Apply *Cassia Fistula* seed gum as auxiliary bio-coagulant for fish processing wastewater treatment

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Abstract

Coagulation-flocculation has been considered as an effective method for various water and waste-water treatment at the first stage to remove turbidity, total suspended solids (TSS) and chemical oxygen demand (COD). Polymeric coagulants isolated from plants are new alternatives for synthetic coagulants as they are highly bio-degradable, non-toxic, non-corrosive, less sludge voluminous and pH independent. The aim of this study is to check the ability of *Cassia fistula* seed gum coagulants (MHY) in fish processing's effluent treatment. Jartest experiments were done for two sources of wastewater from two different factories to figure out coagulants dose by considering the changing in color, TSS and COD removal by using PAC as coagulant and with the aid of MHY. The first main parameters varied from 2624 - 2683 mgO_2/L for COD, 580 - 571 mg/L for SS and 333.72 - 334.09 Pt-Co for color intensity. Results obtained indicated the best dosage of PAC is 480 mg/L, and with supplement of 4 mg/L MHY it could remove 70.54 - 80.50% of COD, 68.34 - 70.12% of SS and 35.94 - 37.01% color. Natural products such as *Cassia fistula* seed gum have been use as auxiliary coagulant in coagulation-floccula-tion process to improve the quality of fish processing wastewater.

Keywords: *auxiliary coagulant, chemical coagulant, fish processing wastewater, seed gum*

1. Introduction

Apart from the benefits of fish processing industry, its development is polluting the water environment, dramatically impacting the quality of receiving water source. The pollution from the wastewater of seafood processing varies significantly depending on the raw materials (shrimp, fish, squid, octopus, crab, clam, mussel, etc.), the type of products, on the season and even on the working day (Johnson *et al*., 2008). Especially, the concentration of the pollutants from the processing lines is very high exhibiting via the pH ranging from 6.5 - 7.0, SS from 500 - 1200 mg/L, COD varying 800 - 2500 mgO_2/L, BOD_5 from 500 - 1500 mgO_2/L, TKN from 100 - 300 mg/L, total phosphor 50 - 100 mg/L, and oil and fat 250 - 830 mg/L (Le Hoang Viet & Nguyen Vo Chau Ngan, 2014). The waste-water from fish processing contains biodegradable organic pollutants indicated by BOD/COD ratio 0.6 to 0.9 (Nguyen Trung Viet *et al*., 2011). Especially, the waste-water generated from the processing of catfish has very high oil concentration of 250 up to 830 mg/L (Ngo Xuan Truong, 2008). In addition, the fish processing wastewater characterizes high composition of organic matters, color and suspended solid (Lam Minh Triet, 2006).

Even though the chemical coagulants are much efficient in treating the water, one of the concerns is that their excess amount in treated water may potentially cause human health problems. For instance, the excess amount of aluminium in water after treatment was one of the causes of the Alzheimer disease (Amagloh & Benang, 2009). Researches of Letterman & Driscoll (1988), Miller *et al*. (1984) also pointed out the probability of aluminium accumulation in environment when using aluminium sulphate in water treatment. This situation has raised the need of developing the biological coagulants whose excess amount is nontoxic to the environment.

Many studies have proven the efficiency of using the gums extracted from different types of seed for treating the water for daily life activities in the poor countryside. In Vietnam, there are few studies applying this method; for instance, peas, *Cassia fistula*, drumstick tree (*Moringa oleifera*), etc. have been used to produce coagulants for treating daily wastewater as well as textile wastewater. At present, there is almost no wastewater or drinking water treatment system at big scale using the natural gum as the coagulants or auxiliary coagulants instead of the existing chemical compounds.

Therefore, study "Apply *Cassia Fistula* seed gum as auxiliary bio-coagulant for fish processing wastewater treatment" is essential. The result from the study would give to the selection of suitable coagulant and auxiliary coagulant to treat seafood processing wastewater

2. Methodology

2.1 Materials

Wastewater:

- Factory 1: the wastewater collected from fillet lines of the fish processing section, Mekong Joint-stock Seafood Company, Tra Noc Industrial Park, Can Tho city.

- Factory 2: the wastewater collected from fillet lines of the fish processing section, Hung Ca Ltd. company, Thanh Binh Industrial Park, Dong Thap province.

Chemicals: using the chemical coagulants and auxiliary coagulants including:

- PAC: polymer $(-CH_2CHCONH_2-)_n$ and $Al_n(OH)_mCl_{n-m}$ which are industrial grade.

