Decrease levels of total suspended solid in tofu liquid waste using biocoagulant charcoal

Sarti Saenab1, Rahmat Zarkasyi Ramadhani1, Usman1, Makhrajani Majid1 and Iradhatullah Rahim2

1Faculty of Health Sciences, Universitas Muhammadiyah Parepare, Indonesia
2Faculty of Agriculture, Animal Husbandry, and Fisheries, Universitas Muhammadiyah Parepare, Indonesia

Email: iradhat76@gmail.com

Abstract. A coagulant is a chemical needed by water to help settle small particles that cannot settle on their own. Meanwhile, total suspended solids (TSS) result from filter dissolved solids by gravity deposition, usually in chloride particles, and indicate the sedimentation rate. This study aimed to determine the effectiveness of bio coagulants to reduce levels of total suspended solids (TSS) in liquid tofu waste to find out which is more effective as a bio coagulant in liquid tofu waste. This research is experimental, consisting of 2 stages: the manufacture of charcoal from bio coagulants and the measurement of total suspended solids (TSS) levels. The data collected were tabulated and then analyzed descriptively. Three types of bio coagulants used were tamarind seeds, coffee husks, and cocoa pods. The results showed that there was a decrease in the TSS value before and after coagulation was given. The highest TSS reduction was obtained from bio coagulant charcoal from cocoa pods which reached 54.28% for a coagulant dose of 2 mg/l, while for a coagulant dose of 5 mg/l it could reduce TSS by 70.71%. It means the cocoa pods waste have a potential to use as coagulant to control sedimentation in the environment.

1. Introduction
Tofu businesses in Indonesia generally still use simple technology, so the efficiency of resource use (water and raw materials) is still low. This causes the level of waste production is also relatively high. Tofu industry activities are dominated by small-scale businesses with limited capital and do not carry out waste treatment [1]. Liquid waste from the tofu factory is usually disposed of directly into the nearest ditch or river, without any prior treatment [2]. The content of organic matter in the waste has an impact on the river. The river is cloudy and can be acidic or alkaline, the water becomes dirty, the surface of the water is coated with oily materials or other solid materials that cause surface closure [3].

Wastewater from the process of making tofu produces liquid waste which is a source of pollution for the environment. If the waste is discharged into the waters without treatment, it can cause death for microorganisms that play an important role in regulating the biological balance of water. Therefore, the handling of this liquid waste needs to be done. The tofu liquid waste produced contains suspended and dissolved solids. These solids can undergo physical, chemical, and biological changes that can cause health problems. This change in solids can produce toxic substances or create a medium for the growth of
pathogens, either in the tofu product itself or the human body. If left unchecked, this wastewater will change color to blackish brown and will cause a foul odor. These suspended solids come from the remains of soaking, washing, and boiling soybeans as ingredients for making tofu. Suspended solids can reduce the penetration of sunlight into the water, so it can affect oxygen regeneration and photosynthesis. Deposition and decomposition of organic matter can also reduce water quality which will affect water turbidity. The solution that can be done to overcome this problem is to treat the tofu liquid waste by settling (coagulation) of suspended solids before disposing of the tofu liquid waste. So that these solids are not wasted into the water.

Coagulation is the process of mixing coagulants with rapid stirring to stabilize colloids and fine suspended solids, then form micro-flocs or micro-flocs [4]. Micro flocs are small deposits produced from the addition of coagulant. Coagulation is carried out to reduce or neutralize the electric charge on colloids and suspended particles. The same electric charge on suspended particles in water that causes the particles to repel each other, thus making the particles or small colloids separate from each other. The coagulation process causes colloidal particles that are difficult to separate from water to become larger floc particles so that they are easy to separate by sedimentation, filtration or other separation processes [5]. The coagulation process serves to reduce or neutralize the negative electric charge on the particles, causing a van der Waals attraction to support the aggregation of colloids and fine suspended substances to form micro-flocs. Coagulation includes all the reactions and mechanisms involved in particle destabilization and the formation of larger particles through the perikinetic flocculation process [6].

Precipitation can be done with various types of chemical coagulants that are freely circulating in the market. However, natural coagulants can also be used or also called biocoagulants. Biocoagulants can be obtained easily, cheaply, even free of charge, around us. Several types of biocoagulants that can be used are derived from grains. Tamarind seeds have active substances in the form of saponins and tannins that can be used to remove microbes in liquid waste [7]. In this study also used other types of biocoagulants that are easily obtained around us. The purpose of this study was to determine the type of biocoagulant that is effective in depositing tofu waste water by measuring the levels of total suspended solids (TSS). TSS is the result of filtering dissolved solids by gravity deposition, usually colloidal particles and to indicate the rate of sedimentation [8]. TSS is the residue of total solids retained by the sieve with a maximum particle size of 2 m or larger than the colloid size. TSS can be in the form of mud, clay, sulfides, metal oxides, bacteria, algae, and fungi.

