Wastewater Treatment by using Natural Coagulant

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Abstract— **Natural coagulant is a natural based coagulant that can be used in coagulation process of wastewater treatment for reducing turbidity. The objectives of this study were to assess the possibility of using natural coagulants as an alternative to the current commercial synthetic coagulant such as aluminium sulphate and to optimize the parameters related in the working condition of coagulation process. Based on the experimental results, it was concluded that this natural coagulant efficiency which can removed up to 99.1% of turbidity in synthetic wastewater is comparable to the synthetic coagulant.**

Keywords— natural coagulant, coagulation, wastewater treatment

1. Introduction

In wastewater treatment, coagulation has been practiced since earliest times and the main objective is to remove colloidal impurities hence also removing turbidity from the water. Coagulant is a chemical used that is added to the water to withdraw the forces that stabilizes the colloidal particles and causing the particles to suspend in the water. Once the coagulant is introduced in the water, the individual colloids must aggregate and grow bigger so that the impurities can be settled down at the bottom of the beaker and separated from the water suspension. Aluminium and iron coagulants are commonly used in most industries. However, when aluminium is used as a coagulant in waste water treatment, it can caused several bad effect on human health such as intestinal constipation, loss of memory, convulsions, abdominal colic's, loss of energy and learning difficulties.

Hence nowadays, there has been great attention in the improvement and implementation of natural coagulants in wastewater treatment. These natural coagulants can be formed or extracted from animal, microorganisms and also plant. Natural coagulant chosen for this project is Hibiscus Sabdariffa or also known as Roselle. Roselle seeds were found to be rich in proteins (27.745%) which are soluble in water and carry an overall positive charge when in solution [1]. These positive charge proteins would bind to the negatively charged particles in the solution that cause turbidity. This project was carried out to investigate the efficiency of this natural coagulant to be used in the coagulation process of wastewater treatment.

2. Methodology

2.1 Materials and Chemicals

Good quality dry seeds of Roselle were carefully selected and collected from Port Dickson, Negeri Sembilan, Malaysia. Industrial wastewater sample is collected from a glove manufacturing company in Selangor, Malaysia. Kaolin with particle size of 0.1-4 μm from Sigma-Aldrich is used to simulate the wastewater turbidity. Chemical used are hydrochloric acid from Astral Lab, sodium hydroxide from Merck and aluminium sulphate also from Merck.

2.2 Preparation of Synthetic Wastewater Samples

Synthetic industrial wastewater was prepared by adding chemical to simulate industrial wastewater properties and to be treated in this project. The synthetic water turbidity value was adjusted to be at the same level with the turbidity value of the collected industrial wastewater which is 80 NTU. 10g of dry kaolin was dispersed into 1 litre of distilled water and mixed for 1 hour at 200 rpm. Prepared synthetic wastewater suspensions were allowed to settle for 24 hours before the experiment.

2.3 Preparation of Roselle Seed

The seedpods were allowed to dry naturally on the tree to make sure there were fully matured before harvesting the seeds for coagulant production. The seeds were then shelled, crushed, ground and sieved to a fine powder with size of < 250μm. The powder is mixed with water to yield a net positive charge from the water soluble proteins of the seeds. The water coagulant suspension was vigorously shaken for at least 5 min after adding water to fully expand the molecules and then filtered by using 2.5μm filter papers before it can be used. The suspension was stored in a refrigerator to avoid deterioration, hence if the suspension is refrigerated; it can be kept up to one week without deterioration [2].

2.4 Experimental Run

There are a few variables that can be affected by temperature such as pH, viscosity, density and floc volume concentration, hence it is very important to maintain and control the temperature for an accurate result. The temperature of the wastewater is remained constant at room temperature throughout the experiment. Sample solution of the coagulants, synthetic wastewater, sodium hydroxide and hydrochloric acid were prepared at suitable concentration to ensure that the experiment would run smoothly and the results can be measured conveniently. In this jar testing experiment, 0.1 M of NaOH and 0.1 M of HCl were used to adjust the pH level to desired pH value of the wastewater.

