TURBIDITY REMOVAL USING FRUIT SEEDS AS A NATURAL COAGULANT

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ABSTRACT

In this study, natural coagulant solutions from rambutan, sugar-apple and jujube seeds were prepared by chopping, grinding, drying and combining with suitable inorganic solvents (NaOH, NaCl, distilled water). Influent factors such as pH of water, dose of fruit seed and solvents to extract were studied to examine the efficiency of turbidity removal with synthetic turbid water by Jar test. The curve of turbidity removal for fruit seeds are rather different compared to that of poly aluminum chloride (PAC). The lower the pH, the higher the efficiencies of three fruit seeds are. At pH = 3, 20 mg/L of coagulants from jujube seeds and at pH = 4, 20 mg /L of coagulants from rambutan and sugar-apple seed are the optimal condition for synthetic turbid water treatment. Under optimal condition of coagulants from jujube, rambutan and sugar-apple seeds the turbidity removal efficiency is 83%, 89% and 86%, respectively. This reveals a potential application of these natural coagulants for water treatment.

Keywords: *Natural coagulants; fruit seeds; turbidity removal; rambutan; sugar-apple and jujube.*

1. INTRODUCTION

Water is an indispensable resource in our lives, and people need it to maintain their living activities and daily activities. Water is necessary in the industrialization and development of humankind. Although water makes up half of the Earth's surface, the amount of clean water for humanity is limited. According to some studies, in the future, people would live in the lack of freshwater. Therefore, water treatment is always a top concern. There are many different methods of water treatment: sedimentation, filtration, adsorption, microbiological treatment, etc. To achieve high efficiency, a variety of chemicals are applied for the treatment process, which not only high cost and but also increasing pollutants into the water.

One of the methods using large amounts of chemicals is coagulation - creating flocs. Coagulant chemicals with charges opposite those of the suspended solids are added to the water to neutralize the negative charges on non-settleable solids [1]. Commonly used coagulants are alum aluminum $Al_2(SO_4)_3$, iron alumina $FeSO_4$ or $FeCl_3$ and PAC (Poly Aluminum Chloride) [2]. According to some studies, the use of chemical coagulation has increased the amount of metal in the water source, which is harmful to human health [3]. Therefore, the research for environmental – friendly coagulants is very necessary. Previous research shows some coagulants have been proven to be good natural coagulants such as catus [4], Moringa Oleifera [5], dragon fruit Foliage [6], chestnuts [7] and fruit seeds [8], Cassia fstula [9].

In this study, rambutan *(Nephelium lappaceum)*, sugar-apple (*Annona squamosal)* and jujube (*Ziziphus jujube*) seeds were used as natural coagulants to remove the turbidity of water. These fruits are three of the popular seasonal fruits in the south of Vietnam. Those seeds are also an waste. In addition, influent factors such as pH, dose of coagulants for water treatment

were also examined in case compare to common chemical coagulants.

2. METHODS

2.1. Preparation of natural coagulants from fruit seeds

The fruit seeds were washed with water and dried at 105^{o}C in 6 hours. After drying, the seeds were pre-grinded and continue to dry at 105°C in 1 hour to completely remove residual moisture. The seeds after that were fine grinded. Seed powder was stored in a cool environment (5^{o}C).

To prepare the coagulation solution, 0.5g seed powder was added into 100 mL three different kind of solvents (NaOH 0.1N, NaCl 0.1N or distilled water) [10]. The mixtures were shaken 150 rpm in 15 minutes to extract the active ingredients of the fruit seeds. These suspensions were filtered through paper filter to extract the coagulants.

2.2. Preparation of synthetic turbid water

Formazin was used as synthetic turbid water for coagulation procedure. Synthetic turbid water for the jar tests was prepared by mixing two solutions. Solution 1 included 10g hydrazine sulfate powder ($NH_2.NH_2.H_2SO_4$) (China) in 100 mL distilled water. Solution 2 included 10g of hexa – methylene – tetramine powder ($C_6H_{12}N_4$) (China) in 100 mL of distilled water. The suspension of solution 1 and 2 was diluted to 1 L, stirred slowly in 1 hour and then let stand for 24 h to allow for complete hydration of formazin with a standard turbidity solution of 4000 NTU.