2. Materials and method

The research was arranged in the form of an experiment arranged in 3 treatments, namely B1 = tamarind seeds, B2 = coffee husks, and B3 = cocoa pods. Meanwhile, tofu water waste was obtained from the tofu factory waste storage in Kalosi, Enrekang Regency in March to June 2021. The tools used in this study were measuring cups, beakers, glass funnels, pH meters, thermometers, magnetic stirrer hotplates, bottles, pipettes, paper filters, ovens, analytical balances, and stationery. The materials used are tofu liquid waste, tamarind seeds, coffee berry husks, cocoa pods, and aquades.

2.1. Production of biocoagulants

2.1.1. Tamarin seed. Tamarind seeds used are tamarind fruit that is ripe / old and dark brown. Tamarind seeds were separated from the flesh, washed thoroughly and dried in the sun for ± 1 day. Then the tamarind seeds after drying were blended until smooth and sifted. Tamarind seeds that have become fine powder in the oven at a temperature of 105 °C for 30 minutes so that it is homogeneous and the water content in the tamarind seeds is constant. Tamarind seed powder is ready to be used as a coagulant.
2.1.2. *Cocoa pods husk.* Cocoa pods were cut into small pieces, washed with running water and then dried for about 1 day. After that, it was done for 15 minutes, then in a blender until smooth so that it obtained cocoa pod skin powder with a light brown color, smooth texture and uniform size.

2.1.3. *Coffee berry husk.* The coffee berry husk is washed until clean and then dried for less than 1 day. After the coffee rind is dry, it is then prepared for 15 minutes, after that it is blended until smooth so that the coffee rind powder is ready to be used as a coagulant.

Tofu liquid waste as much as 250 ml was put into a glass baker and added biocoagulants based on the treatment with a dose of 2 mg. The liquid waste is stirred 120 times for 1 minute, and allowed to settle for 15 minutes.

2.2. *Measurement of total suspended solids (TSS) levels*

The dose of affixing coagulant is practically determined in the laboratory using the jar test study. The jar test procedure is in principle a replica of the water treatment process on a small scale and in batch conditions. The jar test procedure consists of steps [9]: 250 ml of sample is taken and then put into a glass, each glass is then given a coagulant at a dose of 2 mg/l and 5 mg/l. After the addition of the coagulant, rapid stirring was carried out with a stirring speed above 60 rpm for one minute. Stirring was slowed down to 10 rpm to mimic the flocculation process. At this stage, the flocculation enlargement process began to be observed. This slow stirring was carried out for 5-10 minutes, after which it was stopped for later viewing of the deposition process. The deposition process was observed for 5-20 minutes, so that the ability of the flocculation to settle can be seen. After that, the supernatant (the part that does not settle) is filtered using filter paper. By using the same method/procedure, experiments and observations were carried out again for samples of liquid waste in other glasses according to the dose of coagulant added.

Determination of Total Suspended Solids (TSS) Content with filter paper was heated in an oven at 105°C for 1 hour, then cooled in a desiccator and weighed to a constant weight (B grams). A total of 10 ml was filtered. The filter paper and residue were heated in a n oven at 105°C for 1 hour, cooled in a desiccator and weighed to constant weight. The suspended solids content can be calculated in the equation:

\[
\text{Total Suspended Solid} = \frac{(\text{filter paper} + \text{residue} - \text{empty filter paper}) \times 1000 \text{ ml}}{\text{Number of samples (ml)}}
\]  

3. **Result and discussion**

3.1. **Result**

The measurement results on tofu liquid waste after the addition of biocoagulants are shown in Figure 1.
Figure 1. Total Suspended Solid (TSS) levels in tofu liquid waste after the addition of biocoagulants.

Figure 1 shows the highest TSS level in tofu wastewater that was not biocoagulated, which reached a level of 140 mg/l. The lowest TSS level was shown in the cocoa pod skin, both at a dose of 2 mg/l and a dose of 5 mg/l. The lowest TSS level after being given a coagulant of cocoa pod skin reached 41 mg/l at a dose of 5 mg/l.

Figure 2. Percentage of decrease in TSS levels in tofu wastewater when given biocoagulants.

A coagulant dose of 2 mg/l can be seen that there is a decrease in TSS in tofu liquid waste that has been coagulated with tamarind, the decrease in TSS reaches 45.71% while the TSS measurement in tofu liquid waste that is coagulated with coffee berry husk with a percentage of decrease and decrease in TSS 45.71%, and measurement of TSS in tofu liquid waste that was coagulated with cocoa pod skin with a TSS reduction percentage of 54.28%.

As for the dose of 5 mg/l, it can be seen that there is a decrease in TSS in tofu liquid waste that has been coagulated with tamarind, the decrease in TSS reaches 65.71%, while the TSS measurement in tofu
liquid waste that is coagulated with coffee rind with a decreased percentage of TSS 64.28%, and the measurement of TSS in tofu liquid waste that was coagulated with cocoa pod skin was indicated by the percentage of TSS reduction reaching 70.71%.