2.5 Coagulation Activity

The optimum condition of coagulation process is where the least dosage of coagulant is needed and the pH value of the condition that can yield the wanted flocs and contributing to clean water. The pH range tested in this experiment is from 2 to 11 and the concentration of coagulant added is between 20mg/l to 200 mg/l. In this jar test experiment, natural coagulant with a concentration of 200mg/l was first added into 200ml of wastewater. The mixtures were rapidly stirred at 120 rpm after the addition of the dose for about 3 minute. The mixtures were then stirred slowly at a speed of 50 rpm to allow it to flocculate for a period of 20 minutes. After sedimentation process for 1 hour, 100 ml of the supernatant liquid was carefully collected without disturbing settled flocs to measure residual turbidity (RT) value. The same coagulation test without the addition of natural coagulant was carried out as a control and the residual turbidity (RT_C) value was determined. The coagulant activity and total suspended solid values after coagulation process were calculated.

Coagulation activity was measured as:

$$\text{Coagulation activity} = \frac{(RT_C - RT)}{RT_C} \times 100\ (\%)$$

2.6 Analytical method

The turbidity values of the wastewater sample were measured by using a turbidity meter (CyberScan TN 100 IR) from Eutech Instrument in Nephelometric Turbidity Units (±0.01 NTU). The pH values of the wastewater samples were measured by using Professional Benchtop pH meter BP3001 from Trans Instrument with an accuracy of ±0.02. The overhead stirrer used in jar test experiment is R50D Precision Overhead Stirrer from CAT Scientific with an adjustable speed from 50 to 1600 rpm.

3. Research Outcomes and Discussion

3.1 Effect of pH on coagulation activity of Roselle seed

The study of influence of pH on coagulation activity is important as the solubility of matters and particles are depends on the pH level of the wastewater. Wastewater is mainly consists of negative charge particles and the pH value of where these particles are stable is known as isoelectric point. The optimum pH value for coagulation process of both synthetic and industrial wastewater with initial turbidity of 80 NTU were determined. The initial pH was varied from pH 2 to pH 11with a maximum dosage of 200 mg/l of natural coagulant. Fig. 1 shows the results obtained from jar test experiment for both synthetic and industrial wastewater.

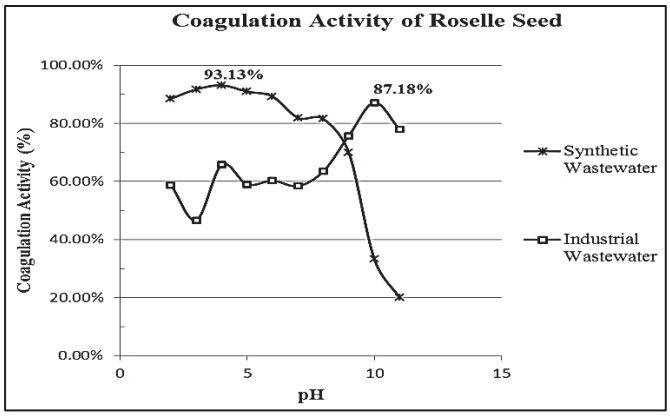

Fig. 1 Effect of pH on coagulation activity of Roselle seeds extract.

As can be seen from Fig. 1, the highest coagulation activity of Roselle seed for synthetic wastewater is at pH 4 with 93.13% turbidity removal. On the other hand, the highest coagulation activity for industrial wastewater is at pH 10 with 87.18% turbidity removal. Coagulation activity of Roselle seed in synthetic wastewater is high at pH range of 6 and below which is in acidic range while coagulation activity in industrial wastewater is high at pH range of 9 and above. The percentage of turbidity removal decreased in the synthetic wastewater for pH 9 and above. This may be caused by excessive addition of sodium hydroxide used as a pH modifier. The reducing in coagulation activity at pH 8 and above suggested that some protein may be denatured at high concentration of sodium hydroxide hence reduced efficiency of coagulation process [3].

