RESEARCHING THE EFFICIENT SS AND COD TREATMENT IN WASTEWATER IN VIET CUONG CRAFT VILLAGES BY COAGULATION AND FLOCCULATION

Pham Huong Quynh*, Nguyen Thi Thu Phuong
University of Technology - TNU

ABSTRACT

Wastewater from vermicelli produce contains high levels of organic matter with COD from 460,8 to 844, 8 mg/L; BOD5 from 209 to 325 mg/L; especially suspended solid (SS) that fluctuates from 625 mg/L to 766 mg/L). In this study, the high suspended solid value is one of the reasons that impedes biological treatment process. The purpose of this study is to find an agent in the coagulation-flocculation method that can treat SS by three coagulants: PAC (Poly Aluminium Chloride), Aluminum Sulfate (AS) and Ferrous Sulfate Hydrate (FSH) to treat effectively SS before entering the biological treatment system. The treatment efficiency of PAC reached the highest of 98.00% with the concentration of 200 mg/L, FSH reached 80.23% with the concentration of 400 mg/L and AS was 95.84% at the concentration of 400 mg/L. pH that the factor influences the SS treatment efficiency was also studied. The results showed that the optimum pH for SS treatment with FSH, AS and PAC were 9, 7 and 7-7.5, respectively. PAC has been used as a coagulant for SS treatment of this wastewater.

Keywords: *Wastewater, vermicelli, PAC, Aluminum Sulfate, Ferrous Sulfate Hydrate*

INTRODUCTION

Edible canna (Canna edulis Ker) was a perennial herb of the family Cannaceae, native to the Andean region in South America.This plant has large starchy rhizomes, which were traditionally used as a staple food for Andean people for more than 4000 years. This crop was now cultivated as the source for starch production in small-scalefactories in China, Taiwan, and Vietnam [2]. Measured diameters of noodles were in the range of 0.73 to 0.88 mm and moisture content of the canna noodles was 15.24% to 15.46%. Their chemical compositions on dry weight basis were as follows: 89.41% to 91.63% starch, 0.21% to 0.33% protein, more than 0.01% lipid, 0.16% to 0.20% ash [6].

All steps in the rice vermicelli production were discharged a big volume of wastewater containing significant amount of starch and sugar [5]. Untreated waste from processing has caused a seriously polluted the environment. Wastewater, which is rich in organic material, especially sugars, is discharged without treatment into streams and bad odors emanate from fermenting extraction residue [5]. The canna flour processing activities have caused many negative consequences to the environment; especially the residuals from this processing are released directly to the environment which led to environment polluted. Concentrations of pollutants of these villages are also high, especially the amount of some chemicals, including COD, BOD_5, SS, total N and P. Particularly, wastewater emited from cassava and edible canna starch processing has low pH and contains high concentrations of pollutants. This should receive due attention because it causes serious impact on community health.

Coagulation- flocculation is one of the common methods for treating wastewater and is used to separate the suspended solids portion from the water. Inorganic coagulants such as aluminum and iron salts are the most commonly used. When added to the water, they furnish highly charged ions to neutralize the suspended particles. In practice, the commonly used coagulants are Aluminum

* *Tel: 0916 827728; Email: quynhktmt@gmail.com*

Sulfate (AS) $Al_2(SO_4)_3.18H_2O$, Ferrous Sulfate hydrate (FSH) $FeSO_4.6H_2O$, and PAC (Poly Aluminum Chloride). They are the coagulants of choice for many industrial and sanitary wastewater treatment applications, due to its high efficiency, effectiveness in clarification, and utility as a sludge dewatering agent. The purpose of adding coagulant aids was reported to increase the density to slow-settling flocs and toughness to the flocs so that they will not break up during the mixing and settling processes [4].

METHODS

Material

Wastewater from production and processing of canna vermicelli in Nguyen Thanh Kien's household in Viet Cuong Craft Villages, Hoa Thuong commune, Dong Hy district, Thai Nguyen province.

