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Water Recycling System Through Filtration to Increase Production Efficiency at Small-Scaled Tofu Industry

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Abstract

Tofu industry, which consider as a small and medium scale industry (UMKM), use a lot of water in its production process. In order to increase its profit, they need to increase the efficiency of clean water usage. One method is through recycling the wastage water into a clean water so it can be used in the production process. In order to recycle the wastage water, people make use of a passive filter to reduce the dissolved solid and acidity in wastage water so it can be similar with fresh water. From the results of our experiment, an average of 30 litres of recycled water can be used in the production process which reflect to increment efficiency of 5% per day in production process. Therefore, a*s an impact of the economy, this water recycling process will reduce the production cost of making tofu using of recycled water. And from the social aspect it affects the reduction of fresh water from the ground and reduce odours that will occur in environment.*

Keywords*: filtration; recycled water, small-scaled tofu industry*

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Introduction

Tofu and tempeh are favourite food in Indonesian society. They can be enjoyed from lower to high class society. Tofu and tempeh have been acknowledged as a nutritious and healthy food with affordable price from long time ago. Almost, in every city in Indonesia, one can find tofu and tempeh industry. The industry, mostly, are categorized into small scaled industry or home-industry because they are managed by a village or a household. Most of them join into an association called "Koperasi Pengusaha Tahu dan Tempe (KOPTI)". This association will help them in managing the production and its cost as well as given them training. One of the association is located in Semanan, West Jakarta, which is the area where this community service was carried out.

Tofu production produce a lot of wastewater. This wastewater comes from tofu making process, which are cleaning, cooking, and pressing process. The wastewater contains a high concentration of pollutant, high in acidity and it should not been directly throwed into water resources because it can pollute the water. Hence, tofu industry need tools that can process the waste in order to reduce pollution risk and maintain clean water resource (Pamungkas & Slamet, 2017).

Mulyadi (2014:16) write in his books that "Production cost is the cost in processing raw material into a finished product", the information is used for this case study. In tofu production, one of this production cost is the cost of water usage. One way to reduce production cost is through reduced water usage in production (efficient water usage). Besides that, high water usage will lead to high wastewater. This high wastewater can pollute the environment. Usually, home industry do not have a proper water disposal system and they normally throw their wastewater in the sewer or river that they can pollute and give off a bad smell. They seldom recycle their wastewater.

Based on those facts, this community service's topic was chosen, about water efficiency in tofu production. This topic based on the needs of people that manage small scaled tofu industry in Semanan. They would like to increase their profit margin without increasing their price, thus they need to reduce the production cost. One method of reducing the production cost is through efficiency usage of clean water. This efficiency can be achieved through processing the wastewater into a clean water so they can use it back in the production. One of

this processing technique that make use of physical means are water filtration (Ayu Ridaniati Bangun et al., 2013). Water filtration is the water processing technique where the water is flowed into filtration medium to filter big and solid particle from the waste water (Dandy & Voijant, 2016). Wastewater from tofu production consists of organic material which are 40-60% Protein, 25-50% Carbohydrate, 10% fat and other solid suspension that can react physically, chemically and biology and produce toxic substance (Eva & Yusuf, 2015). In order to filter those materials, normally zeolite and carbon material are used.

Limestone and active carbon are highly used in water processing and well known. In research done by Mulasari, mixture that consist of 75% limestone and 25% active carbon has a high material reducing in filtering wastewater. The mixture manage to reduce Chlorine concentration as much as 65%, Iron (Fe) concentration as much as 67% and total dissolved solid in water up to 63% (Rahmah & Mulasari, 2016). As an impact of the economy, this water recycling process will reduce the production cost of making tofu using of recycled water. And from the social aspect it affects the reduction of fresh water (fresh water conservation) and reducing odours that will occur in environment.

Methods

Partner in this community service are KOPTI's officials and people that manage small-scaled tofu industry in Semanan. In this community service, the partner acts as training and counselling participant and also help community service team as a team in building the water filtration system. In conducting this community service, the team performed several steps, which are:

a) Introduction and Focus Group Discussion (FGD), at this step, the team would introduce the community service activity to the public figure and people around the area. FGD would be conducted to understand about the problem in their area especially clean water problem.
b) Design and development of clean water processing system. This step involves design of clean water processing system as well as installation of the system in their production system. In this step, our team and KOPTI official worked together for the installation.
c) Counseling and Training in managing water usage with 3R motto (Reduce, Reuse and Repair)

The detail of each steps are explained as follows:

A. Introduction and Focus Group Discussion (FGD)

This community service was started with introduction and FGD activity. According to the literature (Rizal Bisjoe, 2018), in solving the problem in community, one first need to find out and dig the problem that is happened in the community. These activities were conducted twice where the first activity was the introduction session, where the team gave the insight about energy efficiency that can be done in tofu production. Tofu production environment is shown in Fig. 1. Second activity was focused in FGD with the topic of efficiency increment in tofu production process (Fig. 2). This activity was participated by 6 people from KOPTI's official and small-scaled tofu industry's managers. The result of this activity is that they agree to do an efficiency in water usage. The result of FGD is shown in Table 1. One of the proposed solution for water usage efficiency is through the usage of filtered wastewater in tofu's production especially in pressing process.

