

# Utilization of Natural Coagulant Substance (Tamarind and Winged Bean Seed) on the Quality of Tofu Wastewater in Muntilan, Magelang

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## Article Info

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## ABSTRACT

The aim of this study is to determine the effect of various mass in tamarind and winged bean seeds on pH, TDS, and COD in tofu factory wastewater. The research was conducted at the Chemistry Research Laboratory of FMIPA UNY in December 2018. The results showed that the addition of various mass in tamarind and winged bean seeds as much as 7, 9, and 11 grams of tofu factory wastewater had an effect on pH which increased from the initial condition of 2.5 to 2.6; 2.7; 2.8 in tamarind seeds, and 2.8; 2.9; 3.0 on winged beans. The COD test increased from the initial condition of 6619.20 mg / L to 7312, 64; 7880, 00; 8195.20 mg / L in tamarind seeds, and 9140.80; 10464.64; 9329.92 mg / L in winged bean seeds which have decreased again in the addition of 11-gram coagulant substance mass. TDS test has increased from the initial conditions of 1512 mg / L to 1715; 1736; 1848 mg / L in tamarind seeds, and 1890; 1988; 1855 mg / L in winged bean seeds.

**Keywords:** *tofu wastewater, pH, COD, TDS*

## 1. INTRODUCTION

Water is a very important compound for human life and other living things, its function for life cannot be replaced by other compounds. Almost all activities conducted by humans need water. The quantity and quality of water that is in accordance with human needs is an important factor that determines the health of their life. Water quality is related to the presence of other materials contained in water, especially synthetic compounds in both organic and inorganic forms as well as the presence of microorganisms (Achmad, 2004).

The amount of pollution in water is caused by household waste, industrial waste, and agricultural waste. Pollution can reduce water quality. Therefore, considering the importance of water and the magnitude of the impact caused to the environment, the right method is needed to treat water.

Tofu industry produces the waste that contains a lot of organic substances. If the waste is discharged into the environment without any treatment process, it will cause environmental pollution. In Indonesia, tofu industries (the small-scale industry) mostly do not treat their waste due to the problem of the high-cost treatment process (Faisal, 2015: 506).

One of the pollutants found in tofu waste is the content of TDS (Total Dissolved Solids). The presence of TDS in high concentrations in water can cause contamination and even death to aquatic organisms. High TDS will reduce the ability of water to maintain water ecosystems. TDS analysis is needed to determine the pollution load and to design a wastewater treatment system.

Therefore, an effort is made to process the TDS in order to obtain the content of TDS (Total Dissolved Solid) which is in accordance with the quality standard.

Water treatment methods, especially wastewater that is commonly used are the physical-chemical process, namely coagulation-flocculation followed by sedimentation. In the coagulation-flocculation process, alum or alum are commonly used as coagulants but relatively require high costs. Therefore, research is needed on the use of natural materials that can be used to treat wastewater.

The number of natural ingredients used as an alternative substance coagulant, one of them is in the form of grains. Many plants in Indonesia can be used as alternative coagulants (natural coagulants) such as tamarind seeds (*Tamarindus indica* L) and winged bean seeds (*Psophocarpus tetragonolobus* L.). The seeds from tamarind are still not used properly and are just thrown away. Java can be used as a coagulant in the coagulation process because the content of protein in these seeds acts as polyelectrolytes. The dissolved protein from tamarind seeds contains the  $-NH_3^+$  group which can bind negatively charged particles so that the particles are destabilized to form a particle size that can eventually be deposited. This group is the active side of the coagulant (Hendrawati, Syamsumarsih, & Nurhasni, 2013).

According to Mawaddah, Zaharah, & Gusrizal (2014) at low pH, the amine group ( $-NH_2$ ) found in the tamarind seed protein will be protonated to  $-NH_3^+$  as the active side of the coagulant which binds the negative group to Tempe liquid waste. So that the lower PH ability of tamarind seeds in reducing organic substance is also increasing. At high pH, the COOH group in the protein will be deprotonated to form a negative COO charge - causing tamarind seeds to lose the active side of the coagulant.

Based on research conducted by Enrico (2008) tamarind seeds with a dose of 3000 mg/L at pH 4 were able to reduce turbidity 87.88%, TSS 98.78%, and COD 22.40% in tofu waste. In this research, the tamarind seed powder was used as an alternative coagulant with natural ingredients in the processing of tempe wastewater with the parameters of turbidity and the values of COD.

