

Identification Soybean Processed Waste Environmental Impact and Management Alternatives

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Abstract

This research was conducted by direct observation in one of the industries in the city of Jakarta. Data processing is carried out by reviewing the literature and using Simapro 9.1.1.7. The purpose of this study is to determine the selection of the most appropriate taju-processed waste treatment to be carried out in industrial studies. Processed soybeans such as tempeh and tofu are some of the foods that the people of Indonesia favour. The Tempe and Tofu processing factory produce tofu with the essential soybean ingredients as much as 17 kg every day. The tofu production process starts from soybean immersion, grinding, boiling, filtering, compaction, moulding, cutting, to frying tofu. Production activities from the tofu industry will certainly produce solid and wastewater. These wastes can have a negative impact on the environment. Therefore, the waste must be managed and treated correctly to create an environmentally friendly industry and improve environmental quality. Tofu industry waste management and treatment can be done by identifying the generation of waste that is a priority to be treated and choosing waste treatment technology. There are three alternatives for wastewater treatment from the tofu industry: the chlorine in wastewater, ponds by forming biofilms using biofilter media, and Trickling Filters.

Keywords: Processed soybeans, wastewater, management, treatment

1. Introduction

Tofu is a healthy, nutritious and popular soy-based food. Based on the Central Statistics Agency data, around 38% of soybeans in Indonesia are consumed in the form of tofu products [1]. Tofu is produced through a process of grinding, refining, pressed into a board and then cut into 5 cm cubes on the side [2]. The tofu factory is located in the South Jakarta area, which is located in South Jakarta. The tofu factory has four rooms that are shared to manufacture tofu and tempeh in one building with a length of 48 m and a width of 6 m. The tofu production process consumes 17 kilograms of soybeans and produces 1 quintal of processed soybeans in a day. Due to the significant use of water in making tofu, the waste generated is also quite large. The quality of the wastewater produced by tofu dregs has a relatively high organic content and can be treated by biological processes [3, 4]. Production capacity from year to year always increases in line with market demand. The solid waste of the tofu industry produced is in the form of tofu dregs from the filtering of boiled soybean porridge. Tofu dregs still contain high enough protein to cause unpleasant odours and tastes, so they need to be appropriately managed.

The environmental management strategy of the tofu industry has begun to change according to the current ecological conditions. These changes lead to preventive or preventive efforts that continue to be developed sustainably. Management and processing of industrial tofu waste are essential to study because they are related to business actors who can increase their income from waste processing and

demand to create an environmentally friendly industry and improve environmental quality. Wastewater treatment technology in developing countries tends to use biological treatment technology. However, natural treatment depends on the biodegradability of wastewater [5]. Previous research has shown that tofu wastewater can be treated by biological processes and has reasonably high effectiveness [6, 7, 8]. Even now, waste to energy technology has been developed by utilizing microorganisms from tofu industrial wastewater [9, 10, 11]. This study aimed to determine the management of soybean processed waste as follows, identify priority waste generation, and choose the most appropriate biological waste treatment technology.

2. Material and Methods

This research was conducted by conducting field surveys and literature studies. The field survey was conducted in the South Jakarta area. When the survey was conducted in August – November 2019. The survey location is one of the cooperatives managed by the community itself. The survey was conducted to find out the scheme of the tofu industrial processing process. Identification of waste generation and characteristics is carried out using a literature study approach. The calculation of the environmental impact of tofu industry activities is carried out using the Simapro 9.1.1.7 Software. The database used is Agri-footprint 5 with an impact analysis method in accordance with the 2018 Environmental Declaration Product (EPD) 2018. Waste minimization studies are carried out by looking at the existing conditions of the industry. Waste treatment technology is carried out by providing recommendations from the literature that has been carried out.

3. Results and Discussion

Waste Generation Identification

The activities carried out by this factory are processing soybeans into tempeh and tofu products. Initially, some of the tools used were still traditional, such as burning using kerosene. However, kerosene is getting scarcer, so the fuel is replaced with wood. Burning wood produces charcoal which makes the factory look rundown. From Figure 1, it can be seen that the tofu production process begins by soaking soybeans for 4 hours in water. This activity is done so that the soybeans become softer. Soybeans that have been soaked are then put into a grinder.