- Gum extracted from *Cassia fistula* seeds (gum MHY) collected in Binh Duong province. The gum was in solid state with the extraction efficiency is 150 g gum over of 1.4 kg seed as previous reported by Pal & Singh (2004) or Bhatnagar *et al.* (2013).

- Instruments: the experiments were carried out using the Jartest apparatus (Lovibond, Germany). The Jartest model consists of 6 paddles simultaneously rotating at the same speed. The speed could adjustable through the gear. The blades are in the turbine form consisting of 2 flat parallel plates. The time was controlled to decide the best operating parameters.

2.2 Selecting the parameters for coagulation

According to Nguyen Thi Lan Phuong (2008), in a standard Jartest experiment, the stirring time of 2 - 3 minutes is normally considered as quick stirring time (stirring speed is in the range of 100 - 200 rpm, respectively) while 20 - 30 minutes is considered as slow one (stirring speed ranges from 20 - 50 rpm). In addition, the sedimentation time usually varies from 30 - 60 minutes.

All experiments were performed on Jartest apparatus in which samples were put in 6 beakers with the volume of 2 L. Each beaker contained 1 L of the same wastewater so that the wastewater could not escape from beaker when operate the experiment. The quick stirring speed was fixed at 120 rpm in 2 minutes meanwhile the slow one was 40 rpm keeping for 25 minutes. The sedimentation time was 30 minutes.

Huynh Long Toan (2014) reported that the used amount of coagulants may vary from 200 - 1000 mg/L for waste-water and 20 - 100 mg/L for drinking water. Meanwhile, Le Hoang Viet *et al.* (2014) reported the best amount of chemical coagulant for the coagulation process of slaughter wastewater was 400 mg/L. Then, in this study, the amount of PAC was chosen in the range of 200 - 600 mg/L (the step between samples was r = 20 mg/L).

In selecting the auxiliary coagulants, according to Tran Hieu Nhue (2001), the best concentration of the auxiliary coagulant usually falls in the range of 1.0 - 5.0 mg/L. Then, chosen the auxiliary coagulant concentration of 1.0 - 5.0 mg/L (the step between samples was r = 1.0 mg/L).

2.3 Experimental setup

2.3.1 Experiments 1

Purpose: to find the optimum amount of PAC for the coagulation of the samples. The obtained result of this experiment would be used for the next experiments.

Experimental procedure is as follow:

- Step 1: 6 beakers were put on the Jartest apparatus; each one contained 1.0 L of wastewater.

- Step 2: quickly stirred the wastewater in 2 minutes with the stirring speed of 120 rpm. Depending on the experiment, various chemicals with suitable amount were added into the beakers. Then, slowly stirred with a speed of 40 rpm for 25 minutes and then the solutions were sediment naturally in 30 minutes.

- Step 3: observed the sedimentation of the sludge, the clear water was decanted for pH measurement as well as the analysis of pollution parameters including the color intensity, SS and COD measures.

Each experiment was repeated for 5 times. After data analysis, optimum quantity of PAC was obtained as X (mg/L). The arrangement of samples on the Jartest was illustrated in Figure 1.