Fig. 1 Tofu production environment in Semanan

The team had done several literature study and the needs from tofu industry, and choose to recycle wastewater through filtration system (Roshan, 2014). One of the filtration system that was used in tofu industry such as filtration system that was build by Eva (Eva, 2015). The system is build from a big tank where the water is through a sedimentation process before it is filtered with material such as river stone, palm fiber, tile, sand and coir. The system is quite big and costly to make. The other filtration system which is build by Agung Wahyu Pamungkas in tofu industry at Surabaya (Pamungkas, 2017). The filtration system make use

of digester to break down the material, after that it go through settler tank for sedimentation and pass through an anaerobic filter. The system is effective to clean the wastewater but it need a quite high cost which is around 200 to 500 million Rupiahs.

Fig. 2 FGD activity

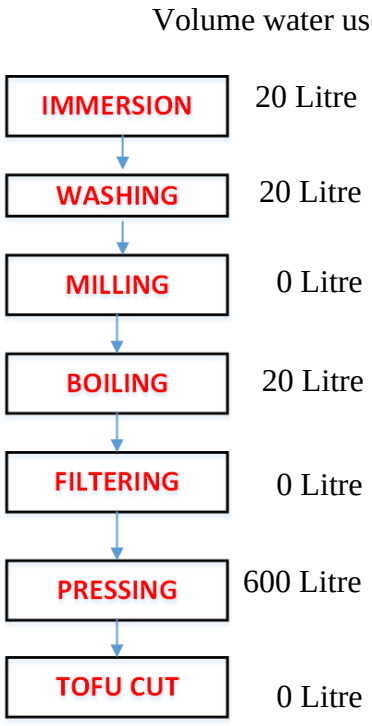

Fig. 3 Tofu's process production and water usage

Table 1. FGD Result

Efficiency selection	Respond		
	Agree	Neutral	Disagree
Manpower		√√	√√√√√
Raw material		√√√	√√√
Transportation		√√√	√√√
Water Usage	√√√√√	√	
Electricity	√√√	√√√	

B. Filter design

After several consideration, the filtration system that is chosen was a passive filtration because it consumes no energy and easy to make. Beside that the production cost was quite low. The filtration materials that is chosen were only three material which were, sponge, limestone and active carbon. Fig. 4 shows the configuration of the filter system and position where the inner and outlet of the water.

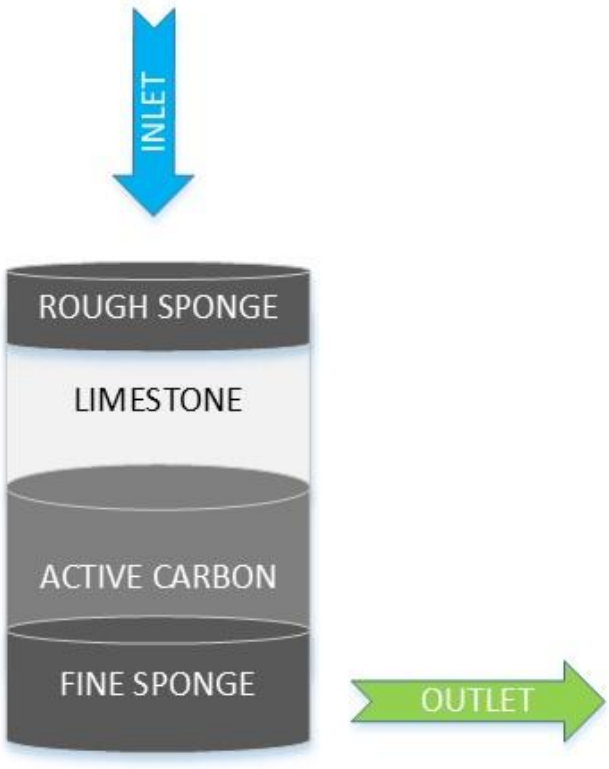

Fig. 4 Schematic of the filtration system

The specification for the sponge, lime stone and active carbon are shown in Table 2.