2.3. Experiment on influent factors for coagulation

The coagulation test for turbidity removal in water was carried out by jar test machine (JLT 6 Velp Scientifica). In detail, jar tests are conducted on six beakers (jars) with 500mL synthetic water. The study involved steps: (1) rapid stirring 100 rpm in 2 minutes; (2) slow stirring 40 rpm in 5 minutes, 30 rpm in 10 munites; 20 rpm in 10 minutes; and (3) sedimentation in 30 minutes [10]. The water samples after sedimentation were measured the turbidity by Spectrophotometer (Hitachi U2910) at 450 nm and it was expressed in nephelometric turbidity units (NTU). The efficiency of turbidity removal is given by the equation:

$$\%\text{Turbidity} = \frac{To-T}{To}\ x\ 100 \qquad (1)$$

Where as

T_o is the initial turbidity of synthetic turbid water, mg/L

T is the turbidity of water after coagulation, mg/L

The efficiencies of turbidity removal were influenced by many factors such as pH, dose of coagulant, solvent to extract coagulant, etc.

The Extracting process of the active components in the fruit seeds depend on the solvents. The suspension in three different solvents: NaOH 0.1N, NaCl 0.1 N and distilled water were examined the effect of solvents.

The effect of pH was studied by changing pH of the synthetic water in the range of 3-8, and the coagulation test was performed by jar test procedure at room temperature with an initial turbidity of 200 NTU and coagulant dosage of 20 mg/L.

The effect of coagulant dose (20 – 50 mg/L) for the reducing turbidity process was studied with the fixing of the optimal pH, the initial turbidity of 200 NTU and the solvent.

3. RESULTS AND DISCUSSION

3.1. Effect of solvents for extracting active components

Three solvents (NaOH 0.1N; NaCl 0.1N; Distilled water) were used to extract the active components in the fruit seeds by mixing seed powder at 150 rpm in 15 minutes. The color of the coagulant used NaOH is darker than NaCl and distilled water. It could be seen that the concentration of active components in coagulants concentration is extracted in NaOH higher

than in NaCl and distilled water. In addition, due to the natural viscosity of NaOH, the coagulants could be also as natural polymers.

Under the same conditions of coagulant dosage (20mg/L), initial turbidity (200 NTU), there is a big difference among the efficiencies of three solvents: NaOH, NaCl and distilled water (figure 1). For all three types of fruit seeds, the turbidity removal of the coagulants which mixed with NaOH were more effective than other solvents in range of pH 3 – 8. Therefore, NaOH 1N was chosen as solvent for other experiments [10].

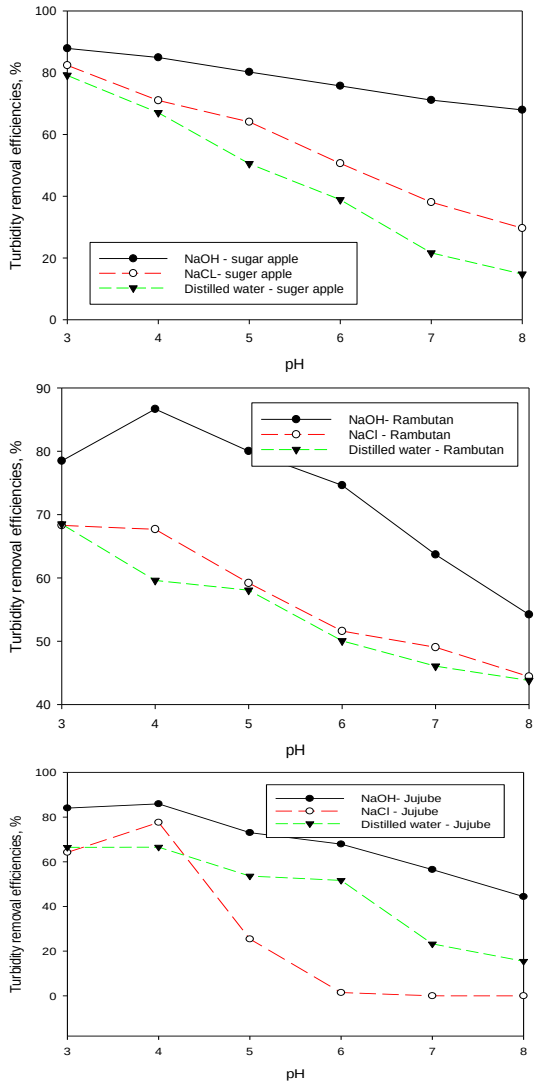

Fig. 1. *The effect of coagulants from fruit seeds (a) sugar – apple; (b) rambutan; (c) jujube on synthetic turbid water with different solvents (NaOH 0.1N; NaCl 0.1N and distilled water)*