## 2. RESEARCH METHOD

This study included an experimental study conducted by testing winged bean and tamarind seeds as natural coagulant substances in tofu wastewater. The type of research used is a type of quantitative research by calculating COD, TDS, and pH. The research design was an experimental design (experimental design) which was to experiment using winged bean seed as a natural coagulant.

### 2.1. Place and time of research

This research was conducted at Chemistry Research Laboratory in the Faculty of Mathematics and Science, Yogyakarta State University. The research was held in December 2018.

### 2.2. Samples of Tofu Wastewater

The samples of tofu wastewater used in this research consisted of 3 types, there were 7; 9; and 11 grams. All of the samples bought from the collector in Muntilan, Magelang and Central Java. The collector collected the samples of tofu wastewater from Tofu Factory.

### 2.3. Research procedure

#### *Preparation of Coagulant*

Tamarind and winged bean seeds were separated from its flesh and cleaned. Afterward heated using an oven at  $105^\circ\text{C}$  for 60 minutes then pounded into powder form and sifted using a sieve of 50-60 mesh to homogenize and to make the surface area of coagulant be the same. After that, it was stored in a desiccator. This powder then used as a coagulant in the coagulation process.

#### *Sampling*

Samples were obtained from one of the tofu wastewater industries in Muntilan. The sampling technique is taken directly as much as 5000 mL into jerry cans from the tofu wastewater of drainage stream.

### *Process of Coagulation*

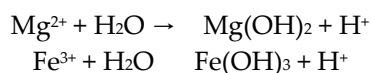
The wastewater that has been initially analyzed was put into four beakers, each of 250 mL, then added tamarind and winged bean seeds powder with the various mass of 7, 9 and 7 grams (dose 0,007; 0,009; 0,011 gram / L ) to each of them. Afterward, stirred at rapid speed for 3 minutes, followed by slow speed for 12 minutes and deposited for 60 minutes to finally filtered using Whatman No 1 filter paper. The next step was taking the filtrate to analyze COD, TDS, and pH parameters.

### **2.4. Materials and equipment**

The equipment used in this study were blenders, sieves, spoons, pH meter dry cups, beaker cups, measuring cups, measuring pipettes, analytical scales, tongs, ovens, label paper, filter paper, and plastic funnels. The materials used were 20 L tofu wastewater, each mass of the seed (tamarind seeds, trembesi seeds, winged bean seeds, and moringa seeds) 1 kg and distilled water.

### **3. RESULTS AND ANALYSIS**

The working principle of the coagulant is to destabilize suspended particles (colloids) and to increase the rate of floc formation. In tamarind seed extract contains metal ions  $Mg^{2+}$  and  $Fe^{3+}$ . In 500 mg of tamarind seed extract there are 0.9 mg  $Mg^{2+}$  ions and 0.4 mg  $Fe^{2+}$  ions. Organic material contained in water/waste has a negative charge which can bind with positive ions contained in the coagulant (Ramadhani & Moesriati, 2013). The reactions that occur are :



In this reaction, the organic substance contained in water has a negative charge and will bind with the positive ions contained in the coagulant and makes the colloidal system in the water becomes unstable. This bond will form larger floc after a slow stirring process because the particles collide with each other and remain united to then settle as a sediment (Wardani, & Agung, 2016).

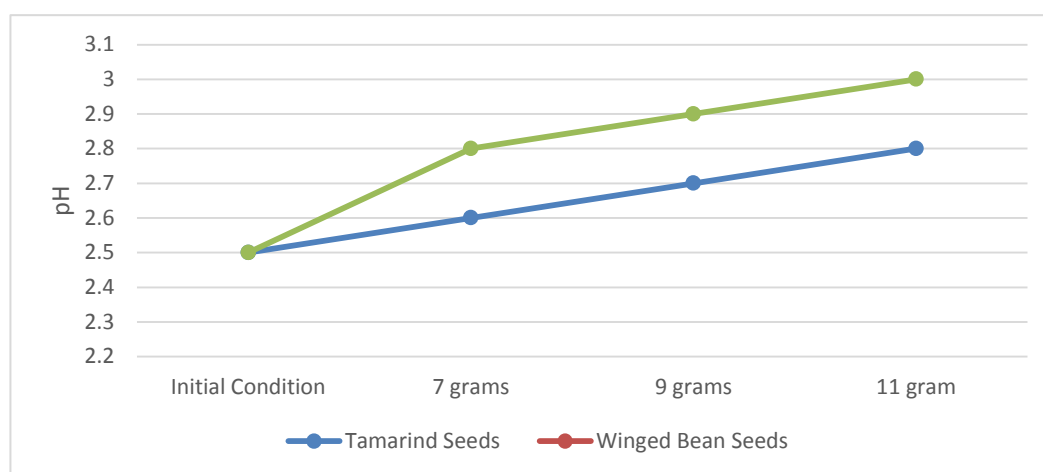
In general, tamarind and winged bean seeds contain lots of protein, carbohydrates, fiber, and high mineral contents. The ability of tamarind seeds as bio-coagulant is caused by the high protein content that can act as a natural polyelectrolyte, the tannin content in these seeds and natural polymers such as starch act as flocculants. Based on pH, COD, and TDS tests on wastewater, tofu has been treated with the coagulant of tamarind and winged bean seeds which showed results that can be seen in Table 1.

