of natural coagulants as a substitute for chemical turbidity removal. Natural coagulants such as Tamarind Seed, Lime Seed, and Banana Peel were used to replace chemicals in treating turbid water. The dosage used ranges between 10 mg/L to 40 mg/L for all coagulants. The artificial turbid water in this study was produced using kaolin powder, which was adjusted to 100NTU. Conventional jar test apparatus was used to test the efficiency of the natural coagulants. The test result shows that the natural coagulants successfully reduced the turbidity of the turbid synthetic water. From the findings, the turbidity removal efficiency of tamarind seed, lime seed, and banana peel is 42.5%, 34.2%, and 36.9% respectively. Tamarind seed shows better coagulation and turbidity removal compared to banana peel and lime seed. Adding natural ingredients instead of chemicals in the water treatment process offers a cost-effective, environmentally friendly, and sustainable alternative. Moreover, the usage of this natural coagulant could help in reducing the chemical waste product to the environment, which is usually produced when using chemicals. Therefore, natural coagulants have the potential to reduce the level of turbidity in water.

Keywords: Natural coagulant, turbidity, water treatment, wastewater

INTRODUCTION

Aluminium Sulfate and Calcium Carbonate are commonly used as chemical substances to remove turbidity in the water treatment process. In most cases, these are expensive and not cost-effective because they are required in high doses. These substances were reported to cause severe problems to human health and environmental problems if the concentration is not properly controlled (Latheef, Saheed, Basheer, & Johnson, 2008). Therefore, the best alternative is to develop a cost-effective, easier, and environmentally friendly process of water clarification.

Natural organic polymers have been used as coagulants in high water turbidity for over 2000 years, especially in highly populated countries such as India, Africa, and China. The natural coagulant was produced from plant seeds, leaves, and roots (Latheef et al., 2008). The advantages of selectivity of these natural coagulants used are less harmful to human health and cost-friendly due to their abundance of sources. Natural coagulants were suggested as an excellent substitute for chemical coagulants by many researchers because of their easy availability, low price, environment friendly, multifunction, and biodegradable nature in water purification. Three possible coagulants were selected for this study, which are Tamarind Seed, Lime Seed, and Banana Peel.

The present study aims to investigate the potential of this selected natural coagulant to reduce the level of water turbidity. Turbidity is one of the physical properties in water quality testing which describes the clarity or cloudiness of water. High water turbidity will affect the aquatic ecosystems, where lessen sunlight dispersion and this indirectly will reduce the oxygen concentration as it will also affect photosynthesis. This will eventually affect the reproduction of aquatic life such as fish and plants. Besides that, suspended particles in high water turbidity will contributed to the adhesion of heavy metals and toxic chemicals. Therefore, high turbidity in water indicates the low quality of water.

METHODOLOGY

Experimental action research will be used as a methodology for this study, where natural resources such as tamarind, banana, and lime as coagulants in the water treatment process will be used. The natural coagulants were obtained from the local market and the local farmers donate some. The natural coagulants are then processed into powder to make it easier to produce the extract. All the experimental procedures were conducted in the Water Quality Laboratory of Politeknik Kuching Sarawak. The jar test apparatus was set up in the experiment to determine the optimum dosage of natural coagulants used in this study. Turbidity was measured using a turbidity meter and expressed in Nephelometric Turbidity Units (NTU).

PREPARATION OF NATURAL COAGULANTS

Tamarind Seed

Tamarind fruit is bought from the local market and the good quality seeds were taken out manually and cleaned to take out the pulp that is still clinging to the seed. The Tamarind seeds were dried in an oven for about 2 hours at 100 °C. The dried seeds are then grounded using a kitchen blender until desired texture is achieved. The grounded seeds were sieved through a 0.4mm sieve pore size and stored. A half-gram (0.5g) of the grounded tamarind seed powder is weighed and mixed with 100 ml of distilled water. The mixture is stirred for about 1 hour at 120 rpm for maximum blending and filtered using filter paper. The picture of the tamarind seed solution is shown in Figure 1. This extract (filtrate solution) is used for coagulation studies.



Figure 1. Preparation of tamarind seed stock solution



Figure 2. Weighing dried banana peel



Figure 3. Preparation of banana peel stock solution

Banana Peel

Bananas (*Musa Acuminata* species) were obtained from some local farmers and the peels are collected. The procedures of preparing the coagulant were done in line with the procedure described by (Zurina et al., 2014). The banana peels were washed with water to remove any impurities and rotten peels. Then, cut it into small pieces of size ranging from 0.5 to 0.6 cm. The cleaned peels were then dried using the oven for 2 hours at 100°C. Then, 11.6g of the cut and dried banana peels were soaked in 100 ml of distilled water. It was then stirred using flocculator for 1 hour at 120 rpm. Finally, the mixture is filtered using filter paper to get the banana peel extract. The preparation of the Banana Peel extraction process is shown in Figure 2 and Figure 3.