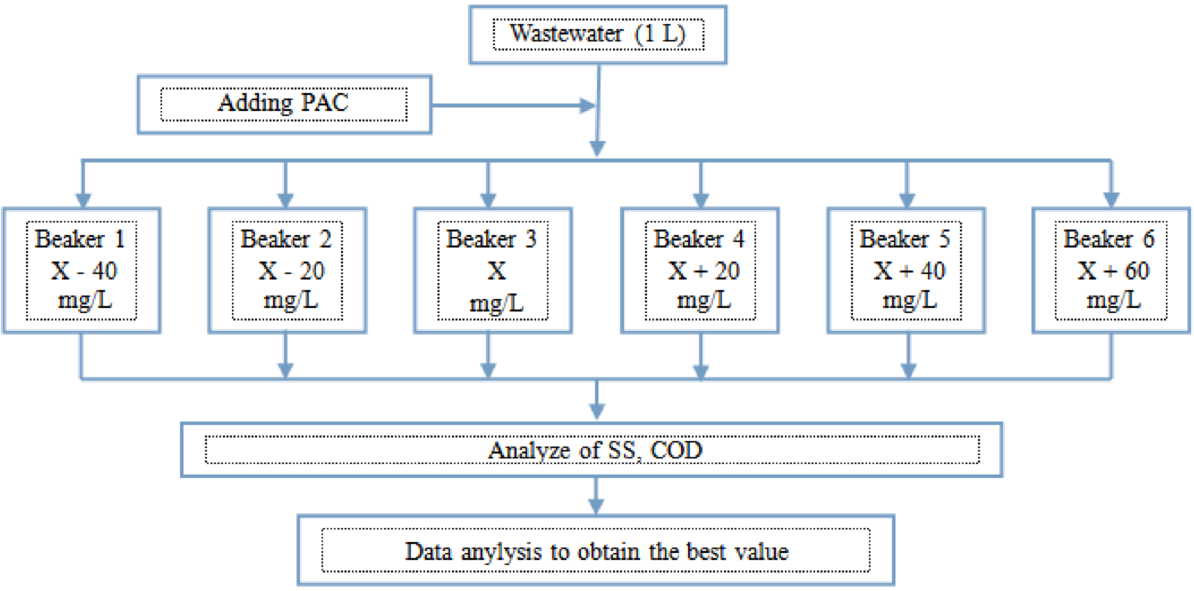

Figure 1 Experimental arrangement to determine the amount of PAC (experiment 1)

2.3.2 Experiment 2

The purpose of this experiment was determining the best amount of gum MYH as the auxiliary coagulation.

Purpose: to find the optimum concentration of gum MYH as the auxiliary coagulant in combination with PAC as the coagulant.

Procedure: the experimental setup was similar to the experiment 1. The amount of PAC was chosen as the optimum one while the concentration of biological gum MYH was varied with the step between different samples of r = 20 mg/L. The results were presented as Y (mg/L gum MHY).

2.4 Sample collection, data analysis

Sample collection and storage:

- Sample collection and storage were performed following the guidelines of TCVN 6663-1:2011: National standard in water quality and sampling.

- The wastewater for all experiments were collected 10 times (5 times for each factory). The uniform time-point of collection is at 10 am.

Sample analysis: all samples were analysis according to the described procedure of current Vietnamese standards.

Data analysis: raw data were analyzed using MS Excel 2010 and statistics were done with SPSS.

3. Results and Discussion

3.1 Determining the optimum PAC quantity

The results showed that the concentration parameters of wastewater were much higher than the permission discharge standard of QCVN 11:2008/BTNMT - The National technical regulation on the effluent of aquatic products processing industry. It was clear that the polluted level of wastewater sources are quite similar which is advantageous for the comparison and evaluation of the treatment efficiency when using the gum MHY as the auxiliary coagulant in combination with PAC as the coagulant.

Table 1. Analytical results of input wastewater

Parameter	1st factory	2nd factory	QCVN 11: 2008/ BTNMT (col. A)
COD (mgO_2/L)	2624	2683	50
SS (mg/L)	580	571	50
Color (Pt-Co)	333	334	50*

**: QCVN 40:2011/BTNMT - National technical regulation on industrial wastewater (column A)*

Figure 2 showed the uniform changing of COD and SS removal efficiency when varying the PAC concentration. Particularly, in both cases, removal efficiency of COD and SS was highest when the concentration of PAC was 480 mg/L at which the treatment efficiency of COD and SS were 59.41% and 45.9%, respectively. In addition, the efficiency gradually decreased when increasing the concentration of PAC. Finally, the lowest removal efficiency which was 46.25% for COD and 21.31% SS, respectively, was obtained at the PAC amount of 540 mg/L.

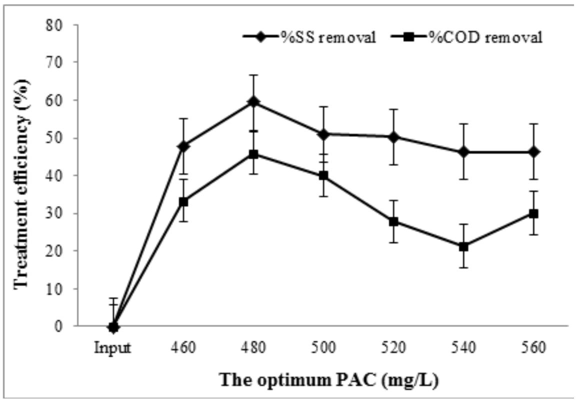

Figure 2. Efficiency in COD and SS removal at different concentration of PAC

The reduction in the efficiency could be attributed to the destabilization of the colloidal particles at the PAC concentration which is higher than the necessary one diminishing the coagulation efficiency (Ngo Xuan Truong *et al*., 2008). Then, the best PAC concentration of 480 mg/L was chosen for the succeeding experiments.