**Table 1.** Analysis Result of Tofu Wastewater Samples

No.	Tofu Wastewater Samples	Result		
		pH	COD	TDS
1	Initial conditions	2.5	6619.20	1512
2	Tamarind 7 grams	2.6	7312.64	1715
3	Tamarind 9 grams	2.7	7880.00	1736
4	Tamarind 11 grams	2.8	8195, 20	1848
5	Winged Bean Seed 7 grams	2.8	9140,80	1890
6	Winged Bean Seed 9 grams	2.9	10464,64	1988
7	Winged Bean Seed 11 grams	3,0	9329,92	1855
Method specifications		pH meter	APHA 22 <sup>nd</sup> edition 5220-C	Potensiometri

### The Effect of Tamarind and Winged Bean Seeds Coagulants on pH

The results showed that tofu wastewater after being treated with coagulant of tamarind and winged bean seeds had an effect on pH values which can be seen in Figure 1.



**Figure 1.** The Effect of tamarind and winged bean seeds coagulants on pH of tofu wastewater

A pH is the acidity level used to express the acidity or alkalinity of a solution. pH is defined as the cologarithm of dissolved hydrogen ( $H^+$ ) ion activity. The coefficient of hydrogen ion activity cannot be measured experimentally, so its value is based on theoretical calculations. The pH scale is not an absolute scale. It is relative to a set of standard solutions whose pH is determined based on international agreement.

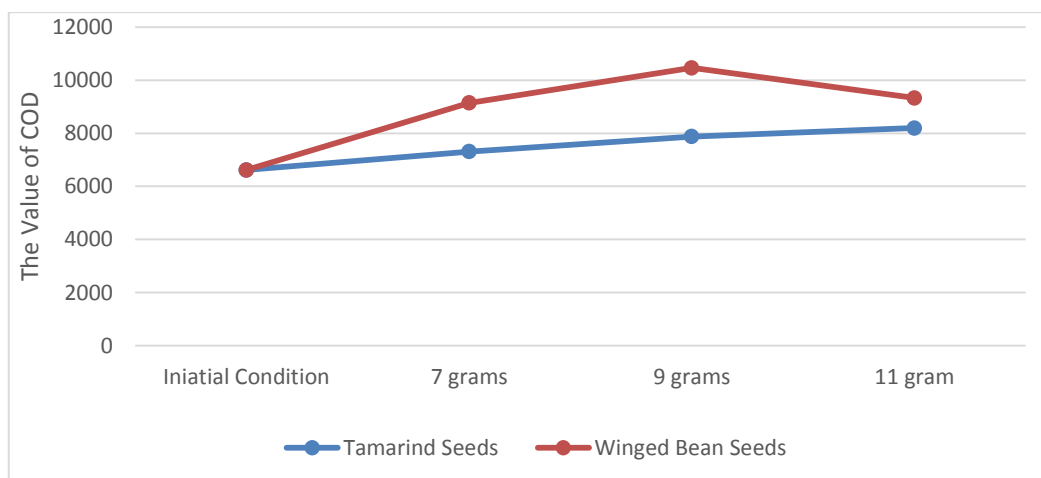
Tamarind and winged bean seeds have acidic pH levels around 2–4. Accordingly, they are more suitable for processing wastewater that has an acidic pH. Based on the results of the research in Figure 1, the pH value increases from the initial conditions after the addition of coagulants, due to binding  $H^+$  ions by tamarind and winged bean seeds. The particles of tamarind and winged bean seeds are able to bind  $H^+$  ions from liquid waste becomes lumpy and settles quickly (Nurika, Mulyarto, & Afhsari, 2007). In addition, the increase in pH occurs due to the presence of tannin compounds in tamarind and winged bean seeds. Tanin is a substance that is widespread in plants, one of which is in immature fruit. By the presence of tannin compounds, it can be concluded that the coagulant substance is able to increase the pH of the sample even though the result is not significant because of the increasing value only around 0.1.