3.2 Effect of natural coagulant dosage on coagulation activity

Based on Fig. 1, the optimum pH for coagulation process of synthetic and industrial wastewater are 4 and 10 respectively. In this project, optimum dosage of roselle seeds extract for both synthetic and industrial wastewater was determined in their respective optimum pH level and these results are presented in Fig. 2.

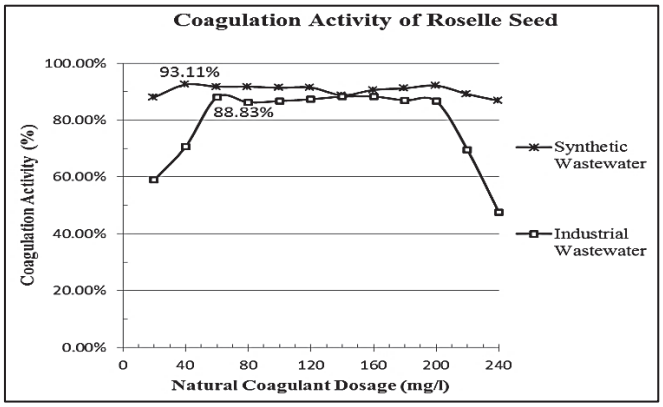

Fig. 2 Effect of coagulant dosage on coagulation activity of Roselle seeds extract.

According to Fig. 2, the optimum dosage of roselle seed extract in the removal turbidity of 80 NTU is 40 mg/l for synthetic wastewater and 60 mg/l for industrial wastewater. The turbidity value was reduced from 80 NTU to 5.5 NTU for synthetic and to 10.3 NTU for industrial wastewater. Coagulation activity of roselle seeds was decreased by increasing dosage of its extract. This declination may be caused by charge reversal and destabilization of colloidal particles due to overdosing of protein.

3.3 Coagulation activity of Roselle seed extract

Based on this result, industrial wastewater required higher amount of roselle extract in order to achieve high turbidity removal. This showed that the coagulant activity of roselle seed was reduced when there are unwanted particles existed in the wastewater. This may be caused by the various contaminants existed in the wastewater that inhibit the natural coagulants to perform at their best. Basically the coagulant dosage required to reduce the turbidity level is depend on the characteristic of the wastewater and the aim of the treatment process. Wastewater consists of high amount of negative charge particles required high amount of natural coagulant for complete stabilization.

The highest turbidity removal efficiency for aluminium sulphate was within 82.9-99.0% over wide range of turbidity. The best performance of alum was observed at pH 7 over the selected range of turbidity but its performance decreased to some extent at pH values of 4, 5 and 8. [4]. The highest removal efficiency of roselle seeds was within 81.2 to 93.13% for synthetic wastewater at pH 4 and within 76.8 to 87.18% at pH 10. This showed that the natural coagulant extracted from roselle seeds gave comparable performance with existing synthetic coagulant in coagulation water treatment process.

4. Conclusions

The quality of the wastewater treated by using natural coagulant is comparable to the quality of the wastewater treated by commercial coagulant and hence can be used to replace aluminium sulphate as commercial coagulant. The highest removal efficiency of roselle seeds was within 81.2 to 93.13% for synthetic wastewater at pH 4. However, the highest removal efficiency for industrial wastewater was within 76.8 to 87.18% at pH 10. For future work, the optimum method of extraction of each of the natural coagulants can be found. There are various types of protein extraction such as solvent extraction which are using water, oil, sodium hydroxide and alcohol like ethanol to extract the protein out of the seed. The best extraction method would be the one that can extract the most coagulant chemicals out of the kernel. Hence, the best method for extraction of this coagulant can be determined together with the optimum condition such as coagulant dosage, temperature, pH and turbidity of the water.

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