Table 2. Material specification

Material	Properties	Weight (gram)
Sponge	(1) Density:14-110kg/m3 (2) Hardness:30-90 (3) Tensile Strength: 0.75-1.50kg/cm2 (4) Tear Strength: 0.5-1.46kg/cm2 (5) Specific Elongation:70-140%	300
Lime Stone	% CaCO3 92 – 95 % MgCO3 2.50 (max.) % Silica 1.50 (max.) % Fe2O3 0.2 (max.) % Others 0.6 Size 0 – 6 mm/ 6 -25 mm/ 25 -50 mm	600
Active Carbon	ign. Residue ≤2% (600 °C) loss: ≤10% loss on drying surface area: 800-1500 m2/g mp: 3550 °C bulk density: 150-440 kg/m^3	1400

Results and Discussions

In order to find the correct combination for the filtration system for this community service, the team conducted a small experiment by taking a small sample of wastewater and tested in laboratory environment. The analysis was done based on the reference (Tarru, 2019). The analysis was done to find the correct combination of limestone and active carbon that can filtered the wastewater into clean water. The steps done were:

A. Wastewater sample taking and small prototype

In this step, the team collected the wastewater sample from the tofu production process. The team measured the pH level and dissolved solid in the water using pH meter and TDS meter.

During collection, the team also made a small filtration system with the steps as follows:

1. Preparing three 1.5 liter plastic water bottles. The bottles then be filled with filtration medium such as sponge, active carbon, limestone and cotton with each bottle has different combination (Laras, 2015). There are three variant that were used, which are the variant with composition of limestone and active carbon with proportions of 70:30, 50:50, and 30:70.
2. The bottom of the water bottles were cut so they could be filled with the wastewater from the bottom. The water bottles then be positioned vertically with the bottom part facing upward, so the wastewater flowed from bottom of the bottle to the top. (Fig. 4). This way, the bottle was able to filter the wastewater passively.

3. The filter process were done three times, where the wastewater would pass the bottle three times. After that, the filtered water was kept inside another plastic bottle and stored in the glass jar.

4. The filtered water then brought to the laboratory to be applied a physical and biological test such as smell, color, pH and TDS.

Fig. 5. Sample testing of wastewater filtration

Fig 6. pH and TDS testing for filtered water in laboratory environment

B. Laboratory test

The filtered water that has been kept in glass jar were tested in the lab. The tests were:

a) Smell test. The test were done by making use of human's sense of smell. The filtered water were smelt to know their odor. The results are shown in the Table 3.
b) Visual test. The test were done by making use of human's sense of vision. The filtered water was compared to check if it was clear. The results are shown in Table 4.
c) Acidity test. The test were done using pH meter. The purpose of the test was to know the acidity of filtered water and the result are shown in Table 5.
d) Dissolved solid test. The test were done using TDS meter. The purpose of the test was to know how many small solid material were still in the filtered water. The result shown in table 6.

Table 3. Result of smell test for filter percentage 70:30, 50:50 and 30:70

Ratio percentage composition of limestone and active carbon in filter	70:30		50:50		30:70	
Trial	**Pyshical condition (smell)**					
	Before filtration	**After filtration**	**Before filtration**	**After filtration**	**Before filtration**	**After filtration**
1	+	-	+	-	+	-
2	+	+	+	-	+	-
3	+	+	+	+	+	-

Remarks: +: have odor - : no odor

Table 4. Result of vision test for filter percentage 70:30, 50:50 and 30:70

Ratio percentage composition of limestone and active carbon in filter	70:30		50:50		30:70	
Trial	**Pyshical condition (clarity)**					
	Before filtration	**After filtration**	**Before filtration**	**After filtration**	**Before filtration**	**After filtration**
1	+	+	+	+	+	-
2	+	+	+	+	+	-
3	+	+	+	-	+	-

Remarks: +: cloudy - : clear

Table 5. Result of acidity test for filter percentage 70:30, 50:50 and 30:70

Ratio percentage composition of limestone and active carbon in filter	70:30		50:50		30:70	
Trial	**pH**					
	Before filtration	**After filtration**	**Before filtration**	**After filtration**	**Before filtration**	**After filtration**
1	4.5	5.08	4.5	6.2	4.5	6.69
2	4.4	5.2	4.6	6.1	4.4	6.5
3	4.4	5.5	4.4	6.1	4.6	7.56

Table 6. Result of Dissolved solid test for filter percentage 70:30, 50:50 and 30:70

Ratio percentage composition of limestone and active carbon in filter	70:30		50:50		30:70	
Trial	**TDS(ppm)**					
	Before filtration	**After filtration**	**Before filtration**	**After filtration**	**Before filtration**	**After filtration**
1	1200	1100	1200	1050	1230	350
2	1250	1050	1250	1000	1250	360
3	1450	1105	1350	1050	1350	365

From the experimental result, the team was able to see that the filter that have the best filtration result were the filter that have combination of 30% limestone and 70% active carbon. The result shown that the filter able to reduce dissolved solid from 1230 ppm to 360 ppm, returned the water's pH to neutral (near 7), less odor and have clear vision. Thus, the team built a prototype with this combination.