According to Enrico (2008), the higher the pH, the lower the amount of organic substance absorbed by the tamarind and the winged bean seeds coagulant. At low pH, the amine group ( $-NH_2$ ) contained in the protein of tamarind and winged bean seed will be protonated to  $NH_3^+$  as the active side of the coagulant. The higher the concentration of  $H^+$  in the solution will increase the active side of tamarind seeds. Hence, the lower the pH ability of tamarind and winged bean seeds in reducing organic substance is also increased (Mawaddah et al., 2014). This is in accordance with previous studies, that the more coagulants are added, the higher the pH value, i.e. 1, 3, 5, 7, 9, and 11 grams doses per 500 mL of pharmaceutical industry of liquid waste can increase each pH to 4.53; 4.63; 4.77; 4.84; 5.74; and 5.82 (Poerwanto, Hadisantoso, & Isnaini, 2015). In addition, the magnitude of TDS affects pH. The higher the TDS, the lower the pH, to acidity (Bruvold & Ongerth, 1969).

### The Effect of Tamarind and Winged Bean Seeds Coagulants on COD

Testing of COD or Chemical Oxygen Demand was conducted at the Health Laboratory Center, Yogyakarta using the APHA 22nd edition 5220-C, 2012. The method was carried out for

approximately two weeks of testing. The result showed that tofu wastewater after given tamarind and winged bean seeds coagulant had an effect on the COD value which can be seen in Figure 2.



**Figure 2.** The Effect of tamarind and winged bean seeds coagulants on COD of tofu wastewater

A high value of COD can reduce dissolved oxygen in water. Then the value of COD in water must fulfill the established quality standards as not pollute the environment. The COD Test is a test conducted to determine the amount of oxygen needed by organic materials contained in water (Effendi, 2003). In this reaction, almost all substances can be oxidized to CO<sub>2</sub> and H<sub>2</sub>O in an acidic atmosphere (Fardiaz, 1992).

The COD test is commonly used to measure organic strength from household and industrial wastewater, it can also be empirically related to BOD, organic substance and organic chemistry. The value of COD can be used as a benchmark for the degree of pollution and "self-purification" of water to monitoring the water quality. The determination of COD, organic compounds, inorganic compounds such as Nitrite, sulfite, and iron compounds are all oxidized. Generally, the wastewater of COD is higher than BOD because more compounds are chemically oxidized than Biologically because most wastewater contains toxic compounds for microorganisms (Radojevic & Bashkin, 1999).

Based on the results of the research showed in Figure 1, the value of COD after the addition of tamarind seeds coagulant has increased from the initial condition. Meanwhile, the value of COD after the addition of winged bean seed coagulant increased from the initial conditions with the addition of 7 and 9 grams of winged bean seed. However, it decreased with the addition of 11 grams of winged bean seed. This is not in accordance with the previous research that the value of COD should decrease. Based on the quality standard of COD parameters provided by the Health Laboratory Center and in accordance with the Regional Regulation of Central Java Province No. 5 of 2012 (as reported at [www.jdihukum.jatengprov.go.id](http://www.jdihukum.jatengprov.go.id)), the maximum value of COD should be 275 mg/L. This means that the research conducted releases data that is not in accordance with the quality standards of wastewater according to the Regional Regulation of Central Java Province No. 5 of 2012.

It was caused by the three doses of natural coagulant substances from tamarind seeds were not able to degrade the bacteria. The concentration before the addition of coagulant was above the maximum limit for COD concentration of tofu wastewater. But after the addition of coagulants, the COD concentration actually increased. This is due to the bio-coagulant comes from organic compounds. It caused coagulant to become raw material for oxidation.