3.2. Discussion
Tofu liquid waste before being treated contains high suspended solids (TSS) of 66 mg/l, after being treated by adding tamarind seed powder the TSS value decreased by 45.71%. The treatment is at a dose of 2 grams of coagulant with a final TSS value of 140 mg/l, for the addition of a dose of coffee husks of 2 grams of coagulant and 250 ml of tofu liquid waste can reduce TSS by 45.71%, while cocoa husks can reduce the TSS value by 54.28%. The standard value of wastewater quality for soybean processing business as stipulated by the Regulation of the Minister of the Environment No. 15 of 2008 is 200 mg/l. The final value has not shown that the TSS parameter meets the quality standard [10].

The decrease in TSS in tofu liquid waste with a coagulant dose of 5 mg tamarind seeds 50 mg/l was able to reduce TSS by 65.71%, for coffee berry husk treatment with a coagulant dose of 5 mg it was able to reduce TSS by 64.28% and for cocoa skin treatment, able to reduce TSS by 70.71%.

Tamarind contains active substances in the form of tannins, essential oils, and several natural polymers such as albuminoids, starch, and gum. The decrease in TSS in tofu liquid waste by tamarind seed powder coagulant is due to the tannins contained in tamarind seeds are active substances that can cause the coagulation process. It also has compounds that can inhibit microbial growth, namely by inhibiting the work of cellulase, pectinase, peroxidase and oxidase enzymes.

Tamarind seed powder reduces TSS through the adsorption process and the neutralization of colloidal charge. Suspended particles or colloids in tofu liquid waste are negatively charged. The presence of charges on the surface of colloidal particles causes the formation of an electrostatic field around the particle, causing repulsion and attraction between the two particles. Tamarind seed powder has starch compounds that can accelerate the formation of flocs, by connecting the positive charge particles in the combination of coagulant and negative charge in the tofu liquid waste. Starch compounds contained in tamarind seeds function as a liaison between positive and negative charged particles through the adsorption process.

Coffee rind can be used to adsorb TSS from tapioca industrial wastewater. In increasing the percentage of TSS decrease in tapioca industrial wastewater because the activated charcoal has a wider surface because it is free from hydrocarbon deposits and the pores have been opened so that it is able to adsorb tapioca industrial wastewater. The adsorption process will continue until the optimum contact time is reached, where the greatest absorption of waste occurs by activated charcoal. When the optimum contact time is reached, all the activated charcoal surfaces have been covered by the adsorbate in the form of tapioca industrial wastewater. This is in accordance with Langmuir’s adsorption theory which states that the speed of adsorption on the surface is directly proportional to the part of the surface of the adsorbent or the active site that is not filled by the adsorbed molecule. In the process of adsorption of activated charcoal from coffee husks with adsorbate of tapioca industrial wastewater, a physical adsorption process occurs, where there is an attractive force between the activated charcoal adsorbent from coffee husks and the adsorbate in the form of liquid waste, so that the adsorbate can freely cover the entire solid surface [11].

Cocoa pods contain adsorption which is activated by nitric acid which can reduce the TSS content in POME. POME (Palm Oil Mill Effluent) is a non-toxic high volume liquid waste but has an unpleasant odor. Adsorption is widely used as an effective physical separation method to eliminate or reduce the concentration of various dissolved pollutants (organic, inorganic) in sewage. For the removal of organic contaminants from industrial wastewater, adsorption is one of the best effective and economical methods, so the adsorption process is quite attractive [12].
The formation of positively charged particle bonds from natural coagulants in the coagulation process occurs in the negatively charged particles. Particle bond formation can be enhanced by stirring, resulting in inter-particle saturation with different charges. As a result, floc will be formed. Fast stirring helps the coagulation process evenly into the water, making it easier for the positively charged coagulant particles to bind to the negatively charged tofu liquid waste.

The results of this study indicate that in reducing TSS in tofu liquid waste it is different from the results carried out by researchers. Another study reported that at a dose of 1500 mg/l it could reduce TSS in tempe liquid waste by 76.47%, similar research was carried out in reducing TSS in tofu liquid waste, the best treatment was obtained at a dose of 14 g/l which was able to reduce TSS by 67.29% [10].

The coagulant of tamarind seeds, coffee berry skin, and cocoa pod skin with a dose of 2 g/l has not been able to reduce the TSS level to meet the quality standard, there are several efforts that can be done so that the TSS level is in accordance with the quality standard, namely using a high stirring rotation speed with stirring time. which is relatively fast between 2-15 minutes. While a low stirring speed and a relatively long stirring time between 20-40 minutes are needed after the stirring process. The addition of quicklime also needs to be done so that the pH produced after the stirring process can meet the quality standards. Treatment by combining tamarind seed coagulant, coffee berry husk, and cocoa pod skin (chemical processing) with other methods also needs to be done. The treatment is combined with physical treatment (filtration) or biological treatment, for example with the addition of microorganisms. However, it is necessary to do research first to find out that these efforts can reduce the TSS level of tofu liquid waste in accordance with the quality standards that have been set. The use of this bio-coagulant has been proven to be effective in reducing TSS levels in waste so it is highly recommended for waste management in waters.

4. Conclusions
Tamarind seeds, coffee berry skin, and cocoa pods can reduce TSS in liquid tofu waste. Cocoa pod husk is the best bio coagulant that can reduce the total suspended solids of tofu liquid waste by 70.71% at a dose of 5 mg/l.

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