Methods

Sampling method: TCVN 5999: 1995

Analytical methods:

Characteristics	Standard	Characteristics	Standard
Suspended solids (SS)	TCVN 4560: 1988	**BOD_5**	TCVN 6001-1: 2008
COD	TCVN 4565: 1988	**Total nitrogen**	TCVN 6638: 2000
Phosphate by Ascorbic acid method	TCVN 6202: 1996	**Total phosphorus**	TCVN 6202: 2008
Amoni	TCVN 4563: 1988		

Equipments and chemicals

Equipments

- Determining COD by DRB200, HACH - USA
- Identifying of NH4 +; PO43- with UV-5200, China.
- Determining Coliform by Memmer - Germany.
- Testing coagulation-flocculation by JARTEST JJ-4A - China, with 6 stirrers having speeds of 10-300 rpm and stirrer of 0-1100 rpm.

Chemicals

- Aluminum Sulfate (AS) $Al_2(SO_4)_3.18H_2O$
- Ferrous Sulfate hydrate (FSH) $FeSO_4.6H_2O$
- PAC (Poly Aluminum Chloride)

Experimental description

Wastewater is taken 500ml into a glass of 1 liter, then adjusted pH with NaOH 6N and added the chemicals. Samples were put into the zatest. The mixture is stirred 150 rpm for 30-45 seconds to make the coagulation process and then, reduced 30 rpm for 5 minutes. Then the mixtures were settled for 30 minutes and taken the water settled to analyze.

RESULTS AND DISCUSSION

Characteristics of wastewater

The characteristics of wastewater sample were shown in Table 1. Nitrogen and phosphorus are relatively low because the composition of canna roots is mainly starch, so those of contents in the wastewater are poor. Moreover, pH is also low due to the steps of the process. The wet starch used to produce the vermicelli that is packaged and stored for long periods of time and combined with the high temperature, acid is created. On the other hand, COD, BOD and SS are extreme values because the water which is sucked out of the starch storage tank has high carbohydrate contents such as starch, organic acids (lactic) and so on and they entered to the wastewater.

Table 1. *The characteristics of wastewater in Viet Cuong vermicelli village*

Parameters	Range	Parameters	Range
pH	2.7-3.0	Total N (mg/L)	10.1-14.6
BOD5 (mg/L)	209-325	$NH4^+$ (mg/L)	1.07-2.64
COD (mg/L)	460.8-844.8	Total P (mg/L)	1.73-2.16
SS (mg/L)	625-766	$PO4^{3-}$ (mg/L)	0.32-0.81

Study on SS, COD treatment by coagulation-flocculation

SS, COD treatment with FSH, AS and PAC

The concentration of FSH

The wastewater had been treated with different concentrations of ferrous sulfate hydrate ranging between 50 and 700 mg/L. The pH of samples were adjusted with NaOH from 3.0 to 9.0 to obtain the optimum pH. The agitator worked at high speed (250 rpm) for 30 seconds, then slowed down to 40 rpm for 5 minutes. After that, the samples were collected and analyzed for SS, COD. The analysis results are presented in the Figure 1. It was reported that the neutralization of the electrical charges of particles into the water which causes the particles to clump together [6]. In this figure, with different concentration of FSH from 50 mg/L to 700 mg/L, the effectiveness SS, COB treatment are different, from 59.75% to 80.54 % with SS and 17.40 to 28.32 with COD. It was observed that the most favorable concentration of FSH was noted to be 400 mg/L with the effective treatment of SS and COD being 95.85%, 28.74%, respectively.