3.2. Effect of pH on turbidity removal efficiency

Because pH is an important factor regarding to effect on both coagulation process and charges on protein molecules, the influence of pH on coagulation activity was investigated. Figure 2 shows the effect of pH on treating synthetic turbid water with three fruit seeds (Sugar-apple, Rambutan and Jujube) at coagulant dosage of 20 mg/L. It is found that the pH affects the efficiency of turbidity removal. The curve for fruit seeds are rather different compared to poly aluminum chloride (PAC). Generally, the turbidity removal percentages for fruit seeds are higher than PAC at pH<5 and lower at pH> 5. In addition, the lower the pH, the higher the efficiencies of three fruit seeds are. This results are similar to previous study [1]. Because these coagulants are natural substances which have high concentration of polyphenols. In acidic condition, cations on the amine acids of protein molecules can predominate and thus help the molecules function as well as coagulation agents. As a hermaphrodite molecule, the charge of the protein depends on the pH. At pH > 3, a different amount of cationic and anion mixtures of amino acids in the protein may have reduced, therefore the cation exchange capacity of coagulant during flocculation decrease [10].

During the jar test experiments, bigger flocs was observed under acidic condition, especially at pH 3-4. The higher pH increase, the smaller and fewer flocs. As can be seen in Figure 3, the efficiency of turbidity removal at pH 4 is more than 85% for three coagulants. That is also the optimal pH for coagulants from rambutan and jujube seeds while the highest efficiency of Sugar-apple is at pH =3. However, there is no big difference between pH = 3 and pH =4 with coagulants from sugar-apple seeds.

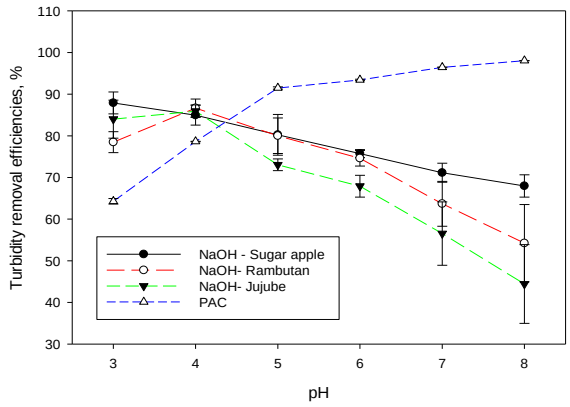

Fig. 2. *The effect of coagulants from fruit seeds on synthetic turbid water at different pH*

3.3. The effect of dosage of coagulants from fruit seeds

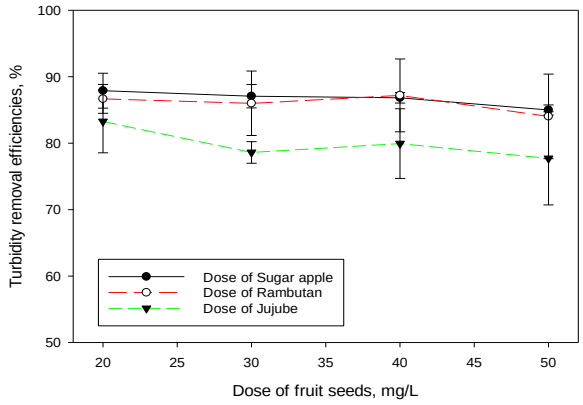

Fig. 3. *The effect of coagulants from fruit seeds on synthetic turbid water at different dosages*

pH values were selected based on optimal pH of every fruit seeds, pH = 3 for sugar-apple seeds and pH = 4 for rambutan and jujube seeds. The results indicated that the efficiencies of turbidity removal were not much change in range of 20 – 50 mg/L. It was rather obvious that the efficiencies of all results were higher than 85% for coagulants from sugar apple and rambutan and 80% for coagulants from jujube. However, the tendency of efficiency reduced while the dosage of three coagulants increased. The use of natural coagulants may increase the organic load in waters [11] resulting in the possibility for undesired and increased turbidity in water after coagulation [12]. This factor may be partly responsible for not increasing turbidity removal percentage when increasing the dosage of natural coagulants.

4. CONCLUSION

In conclusion, the highest turbidity removal efficiency observed at optimal pH = 4 for rambutan, sugar-apple seeds and pH = 3 for jujube seeds were 89%, 86% and 83%, respectively. With only dosage of 20mg/L, these efficiencies of these fruit seeds were rather impressive in replacement for chemical coagulants. It could be concluded that the fruit seeds such as rambutan, sugar-apple and jujube showed tremendous potential as natural coagulants for water treatment purposes. For future study, it is recommended that the rambutan and sugar-apple seeds could be used for real wastewater treatment and surface water.

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