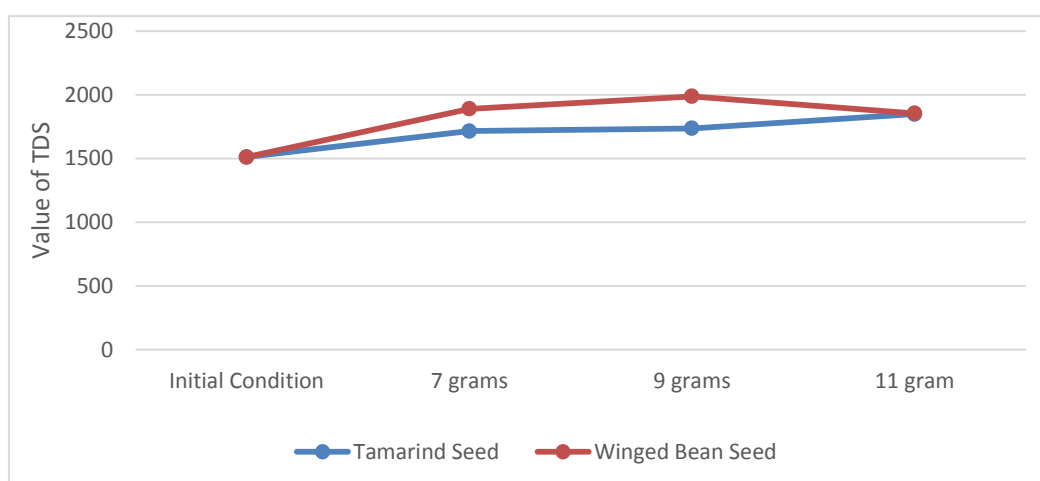
Effendi (2003) states that the value of COD is a measure of water pollution by organic substances which can naturally be oxidized and reduced dissolved oxygen in the water. The value

of COD in the water must fulfill the quality standards, so it will not pollute the environment. The high value of *Chemical Oxygen Demand* (COD) will require very large oxygen to make wastewater can be oxidized through chemical reactions (Wardhana, 2004).

In addition, it was obtained that the smell of tofu wastewater was bad. The smell of tofu wastewater before the treatment was unpleasant and sour. After being treated, the odor decreased. This was due to the presence of essential oils on tamarind and winged bean seed powder which can reduce the sour smell of tofu wastewater.

### The Effect of Tamarind and Winged Bean Seeds Coagulants on TDS

Based on the results of the study showed that tofu wastewater after given tamarind and winged bean seed coagulant had an effect on the value of TDS that can be seen in Figure 3.



**Figure 3.** The Effect of tamarind and winged bean seeds coagulants on TDS of tofu wastewater

Based on Figure 1, the value of TDS after given addition of tamarind seeds coagulant has increased from the initial condition. Meanwhile, the value of TDS after given the addition of 7 and 9 grams of winged bean seed coagulant has increased. However, it decreased with the addition of 11 grams of winged bean seed. The values of TDS have increased due to the excessive use of coagulants in the sample. The more coagulant added causing TDS levels to increase and make the water become more turbid because not all particles interact with colloidal particles to form floc in water. The addition of too much coagulant results in the ability to decrease the level of TDS of tofu wastewater to be saturated so that the remaining coagulant will contaminate the solution. The excess coagulant that does not interact with colloidal particles will also increase turbidity above the optimum dose (Hendrawati, et al., 2013).

In addition, the particle diameter gives effect on the allowance of turbidity because the smaller the particle diameter, the greater the area of contact between the coagulant and colloidal particles in the water. The contact will become tighter; as a result, the process of forming floc in water becomes easier. The smaller (finer) particle diameter of the coagulant, the decrease turbidity of water river tends to be larger (Enrico, 2008). This is due to the smaller particle diameter of the coagulant, the suspension is more homogeneous and the interaction between particles will be faster and causes floc is easily formed. However, in this study, the particle diameter used was not too small because it only used ordinary sieves to sieve the coagulant powder so it did not produce tiny particles. This also increases the turbidity after adding the Java coagulant.

Based on the water quality standards in PP No. 82 of 2001 states that the water-soluble residues of class 4 are 2000 mg/L. The water of class 4 is intended for irrigating plants and/or other similar purposes which requires the water quality. The results showed that the value of TDS in tofu

wastewater had increased but still below on the water minimum level of class 4. Thus, tofu wastewater can be used to irrigate plants or other similar purposes.

## CONCLUSION

The results showed that the addition of various mass in tamarind and winged bean seeds as much as 7, 9, and 11 grams of tofu factory wastewater had an effect on pH which increased from the initial condition of 2.5 to 2.6; 2.7; 2.8 in tamarind seeds, and 2.8; 2.9; 3.0 on winged beans. The COD test increased from the initial condition of 6619.20 mg / L to 7312, 64; 7880, 00; 8195.20 mg / L in tamarind seeds, and 9140.80; 10464.64; 9329.92 mg / L in winged bean seeds which have decreased again in the addition of 11-gram coagulant substance mass. TDS test has increased from the initial conditions of 1512 mg / L to 1715; 1736; 1848 mg / L in tamarind seeds, and 1890; 1988; 1855 mg / L in winged bean seeds

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