C. Development of prototype

After a successful mock-up prototype with 1.5 liter plastic bottle, the team built a prototype of filtration system that make use of plastic pipe and pump. The prototype is shown in Fig. 7. The prototype shown was built from a 40 cm in diameter of PVC pipe with a length of 60 cm. Bottom of the pipe was covered with a plastic cylinder with diameter of 45 cm and the top of the pipe was covered with cylinder cover sized 41 cm. Left and right side of the pipe was being drilled for the inlet and outlet of the filter. A PVC pipe with diameter of 7 cm with

a length of 6 cm was attached on both inlet and outlet of the pipe. In the filter inlet, a pump with the flow capacity of 5 litre/hour was being used. Fig 8 is the blueprint of the design.

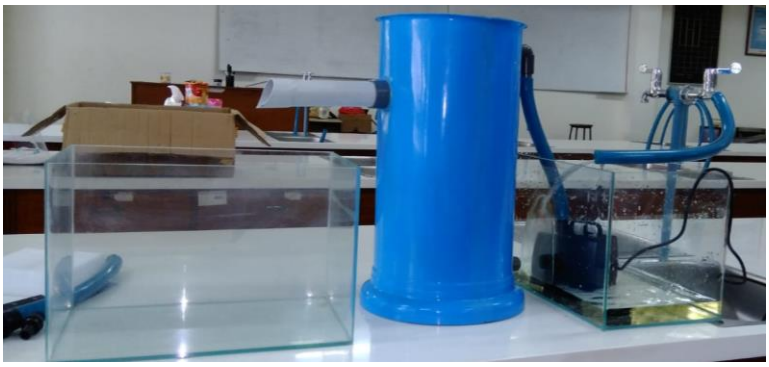

Figure 7. Filtration system that is used in tofu production system

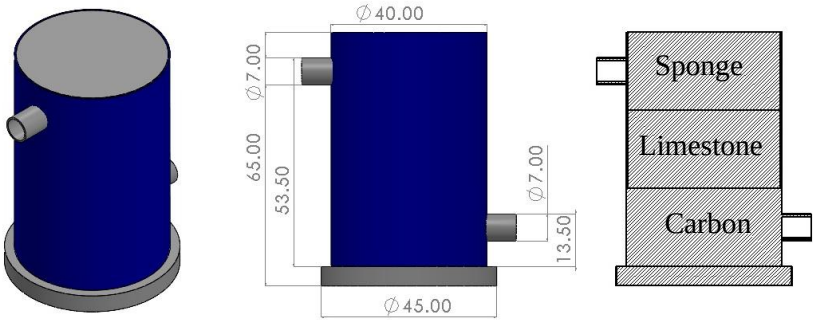

Figure 8 Blueprint of the filter with dimension in centimeter

In building and developing the prototype, KOPTI's official and small-scaled tofu industry managers were also actively participated and gave input for the design. The filter was able to produce 5 liter of clean water per hour based on the pump provided. If the tofu production is done for 6 hours, means that the filter can be used to obtain 30 liter of clean water. This 30 liter of clean water from filtration would be used back in the tofu production process. Thus, it would cut their water consumption from 600 liter to 570 liter. This is equal to 5% of reduction in water usage for one filtration system.

In order to measure the reliability of the prototype, the team had used this prototype in the tofu production for two months. The team found out that the system working fine and every three days the filters needed to be cleaned due to residue material that clogged the material of

the filter and to avoid unpleasant odors. The carbon filter also needed to be changed in each month.

D. Focus group discussion and closing

The prototype of filtration system had been given to people in Semanan. Besides that, to conclude the activity, the team conducted another focus group discussion (FGD) with a topic of water efficiency. In this FGD which attended by SME owners and their staffs, the team collected the idea for using the water efficiently and some words that most revealed from the audience were: Recycle, Reduce, and Repair. The result is shown in Table 7.

Table 7. FGD result for motto

Choice of word	Respond		
	Agree	Neutral	Disagree
Reduce	√√√√√	√√	
Reuse		√	√√√√√
Recycle	√√√√	√√	√√√√
Repair	√√√√√	√	
Replace		√	√√√√√

Conclusion

From this community service activity, there are conclusion obtained:

1) In order to increase profit of small-scaled tofu industry, one can provide an efficiency in water usage. The process is done through filtering the wastewater from the production
2) The filtering process can be done using passive filter with the combination of 30% limestone and 70% active carbon
3) Through this filtering process, one can reduce water consumption from 600 litre per day to 570 litre per day. There is an efficiency of 5% in water usage for one filtration system
4) In order to maintain the efficiency of clean water and to remind the community, it was chosen a motto which are 3R (Recycle, Reduce, and Repair) based on FGD with the community.

For further research in this subject area it is suggested to search for implementation methods with lowest energy consumption for waste water treatment systems.

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