# Effect of *p*H of Coagulant on the Treatment of Wastewater from Tofu Industry

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**Abstract.** Wastewater generated from the tofu industry usually still contains high organic pollutants that can contaminate the surface water. Therefore, it should be treated properly before it can be disposed to the environment. This study aims to evaluate the combination of coagulation-flocculation and ultrafiltration methods in treating the wastewater from tofu industry. Based on the preliminary tests, the wastewater from tofu industry have *p*H, total dissolved solid (TDS), total suspended solid (TSS), turbidity and chemical oxygen demand (COD) of 3.4, 870 – 1080 mg/L, 370 mg/L, 446 FAU and 7954 mg/L, respectively. The coagulant and membrane used in this study were Poly aluminum chloride (PAC) and the ceramic membrane, respectively. Experimental results showed that the best *p*H for coagulation-flocculation process is at *p*H of 7.0, and this pH was then used for ultrafiltration process. The flux of the ultrafiltration membrane increased with increasing the trans membrane pressure due to increasing driving force. The observed parameters such as TSS and turbidity of wastewater decreased drastically after experiencing ultrafiltration process and met the National Environmental Quality Standard. However, the COD of water produced in the ultrafiltration process was still high and did not meet the National Environmental Quality Standard.

## 1 Introduction

Tofu is one of the traditional foods favored by the Indonesian people. In addition to the cheap price, Tofu is also known contains good nutrition. The tofu industry is relatively simple and cheap. Almost every city in Indonesia has tofu industry that is generally managed by small scale household entrepreneurs and regional cooperatives. Currently, the average tofu business in Indonesia is still run with simple technology, so that the efficiency in using resources such as water and raw materials are still low and the level of wastewater produced is relatively high. Tofu industry activities in Indonesia are dominated by small-scale enterprises with limited capital. In terms of location, this business is also very spread throughout the territory of Indonesia. Human resources involved are generally relatively low educational level, and only few of tofu industries treat the wastewater produced [1].

In the process of making tofu, wastewater produced that can potentially pollute the environment due to lots of using water and high organic content in wastewater. Wastewater from tofu industries can content BOD level of about 5,000-10,000 mg/L, COD of 7000-26000 mg/L, pH in the range of 4.0 to 5.0 and TSS in the range of 6000-8000 mg/L [2, 3]. This high level of pollutant, when directly discharged into the aquatic environment can cause bad odors and pollution of the surface and ground water, increase the turbidity of the water and decrease the rate of photosynthesis from phytoplankton and other aquatic plants, so that the primary productivity of the waters will decrease [4, 5]. The levels of COD and BOD indicate the amount of organic compounds contained in a waste, which if high amounts can affect the dissolved oxygen (DO). This is because organic compounds require oxidized oxygen, so that in large quantities its presence can cause DO content to drastically decrease and lead to the death of water organisms because it does not get enough oxygen. The levels of COD, BOD and TSS have been strictly regulated so as not to exceed the environmental threshold. Based on Governor Regulation of Jakarta, the maximum threshold content of the wastewater from food industry is: BOD <75 mg/L; COD <100 mg /L; TSS <100 g/L; and pH in the range of 6.0 to 9.0 [6]. In some cases, the wastewater from tofu industry can be utilized for denitrification of tail water [7], hydrogen production [8], a medium for microalgae culture [9] and bioethanol production [10].

Many studies have been conducted to find alternative methods of tofu effluent treatment that more effective and faster process duration. One of alternative methods that attract a lot of attention is processing by utilizing membrane process. Membrane process is one of the most widely used technologies in water treatment process. Membrane process can be used in the filtration of organic substances in wastewater; one of them is ultrafiltration membrane (UF). Separation using ultrafiltration a membrane is chosen due to the process is simple, energy efficient, and environmentally friendly. In addition, the purity of product treatment is higher than that of conventional method [11]. This study aims to see

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the effect of *p*H of wastewater on the performance and effectiveness of combination of coagulation-flocculation and ultrafiltration processes to reduce TSS, TDS, COD, BOD, dissolved oxygen (DO) and turbidity of wastewater from tofu industry.