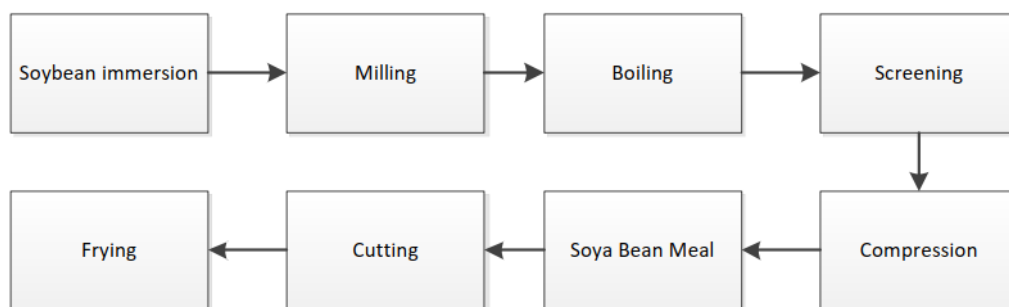


Figure 1. Schematic of Tofu Production Process Activities

In carrying out its production, the tofu industry indeed produces waste from the process carried out. Waste generated from the tofu industry can be in the form of solid waste or liquid waste. Solid waste is generated from the filtering process. Meanwhile, liquid waste is generated from soaking, boiling, compacting, printing and frying. The liquid waste produced in the tofu industry is more than solid waste. In a day, about 13 m³ of liquid waste and two sacks of solid waste are produced. The resulting liquid waste is discharged into the river next to the industry, while the solid waste is used to

make tempe gembus. Liquid tofu waste discharged into the environment is an organic waste that is easily decomposed by microorganisms naturally. Tofu waste that is not treated correctly will cause an odour due to the degradation of organic matter by bacteria [12].

In making tofu in the Soybean Processed Industry in South Jakarta, of course, it produces waste from the process carried out. Industrial waste produced includes liquid waste and solid waste. Two things need to be considered in characterizing waste, namely physical and chemical parameters. The parameters used to indicate the characteristics of the tofu industry wastewater are [13]:

- a. Physical parameters such as turbidity, temperature, solids, odor and others.
- b. Chemical parameters consisting of BOD, COD, TOC, dissolved oxygen (DO), oil or fat, total nitrogen, and others for organic chemical parameters. As for the inorganic chemical parameters, namely pH, Pb, Ca, Fe, Cu, Na, sulfur and others.

The diagram of the waste generated from the process carried out in the tofu industry is described in Figure 2. The results of the calculation of environmental impact weighting based on survey data and running with Simapro 9.1.1.7 Software can be seen in Figure 3. The highest environmental impacts are Eutrophication and Acidification.