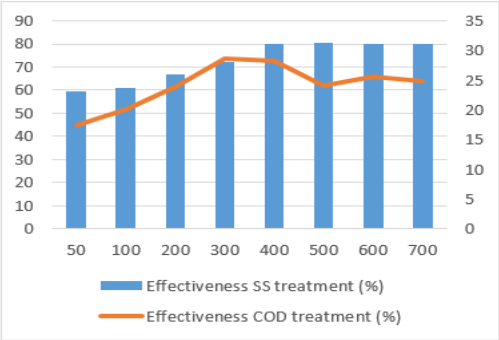

Figure 1. *Effectiveness SS and COD treatment (%) of FSH*

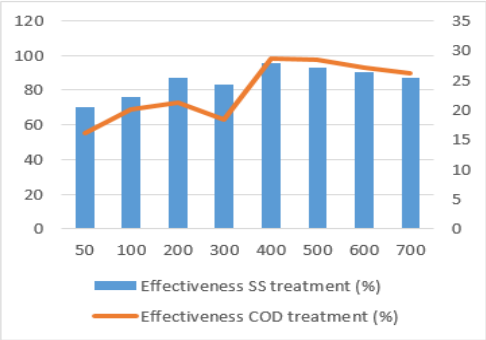

Figure 2. *Effectiveness SS and COD treatment (%) of AS*

The concentration of AS

The AS concentration range was research from 50 mg/L to 700 mg/L. SS and COD were alalyzed and shown in Figure 2. The optimum concentration of AS is 400 mg/L that is effectively COD treatment (28.74%) and SS treatment efficiency (95.85%).

The effect of PAC concentration

The wastewater having pH = 2.48; BOD_5 = 3.24 mg/L; COD = 8.91mg/L; SS 759mg/L is used to assess the effect of PAC concentration. This wastewater was adjusted to pH 8.0 with eight PAC concentrations (25 mg/L- 350 mg/L) and then, SS and COD were analyzed and shown in Figure 3. The results indicates that when changing PAC concentration, the SS treatment efficiency increases significantly from 79.7% to 98% and COD from 11% to 20.93%.

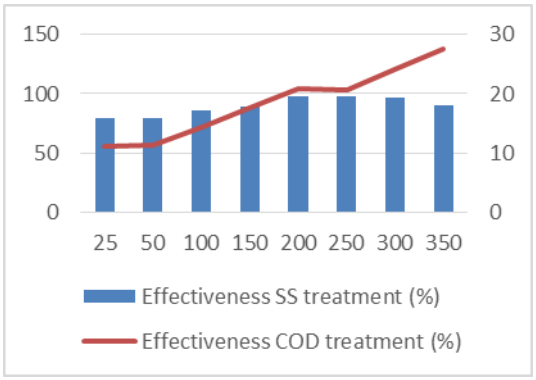

Figure 3. *Effectiveness SS and COD treatment (%) of PAC*

The COD and SS removal efficiency is maximized at 200 mg/L PAC. This could be explained that coagulant PAC entering to the wastewater can change the zeta potential of particles, and most suspended solids in water possess a negative charge, so, they consequently repel each other. This process prevents the particles from agglomerating and keeps in suspended particles. Coagulation and flocculation occur in successive steps intended to overcome the forces stabilizing the suspended particles, allowing particle collision and growth of flocs, which then can be settled and removed (by sedimentation) or filtered out of the water [7]. At low

concentrations of PAC (25; 50mg/L), coagulants are not sufficient to collide and stick with particles, whereas PAC concentrations are too many (300; 350mg/L) at these particles become saturated and processing efficiency is not high. Moreover, early studies on coagulation indicated that the dissolved organic can be removed by adsorption on aluminum precipitation [1]. Literature indicated that the mechanism of coagulation for aluminum salts is controlled by the hydrolysis speciation [3]. So PAC concentration of 200 mg/L is optimal.

The effect of pH

The effect of pH with FSH

FSH concentrations are 400 mg/L as this concentration gives the highest processing efficiency. Adjusted pH ranged from 6 to 10 with 460.8 mg/L of COD, results shown in Table 2. At this pH=9 the SS removal is more than 80% when the COD removal is around 28 %.