## 2 Materials and Methods

Fig. 1 shows the schematic diagram of experimental set up. The variations of wastewater's *p*H were prepared by adding appropriate volume of 2.0 M NaOH solution into wastewater until desirable *p*H of wastewater is achieved. The coagulant used for flocculation-coagulation process was made by dissolving 5 gram of PAC into 200 ml of distilled water. 1 ml of this solution was then added to a 250 ml of wastewater for flocculation-coagulation process. Jar Test VELP JLT-6 was used for flocculation-coagulation process. The first process was conducted at 120 rpm for 2 minutes and then 40 rpm for 10 minutes. The solution was then stayed for 30 minutes before filtered using 10 µm BIPMED BI filter paper, and then was fed to ceramic ultrafiltration (UF) membrane supplied by CV GDP Filter Bandung Indonesia. To create the Trans membrane pressure (TMP) in the UF membrane, pressurized air was exerted into wastewater vessel. The observed parameters such as TSS, turbidity and COD, BOD were measured for the wastewater before and after the flocculation-coagulation processes and after ultrafiltration process. TSS and turbidity were measured using Colorimeter DR/890 and COD was measured using Spectrophotometer UV-Vis BEL UV-MS1 single beam.

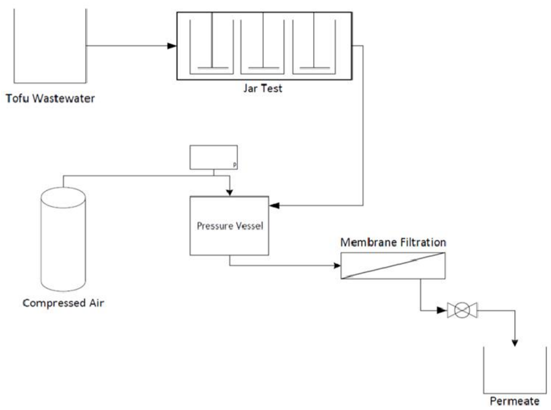


**Fig. 1.** Schematic diagram of experimental set up.

## 3 Results and Discussion

The physicochemical characteristics of wastewater from tofu industry used in the study are tabulated in Table 1. All parameters in tofu wastewater are far from environmental quality standard based on Ministry of Environment Regulation no. 5 Year 2014 [6], so that it cannot be discharged into the environment directly. The tofu wastewater has an acidic *p*H of 3.4 so it is very corrosive. It also has a large suspended solid as designated by the high amount of TSS, COD and turbidity. In addition, the tofu wastewater causes odor and rot when it left for 24 hours due to organic materials in the wastewater indicating that its BOD is high.

**Table 1.** Physicochemical characteristics of the tofu wastewater used in the study

| Observed Parameters | Concentration range | Government Regulation [6] |
|---|---|---|
| *p*H | 3.4 | 6.0-9.0 |
| TDS (mg/L) | 870-1080 | 2000 |
| TSS (mg/L) | 370 | 100 |
| Turbidity (FAU) | 446 | 25 |
| COD (mg/L) | 7954 | 275 |
| BOD (mg/L) | 2900 | 150 |

There are four variations of *p*H applied in coagulation-flocculation process i.e. 6, 7, 8 and 9. This *p*H variation is based on the standard quality of industrial wastewater set by the government. Samples of each variation were then analyzed to find out the values of COD, TSS and turbidity. The best condition is then determined as a fixed variable in the subsequent treatment of ultrafiltration.

Figure 2 shows the effectiveness of the coagulation-flocculation process in reducing suspended solids in which the most effective process is at *p*H 7. The more positive charge generated the more flocks were formed due to the increasing number of cations produced by the coagulant. The similar trend was also shown for the effectiveness of the coagulation-flocculation process in reducing turbidity and COD, as presented in Figure 3 and 4, where the most effective condition is at *p*H 7. This indicates that the *p*H also affects the effectiveness of coagulant in decreasing the turbidity and COD of wastewater. Turbidity is caused by organic substances contained in the wastewater. Organic substances were rejected by using coagulants so that the organic substances in the form of colloids will be destabilized and precipitated. The effect was not only the decrease in the turbidity, but also the decrease in COD. Based on Figure 2-4, the maximum rejection of TSS, turbidity and COD are 66%, 64% and 25%, respectively.

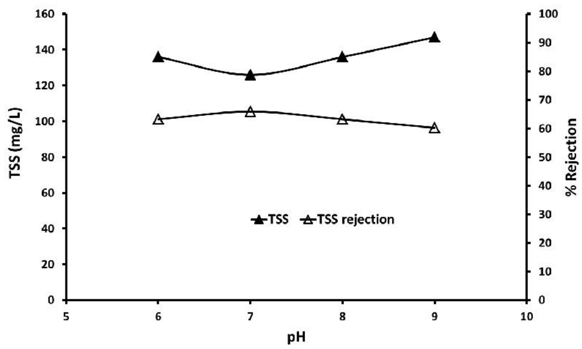


**Fig. 2.** TSS and TSS rejection of wastewater after coagulation-flocculation process as a function of *p*H of wastewater.