Lime Seed

The lime seeds were obtained by slicing the lime fruit using a clean knife. The good quality lime seeds were dried using the oven for 2 hours at 100°C. About 50g of lime seeds were grounded into a fine powder using a kitchen blender. The powder was sieved through a 0.4mm sieve and only particles that passed through the 0.4mm sieve were used. About 6.3g of the seed powder was then mixed with 100 ml of distilled water. The mixture is stirred for about 1 hour at 120rpm for maximum blending. It is then filtered to obtain the

extract for coagulation studies. The preparation of the Lime Seed Stock solution process is shown in Figure 4 and Figure 5.



Figure 4. Weighing lime seed powder



Figure 5. Preparation of lime seed powder stock solution

SYNTHETIC TURBID WATER SAMPLES PREPARATION

The synthetic turbid water was prepared by adding about 30g of Kaolin to 1 liter of tap water. The mixture was stirred for about 1 hour at 20 rpm to achieve a uniform dispersion of Kaolin particles as shown in Fig. 6. The mixture was left to settle for 24 hours for a complete hydration process. The water sample was prepared by diluting the kaolin synthetic stock solution to 6 liters of tap water into the pail where the stock suspension was added little by little until the desired turbidity is achieved. A turbidity meter was used to measure the water turbidity until it reached initial turbidity of 100NTU.



Figure 6. Preparation of synthetic turbid water

JAR TEST PROCEDURE

The coagulation process was performed using Jar Test Apparatus. In this experiment, the synthetic turbid water samples were poured into 4 beakers of 1000 ml with a volume of 500 ml each. The tamarind seed extracts were added to the 4 beakers with dosages ranging from 10 ml to 40 ml respectively as shown in Fig. 7. The mixtures then stir for 2 minutes at 100 rpm and reduce to 40 rpm for 15 minutes using two-spindle steel paddles with flocculation equipment. The mixtures were left to settle for another 15 minutes. The turbidity of the settled samples was measured 3 times using a turbidity meter and only mean values are recorded. The same experiment procedures were then repeated using banana peel extract and lime seed extract. The effectiveness of the natural coagulants

was evaluated by measuring the removal of turbidity and coagulant doses in synthetic turbid water.



Figure 7. Coagulation experiments

RESULTS

Dosage is a vital parameter in the process of water treatment where the determination of the optimum condition for the coagulant agent to function well can be identified. Poor performance results if less dosage is used or overdosing. Optimum dosage determination is very important as it would help to reduce the cost and sludge formation in the water treatment process. Table 1 and Table 2 show the result of final turbidity in NTU and percentage while Figure 8 shows the effect of coagulant dose on turbidity removal.

Table 1. Final turbidity value of samples

The dosage used (mg/L)	Coagulants		
	Tamarind Seed (NTU)	Banana Peel (NTU)	Lime Seed (NTU)
10	62.2	63.1	65.8
20	62.1	64.8	67.7
30	58.4	68.5	70.5
40	57.5	72.9	70.3

Note: *NTU Nephelometric Turbidity Units

Table 2. Percentage of turbidity removal of samples

The dosage used (mg/L)	Coagulants		
	Tamarind Seed (%)	Banana Peel (%)	Lime Seed (%)
10	37.8	36.9	34.2
20	37.9	35.2	32.3
30	41.6	31.5	29.5
40	42.5	27.1	29.7