3.2 Determining amount of gum

3.2.1 For wastewater from factory 1

As can be seen clearly in Figure 3, the treatment ability of gum MHY kept increasing when its used concentration varied from 1.0 to 4.0 mg/L and the efficiency started to decrease at the concentration of 5.0 mg/L. Indeed, the COD and SS removal efficiency reached the maximal at 4.0 mg/L of gum MHY which were 70.54% and 68.34%, respectively. The changing in color intensity varying with the used amount of gum MHY but the highest color removal efficiency was obtained at 2.0 mg/L. However, within the investigated range (1.0 - 5.0 mg/L), there was no significant difference in color treatment efficiency among the samples (changing from 35.62 to 36.5%). Consequently, 4.0 mg/L was selected as the best concentration of gum MHY to be combined with 480 mg/L PAC.

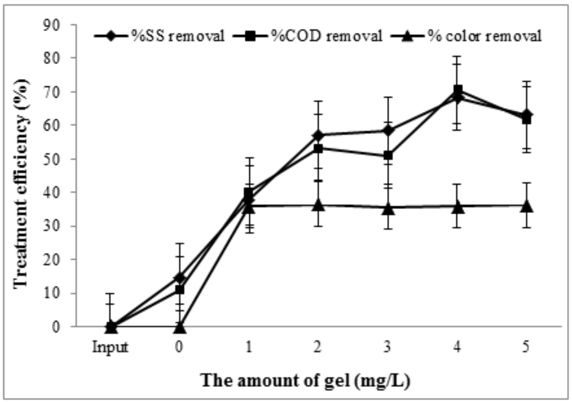

Figure 3. Treatment efficiency of the auxiliary coagulant gum MHY to the wastewater of factory 1

3.2.2 For wastewater from factory 2

It was shown that the effectiveness in waste -water treatment of gum MHY gradually increased when varying the concentration from 1.0 - 4.0 mg/L and started to decrease at the concentration of 5.0 mg/L. In addition, the highest COD and SS removal efficiency was achieved at 4.0 mg/L which were 80.05% and 70.12%. The initial waste-water also gave an apparent color intensity of 312.18 Pt-Co. Consistently, the color removal efficiency showed no remarkable difference within the investigated concentration range and it reached a maximal value of 37.01% at the concentration of 2.0 mg/L. Then, similar to previous experiment, value of 4.0 mg/L was also chosen to be the best concentration of gum MHY to be combined with 480 mg/L PAC.

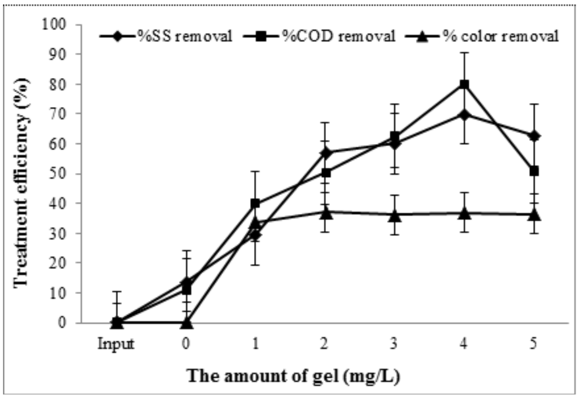

Figure 4. Treatment efficiency of the auxiliary coagulant gum MHY to the wastewater of factory 2

The results from this study were lower in comparison to other studies. When attempting to handle the seafood processing wastewater using micro-organisms, Vo Van Nhan & Truong Quang Binh (2011) reported that the COD treatment efficiency was 94.4%. And it was a bit lower of 86% in the case of Duong Gia Duc (2010). The dissimilarity in the effectiveness was due to the main initial parameters, including the concentration and composition of the waste-water, were different.

It is worth to mention that the effectiveness in improving the quality of wastewater was equal among 5 repeats for both experiments. This was indicated by the unremarkable deviation of the obtained data.

6. Conclusions

The study of physic-chemically treating fish processing wastewater using the PAC as the coagulant in combination with biological gum MHY as the auxiliary coagulant has given several following findings:

- The concentration of chemical using for fish proces-sing wastewater treatment highly affects to the treatment efficiency described by the level of COD, color and suspended solid removal. The best concen-tration of the chemicals for the improvement of wastewater quality using coagulation were determined by the Jartest. In particular, the amount of coagulant PAC was 480 mg/L and the concentration of auxiliary coagulant gum MHY was 4.0 mg/L.

- The combination between PAC and seed gum gave satisfactory treatment with the efficiency in the case of factory 1 was 70.54% COD, 68.34% SS and 35.94% color intensity while 80.50%

COD, 70.12% SS and 37.01% color intensity were obtained for the factory 2.

With the achieved results, it is possible to execute trials on the similar subjects, i.e the seafood processing wastewater with the same pollution concentration. Moreover, it is practical to gradually replace the bio-coagulants, which are friendly to the environment, for the traditionally chemical compounds to improve the quality of received water body.

Acknowledgments

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