The wastewater resulting from coagulation-flocculation process at pH of 7 will further be used as feed water on the ultrafiltration process. The dead end process was applied for the ultrafiltration experiments. The produced water flux in the ultrafiltration process increased with increasing the TMP due to the increase of the liquid driving force to penetrate the membrane pores as presented in Figure 5.

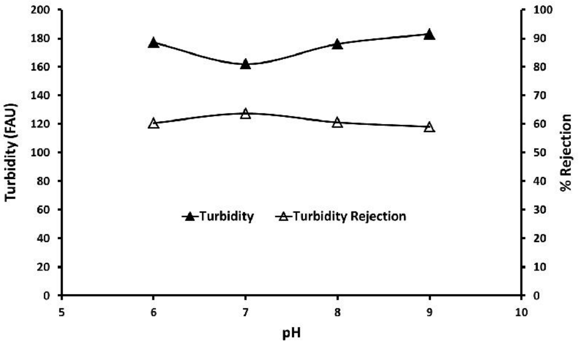


**Fig. 3.** Turbidity and turbidity rejection of wastewater after coagulation-flocculation process as a function of *p*H of wastewater.

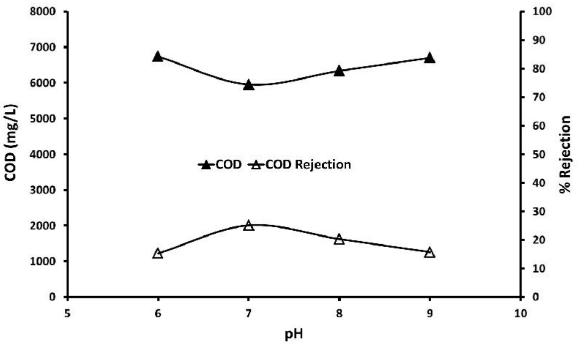


**Fig. 4.** COD and COD rejection of wastewater after coagulation-flocculation process as a function of *p*H of wastewater.

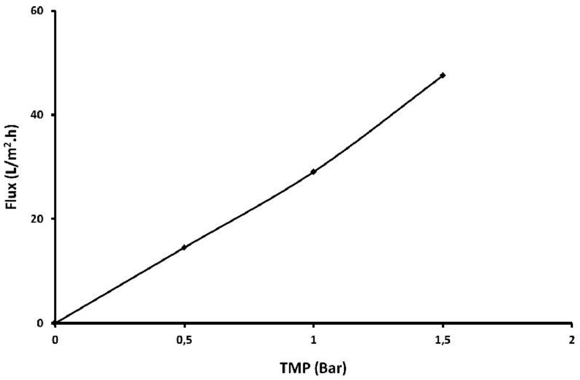


**Fig. 5.** Produced water flux in ultrafiltration process as a function of TMP.

The TSS and the turbidity of produced water from the ultrafiltration process are demonstrated in Figure 6 and 7, respectively. The TSS and the turbidity decreased drastically in the ultrafiltration process with removal efficiency more than 98% and 97%, respectively. It revealed that the ultrafiltration membrane was able to restrain the suspended solids and material causing turbidity not to pass through the membrane pores. The lowest TSS and turbidity of produced water were achived at TMP in the ultrafiltration process of 1.0 Bar. The lowest TSS and turbidity of produced water were 5 mg/L and 10 FAU, respectively, and met the National Environmental Quality standard, which are 200 mg/L and 25 FAU, respectively. The brightness of initial tofu wastewater, after coagulation-flocculation process and produced water after ultrafiltration process are shown in Figure 8. It can be viewed that the produced water from ultrafiltration process is much brighter than initial tofu wastewater.