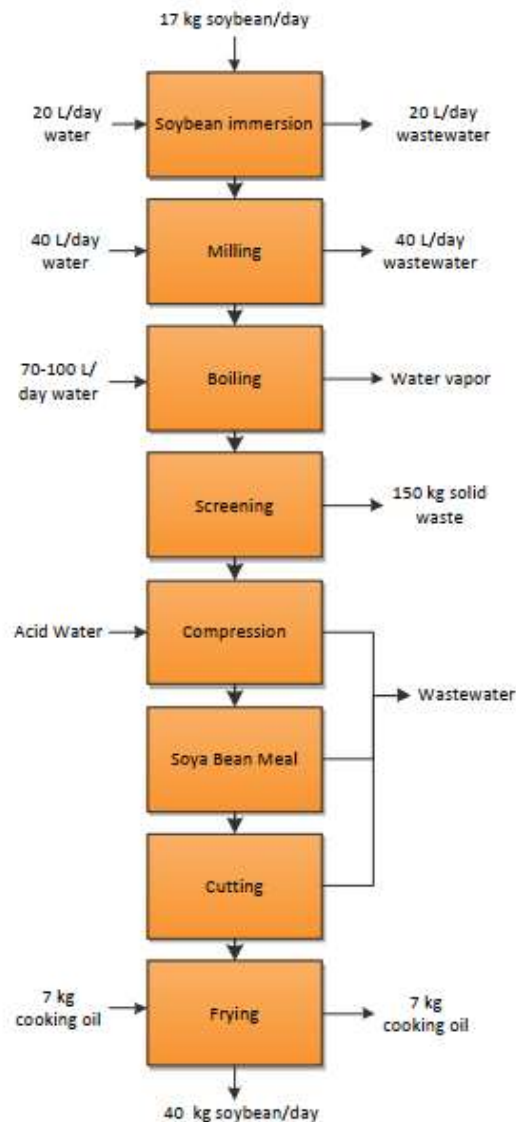


Figure 2. Diagram of Generated Waste

In uncontrolled conditions where industrial waste containing high organic and nutrient content is allowed to enter the waters, it can become a bait for mass algae growth known as algal bloom and eutrophication in water bodies [14, 15, 16]. BOD (Biochemical Oxygen Demand) is a characteristic that indicates the amount of dissolved oxygen required by microorganisms (usually bacteria) to decompose or decompose organic matter under aerobic conditions [17]. Waste from the industrial tofu process contains high dissolved organic matter. A high BOD value indicates that there are many organic compounds in the waste, so that a lot of oxygen is needed by microorganisms to decompose organic compounds. Suppose the content of organic and inorganic compounds is large enough. In that case, the dissolved oxygen in the water can reach zero, so aquatic plants, fish, and other aquatic animals that require oxygen do not allow life [18]. The COD value in tofu industrial wastewater is usually greater than BOD because most compounds are more easily oxidized chemically than biologically.

One of the critical characteristics of tofu industrial wastewater is the degree of acidity. This is because the tofu industrial wastewater tends to be acidic; in acidic conditions, volatile substances will be released. This situation causes the liquid waste produced by the tofu industry to emit an unpleasant or foul odour. pH is very influential in the wastewater treatment process.

Another characteristic of liquid waste produced in the tofu industry is suspended solids or called TSS. TSS are all solid substances (sand, mud, and clay) or particles suspended in water and can be living (biotic) components such as phytoplankton, zooplankton, bacteria, fungi, or dead (abiotic) components such as residues and other inorganic particles [19]. If there is TSS in the water, it will affect the level of turbidity of the water. The turbidity that occurs is caused by the presence of suspended and dissolved organic and inorganic materials. The higher the suspended material content, the cloudier the water [20].

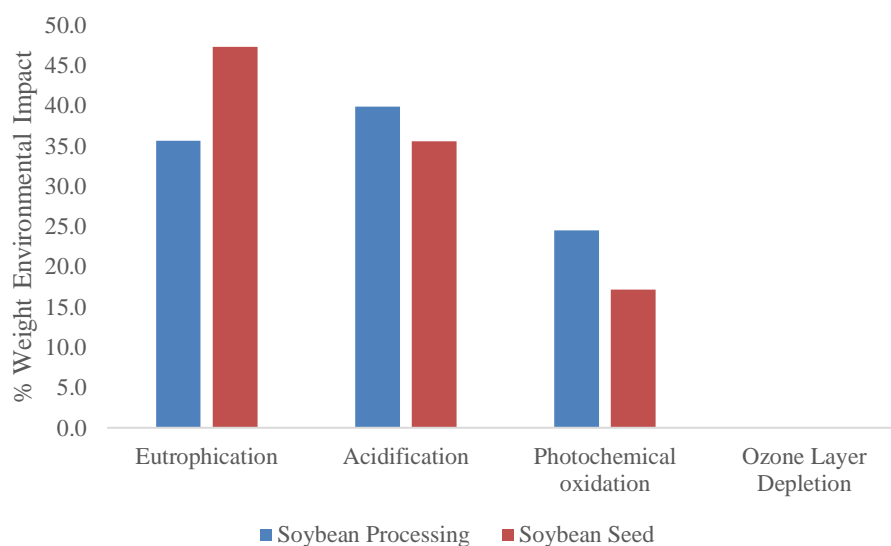


Figure 3. Result of Impact Calculation on Refined Soybean and Soybean Seed Process

Minimization of Soybean Wastewater

Wastewater generated from soaking, grinding, boiling and filtering will be channeled to the tofu waste management site in the factory. In the waste treatment process, an anaerobic process is used to produce methane gas used to generate electricity for the tofu factory's operations. A tool that can make liquid waste have CH₄ is a digester. After going through the digester, the wastewater flows through 6 reservoirs. After that, the liquid waste will be filtered using a red pumice filter. Wastewater that has been screened can be directly discharged into water bodies. The following is a picture of the Wastewater Treatment Plant (WWTP) owned by the Tempe and Tofu Factory. During the compaction process, there is residual water resulting from the compaction process (Figure 4). This residual water

is acidic and is used by the industry to be used as a natural tofu compactor that will be made in the future. The tofu compaction process only takes 10 minutes.