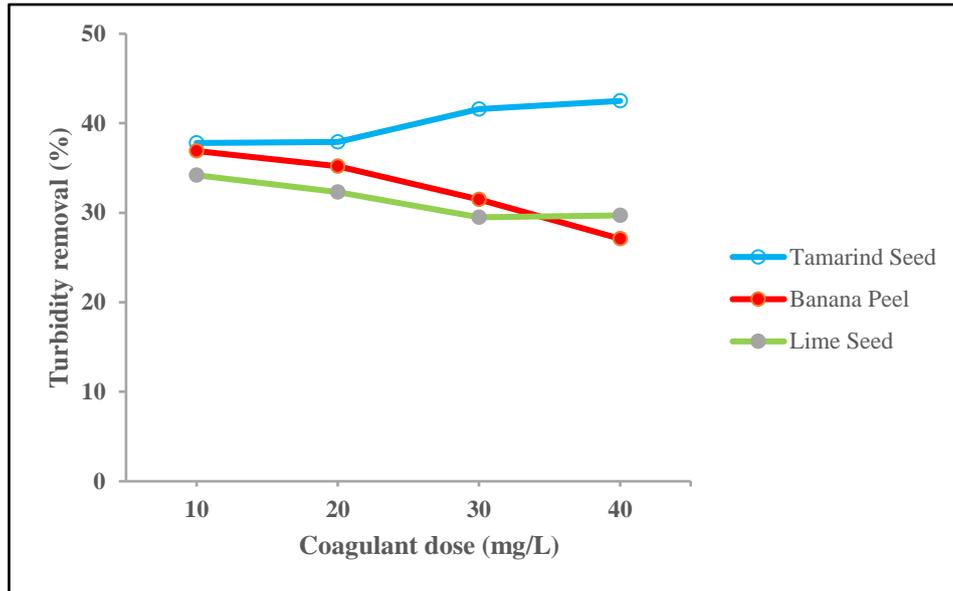


Figure 8. Coagulant dose versus percentage of turbidity removal

Initially, the turbidity removal efficiency for all coagulants was reported to have increased when the coagulant dosages were increased. The highest turbidity removal efficiency for tamarind seed was recorded at 42.5% with a dosage of 40mg/L while 37.8% was the lowest removal efficiency of turbidity with the dosage of 10mg/L but still achieved the highest removal efficiency of turbidity among the banana peel and lime seed. As for the tamarind seed, when the dose of the coagulant increased, the efficient removal of turbidity also increased. This shows that the process of coagulation is much influenced by the dosage of the coagulant. This supported that the amount of dosage used is sufficient enough to remove the turbidity.

As for the banana peel, the result showed that the highest turbidity removal efficiency was recorded at 36.9% with a dosage of 10 mg/L compared to a dosage of 40 mg/L which only achieved 27.1% removal efficiency of turbidity. Gradually, the turbidity removal efficiency declines when increasing the dosage to 20 mg/L and above. The reduction in efficiency removal of turbidity might be because banana peels consisted of polymeric substances such as fiber (11.04%) and protein (10.14%) according to (Memon et al., 2008). Various peaks of different functional groups such as carboxylic acid (C=O), hydroxyl (-OH) and aliphatic amines (N-H) were detected in the polymeric substances which indicated the presence of both positively and negatively charged. These charges might be responsible for stimulating coagulation-flocculation by neutralizing both charged impurities in water (Thirumavalavan, Lai, & Lee, 2011).

This decreasing trend also can be seen for lime seed extract where the declining lines showed up at a dosage of 20mg/L until 40mg/L. The coagulation activity did not run efficiently at a coagulant dose of more than 20mg/L because of the failure of the floc formation. Even though in some cases, the process of coagulation is much influenced by the dosage of the coagulant, however overdosing on coagulants may inhibit the reaction between coagulant and colloidal particles. Overdosing of coagulants may contribute to the unsteady colloidal particle's reaction and reversal of charge (Priyatharishini, Mokhtar, & Kristanti, 2019). The amount of dosage used is not sufficient enough to remove the turbidity and leads to an incomplete coagulation process (Emilia Christy, 2017). The coagulant needs to be added until it reached the optimum dosage. Another factor that can contribute to the high removal efficiency of turbidity is the use of an effective solvent for extraction. The use of this solvent is to extract active components in the natural coagulants which can induce the performance of the coagulant. In the previous study, it was mentioned that NaCl was the most effective solvent for extracting active components

compared to other solvents such as distilled water and NaOH (Zurina, Mohd Fadzli, & Abdul Ghani, 2014). This was in line with the result obtained for the removal efficiency of turbidity in this study.

CONCLUSION

The test result shows that the natural coagulants successfully reduced the turbidity of the turbid synthetic water. From the findings, the turbidity removal efficiency of tamarind seed, lime seed, and banana peel is 42.5%, 34.2%, and 36.9% respectively. Tamarind seed shows better coagulation and turbidity removal compared to banana peel and lime seed. Adding natural ingredients instead of chemicals in the water treatment process offers a cost-effective, environmentally friendly, and sustainable alternative. Moreover, the usage of this natural coagulant will promote a healthy environment by reducing the chemical waste product to the environment. Therefore, the finding from this study concludes that natural coagulants of tamarind seed, banana peel, and lime seed have the potential to reduce the level of turbidity in water.

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