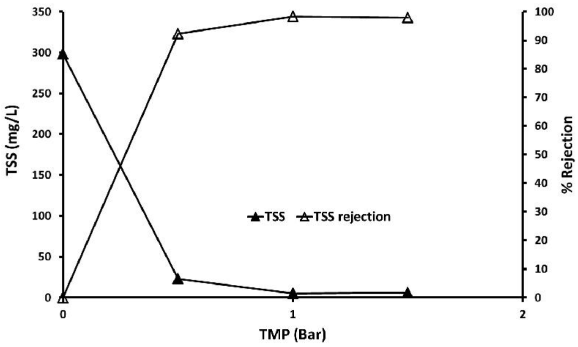


**Fig. 6.** TSS and TSS rejection of wastewater after ultrafiltration process as a function of TMP.

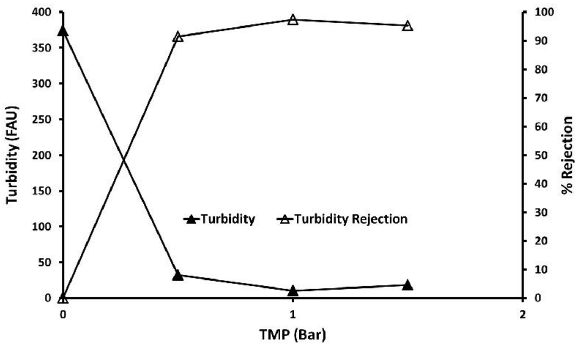


**Fig. 7.** Turbidity and turbidity rejection of wastewater after ultrafiltration process as a function of TMP.

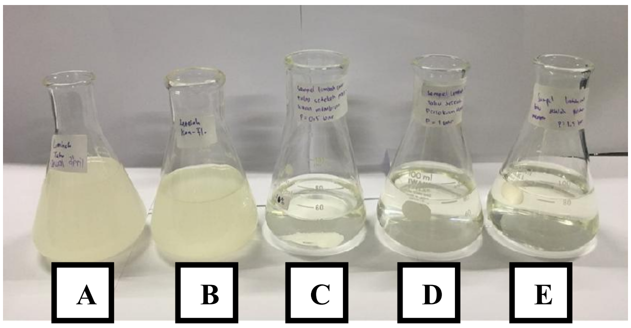


**Fig. 8.** The brightness of wastewater, A: initial wastewater; B: wastewater after coagulation-flocculation process; C, D and E: produced water of ultrafiltration processes at TMP of 0.5, 1.0 and 1.5 Bar, respectively.

Figure 9 presents the COD of produced water after ultrafiltration process. The decrease trend is similar to TSS and turbidity, where the maximum rejection is at TMP of 1 Bar. It revealed that the ultrafiltration membrane is able to restrain the chemical substances not to penetrate the membrane pores until the TMP is 1.0 Bar, but when the TMP is increased, more chemical substances can permeate through the membrane pores due to the higher driving force. The produced water COD did not meet the National Environmental Quality standard, which is 275 mg/L, while the lowest COD of produced water was 1557 mg/L. The high of COD value was due to ion $Na^+$ in the produced water that cannot be restrained by the membrane pores in the ultrafiltration process. The ion $Na^+$ was introduced in the wastewater for *p*H adjustment before pretreatment coagulation-flocculation process in the form of NaOH solution. The ion $Na^+$ can be rejected using reverse osmosis membrane.

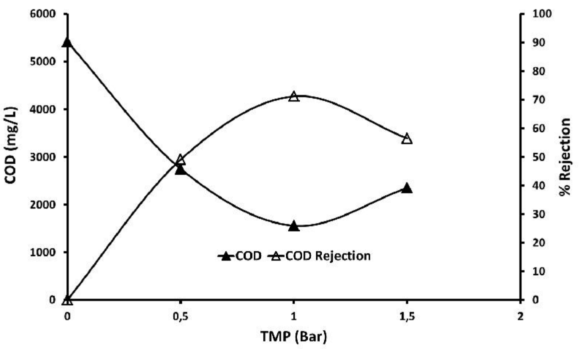


**Fig. 9.** COD and COD rejection of wastewater after ultrafiltration process as a function of TMP.

The parameters resulted from ultrafiltration process for TMP of 1.0 Bar together with the National Environmental Quality Standard is presented in Table 2, where only COD parameter does not meet the requirements of the National Environmental Quality Standard.

**Table 2.** The characteristics of the water product from the ultrafiltration process.

| Observed Parameters | After Ultrafiltration | Government Regulation [6] |
|---|---|---|
| TSS (mg/L) | 1 | 100 |
| Turbidity (FAU) | 9 | 25 |
| COD (mg/L) | 1557 | 275 |

## 4 Conclusions

The study has been directed to assess the effects of combination of coagulation-flocculation and ultrafiltration processes in wastewater treatment from tofu industry. The *p*H of wastewater in the coagulation-flocculation process and the TMP in the ultrafiltration process were the observed parameters their effects on TSS, turbidity and COD. The TSS and turbidity of produced water from the ultrafiltration process met the requirements of the National Environmental Quality Standard, but not for COD. The high of COD was due to $Na^+$ ions in the produced water that cannot be rejected by the membrane pores in the ultrafiltration process. The $Na^+$ ions can be removed using reverse osmosis membrane.

The authors are thankful to the grant from PITTA Project provided by the Directorate of Research and Public Service Universitas Indonesia through Contract No . 2542/UN2.R3.1/HKP.05.00/2018.

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