Figure 4. Acidic Water Produced by Industry

Processing Technology Selection

At the Tempe Tofu Factory, South Jakarta, a separate Wastewater Treatment Plant (IPAL) is already used to treat liquid waste produced from the tofu-making process. However, there is only physical processing, which consists of several sedimentation tanks. Meanwhile, tofu liquid waste contains high organic matter, which requires further processing, such as biological treatment. Therefore, 3 alternative technologies are recommended that can be used to treat liquid waste from tofu production, namely:

- Alternative 1

Processing of tofu factory liquid waste by giving chlorine to wastewater. This treatment consists of reservoir 1 (inlet), reservoir 2 with the addition of chlorine, and reservoir 3 (outlet) [21].

- Alternative 2

Tofu factory wastewater treatment with pond technology by forming biofilm using biofilter media. Biofilters are made of fishing nets and bio-balls and are used as a medium for the growth of microorganisms [22].

- Alternative 3

Tofu factory liquid waste treatment using Trickling Filter. The working principle of the Trickling Filter is to spread wastewater into biofilm media such as bamboo, gravel, ceramics, or others. This media is given attached bacteria that remove organic substances contained in tofu wastewater [23].

The processing in alternative 1 can be seen after the waste is processed in 1 day, starting from reservoir 1 (inlet), reservoir 2 with chlorine, and reservoir 3 (outlet). Then, alternative 1 proved effective in removing TSS by 66.9%, ammonia by 66.2%, and pH previously acidic can become neutral after processing. However, alternative 1 is not effective in processing BOD and COD because after processing, there was an increase in the content of BOD and COD [21]. Other studies also mention that giving chlorine can increase COD levels [24].

Processing progress in alternative 2 can be seen starting from a contact time of 1 hour for BOD and TSS removal, and a contact time of 4 hours for COD removal [22]. Then, alternative 2 proved effective in removing COD by 22.89%, BOD by 41.91%, and TSS by 90.05% [22]. Processing progress in alternative 3 can be seen starting from a contact time of 4 hours to remove BOD and COD so that the GO for processing progress is visible. Then, alternative 3 proved effective in eliminating

BOD of 66.6667% and COD of 40.4651% [23].

Alternative 2 has several drawbacks, such as complicated design, not all parts and construction materials are easily found on the market, and the incoming waste flow must be constant [25]. Meanwhile, alternative 3 construction parts and materials are easy to find on the market, resistant to fluctuations in the amount of wastewater and concentration fluctuations [22]. Therefore, the technology that is easier to implement is alternative 2. Maintenance for alternative 3 must be carried out by skilled/expert personnel [25]. The use of technology for alternative 3 is still rarely applied in Indonesia, so its maintenance is considered problematic. In contrast to alternative 2, which has been more often involved in Indonesia.

Problems that can occur with these two alternatives are clogging and odours. In alternative 2, for the risk of clogging, the probability of occurrence is moderate, and the impact of the problem is severe. Clogging is a blockage that can occur in the sewage pipe so that water can overflow into the environment, and microorganisms in the biofilm can also die [26]. This happens because of contaminants or microorganisms from the biofilm that are carried to the wastewater disposal pipe. In alternative 3, for the risk of clogging, the probability of occurrence is significant and has a severe impact. Clogging occurs due to increased biomass growth caused by differences in volume size in the filter media cavity [27]. For the risk of causing an odour, the likelihood and seriousness values are the same for both alternatives. The likelihood of this happening is excellent and has a severe impact as well. Under conditions of high organic load (>400-500mg/L BOD), it will affect limited filter performance, and anaerobic conditions arise, which cause odours [28].

4. Conclusion

The South Jakarta Soybean Processed Industry produces liquid and solid waste. Wastewater is a priority waste in processing because of its reasonably complex characteristics containing BOD, COD, high pH, TSS, nitrogen, oil and fat. From these parameters, the impact of eutrophication is the highest impact that needs to be reduced from a soybean processing industry. Three alternatives can be an option for processing tofu factory liquid waste, namely by adding chlorine to the liquid waste, ponds (ponds) by forming biofilms using.

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