Table 2. *Effect of pH on removal SS efficience (%) (A) and removal COD efficience (%) (B) using FSH and AS*

	pH	5	6	7	8	9	10
FSH	**A**	75.23	78.85	80.13	80.09	80.54	79.74
	B	25.27	27.66	28.07	28.11	28.32	27.36
AS	**A**	85.12	88.63	95.85	84.36	79.37	79.11
	B	20.74	24.46	28.74	28.11	27.21	26.53

The effect of pH with AS

Adjusted pH ranged from 6.5-8 with COD = 891 mg/L, results shown in the Table 2. At pH 7 COD removal efficiency (28.74%) and SS treatment efficiency (95.85%) are highest.

The effect of pH with PAC

The study was carried out in jatest apparatus with effluent pH = 2.48; BOD_5 = 324 mg/L; COD = 891 mg/L; TSS 759 mg/L. Wastewater is adjusted pH with NaOH to pH 6.0; 6.5; 7.0; 7.5; 8.0; 8.5; 9.0. PAC at a PAC concentration of 200 mg/L. Research results presented in the Table 3.

The coagulation process depends on the pH of wastewater. With pH <4.5, hydrolysis reaction does not occur, so the coagulation process does not happen. When pH increased from 5 to 7, the SS treatment efficiency increased from 85.12% to 95.85%. At this pH, colloidal particles are flexible and forms a bridge between the colloidal particles, finally, they coalesce and settle. The SS treatment efficiency almost decreases because when increasing pH, the colloidal particles become saturated and uncoated. Moreover, the amount of complexes that generated during this process is not only a complex of coagulation but also some chemical reactions that precipitate with heavy metals. Therefore, the amount of OH involved in the reaction will be more than theoretical.

Table 3. *Effect of pH on removal SS efficience (%) (A) and removal COD efficience (%) (B) using PAC*

pH	6	6.5	7	7.5	8	8.5	9
A	82.74	87.22	95.66	95.83	96.13	96.41	96.75
B	18.48	18.73	20.28	20.84	20.93	21.04	21.00

pH plays an important role in coagulation-flocculation, but many wastewater types have different optimum values, depending on the presence of ions in water and heavy metals in water. Adjusting the pH to high will consume a lot of chemicals, and secondary processing consumes an additional amount of chemicals to lower the pH. This study showed that when the pH increased, the efficiency of SS and COD treatment increased. With a pH value of 6.0 and 6.5, the SS treatment efficiency is only 82-87%. When the pH increased to 7.0, the efficiency increased significantly by 8.44%, but there was stability when the pH was increased to 7.5 (8.61%). Increasing the pH to 8.0, 8.5, 9.0 treatment efficiency raised slowly, it is about 0.3; 0.58 and 0.93%, respectively. In addition, the COD removal efficiency increased slowly from pH 7 to pH 9.0. So the appropriate pH for coagulation-flocculation is pH = 7-7.5.

Each coagulant has different structure, so processing efficiency will be different. When using PAC, the dissolution process produces

Al_{13} "keggin polymer", the most active components with remarkable electrical charge. Their hydrolysis rate is also slower than that of Al^{3+}, greatly increasing their retention time in water, reducing the cost of chemicals. On the other hand, since PAC has a higher molecular weight than AS and FSH, higher porosity, better absorption of dirt, faster coagulation time and less fluctuation of pH of sludge wastewater, PACs are more likely to remove organic matters than AS and FSH. PAC has a minimal impact on pH and therefore minimized the need to feed adjustment chemicals. And it is able to do a better job while using 30-60% less aluminum on average. The growth rate of PAC has been very impressive. In many areas where PAC has been marketed for a reasonable time period it has replaced over 75% of the total alum demand.

CONCLUSION

Waste water in Viet Cuong craft village has low pH, high contents of organic waste (COD, BOD_5) and SS. Coagulation-flocculation process is conducted to reduce SS, COD and adjusted pH in wastewater before entering to the biological treatment system. The optimum concentration of FSH was noted to be 400 mg/L with the effective treatment of SS and COD being 95.85%, 28.74%, respectively. It is 400 mg/L for AS that is effectively COD treatment (28.74%) and SS treatment efficiency (95.85%). The COD and SS removal efficiency is maximized at 200mg/L PAC in pH=7-7.5. PAC is chosen for the pre-treatment of canna vermicell wastewater in this study.

REFERENCES

1. Bratby J., (2016), "Coagulation and Flocculation in Water and Wastewater Treatment", *IWA Publishing*.

2. Chansri R., Puttanlek C., Rungsadthogy V., Uttapap D., (2006), "Characteristics of Clear Noodles Prepared from Edible Canna Starches", *Journal of Food Science*, Volume 70, Issue 5, pp. 336-342.

3. Dennett K. E., Amirtharajah, A. Moran, T. F. and Gould J. P., (2007), "Coagulation: It's Effect on Organic Matter", *Journal AWWA*, 88(4), pp.129 –142.

4. Holt P. K., Barton G. W., Wark M., Mitchell C. A., (2002), "A Quantitative Comparison between Chemical Dosing and Electro coagulation, Colloids and Surfaces A", *Physicochemical Engineering Aspects*, pp.211, 233 -248.

5. Nguyen Thi Minh Sang, Tran Hong Con, Dong Kim Loan, (2013), "Study of Starch and Sugar Degradation and Transformation during Biotreatment Process of Wastewater from Rice Vermicelli Production at Craft Villages in Vietnam", *EnvironmentAsia*, Vol. 6 Issue 2, pp. 83-88.

6. Stechemesser H., Dobias B., (2005), "Coagulation and Flocculation, Second Edition", *CRC Press*.

7. http://www.sswm.info/content/coagulation-flocculation (Accessed 20th, August, 2017)

TÓM TẮT

NGHIÊN CỨU XỬ LÝ SS AND COD TRONG NƯỚC THẢI SẢN XUẤT MIẾN DONG LÀNG NGHỀ MIẾN VIỆT CƯỜNG BẰNG PHƯƠNG PHÁP ĐÔNG KEO TỤ

Phạm Hương Quỳnh*, Nguyễn Thị Thu Phương
Trường Đại học Kỹ thuật Công nghiệp – ĐH Thái Nguyên

Nước thải sản xuất miến rong có chứa hàm lượng chất hữu cơ cao COD từ 460,8 đến 844, 8 mg/L; BOD5 từ 209 đến 325 mg/L; đặc biệt là TSS 625-766 mg/L. Hàm lượng SS cao là một trong những nguyên nhân gây cản trở quá trình xử lý sinh học. Nghiên cứu này tìm kiếm một tác nhân xử lý SS bằng phương pháp đông keo tụ với các tác nhân khác nhau (phèn nhôm, phèn sắt và PAC) để xử lý hiệu quả SS trước khi đi vào hệ thống xử lý bằng phương pháp sinh học. Hiệu quả xử lý của PAC đạt cao nhất 98,00% với nồng độ 200 mg/L, phèn sắt đạt 80,23% với nồng độ 400 mg/L và phèn nhôm đạt 95,84 % ở nồng độ 400 mg/L. Một yếu tố ảnh hưởng tới hiệu suất xử lý SS là pH cũng được nghiên cứu. Kết quả nghiên cứu cho thấy pH tối ưu đối với xử lý SS bằng phèn sắt, phèn nhôm là 9, với PAC là 7-7,5. PAC đã được sử dụng làm tác nhân keo tụ để xử lý SS của nước thải miến dong.

Từ khóa: *Nước thải, miến dong, PAC, phèn nhôm, phèn sắt*

Ngày nhận bài: 05/9/2017; Ngày phản biện: 08/10/2017; Ngày duyệt đăng: 30/11/2017

* *Tel: 0916 827728; Email: quynhktmt@gmail.com*