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Use of biogas from tofu industry for domestic use at Probolinggo City - Indonesia

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Abstract. Tofu industries produce by product of whey which is still rich in organic content. Tofu industry of using soy bean of 1400 – 1600 kg/day produces 25 m³ of wastewater per day of 6321 mg COD/liter. This high content of COD and volume of wastewater instead of potential pollution could be transformed into biogas and used by local communities for domestic purposes like alternative energy for cooking. This study is aimed to assess the possibility of using wastewater from tofu industry by local communities for cooking. Asri Tofu Industry with such typical production of wastewater was assessed to treat its wastewater while the by-product of biogas would be used by local communities for cooking. About 38 m³ biogas per day could be produced per day and can be used by at least 117 houses in the nearby factories not far from 300 m from the factory. The use of biogas would reduce local community expenses to buy LPG and woods for cooking.

1. Introduction

Tofu is one of most popular traditional food in Indonesia. Not only tofu is rich for protein and carbohydrate, it is also easy and cheap to produce. Hence it is not surprising that tofu industries are at large in Indonesia. Tofu industries are generally run by home industries where the environment health could be sub-standard [1].

Traditional tofu production is simply to take the advantage of protein which clots easily when mixed with acid. Vinegar or CH₃COOH is commonly used as the acid and whey is the by-product when the protein of soy bean do not clot with the vinegar. Tofu production process is shown in Figure 1.

Wastewater from cleaning and soaking of soy bean may have low organic content and maybe disposed to open water without harm. Whey, however, when it is not recycled, then this highly organic content waste would endanger the environment if disposed directly to open water [1]. Wagiman [2] mentioned that the disposal of untreated wastewater from tofu industries might be due to (1) inadequate budget to install or operate the wastewater treatment plants, (2) no appropriate technology for such home industries, (3) lack of environment awareness, (4) no direct poor impact when wastewater is disposed to open water.



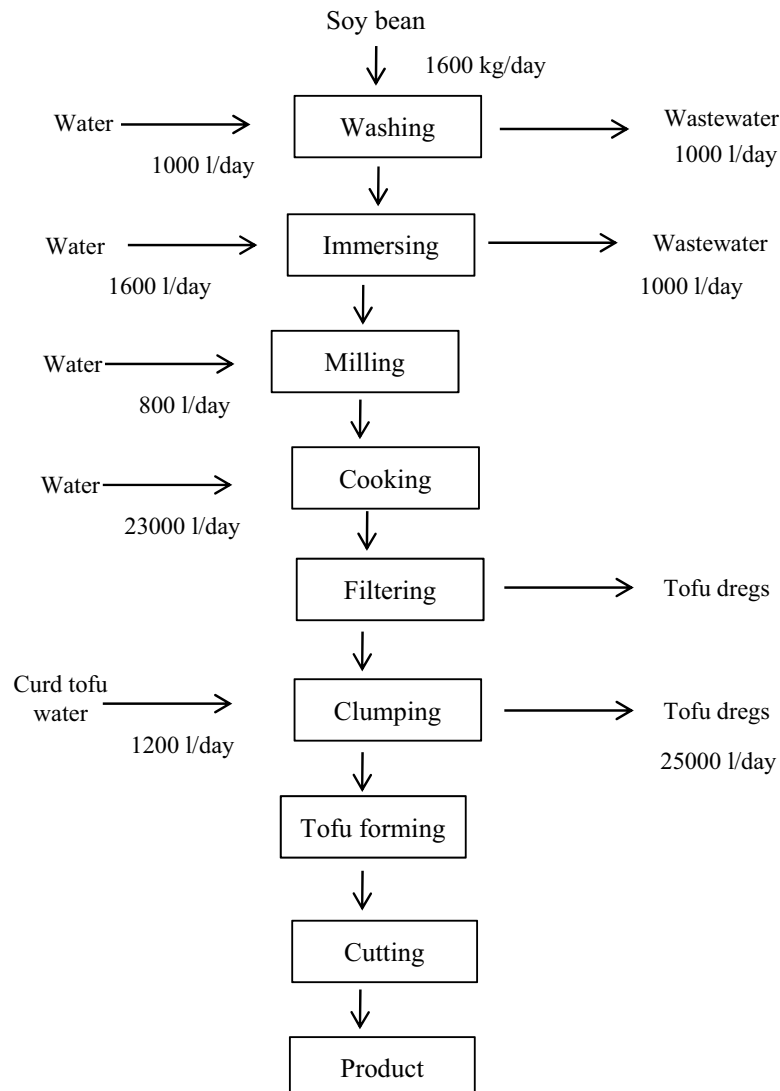


Figure 1. Tofu production process at Factory of Tahu Asri

According to Potter et al. [3], wastewater from tofu industries is amounted 15-20 liters/kg of soy bean used. Some pollution would be 30 g TSS/kg soy bean (1.500-2.000 mg/L), 130 g COD/kg (6500-8500 mg/L), and 6 g BOD/kg (3250-4250 mg/L). This high content of organic enables to use anaerobic treatment process while biogas may also be obtained as by-product. The gas may be utilized to boil the soy bean during the tofu production. According Pamungkas [4] not only biogas is used for tofu production but is also utilized as gas burner to cook at nearby communities. Pressurized biogas is conveyed through PVC pipes from the wastewater treatment plant's gas holders to local houses. Each house connection is charged for retribution for the operation and maintenance of the system. Success of biogas use is dominantly supported by active role of local government, community participation, and availability of local facilitators [5].

Environment Agency of Probolinggo City nurtures two tofu factories, namely Proma and Sumber Baru Tofu Factory, not only to treat the wastewater, but is also to utilize the biogas. Another factory, Asih Tofu Factory, is about to be developed for further biogas utilization. Biogas reactors for the two

earlier factories were provided by the Agency which the biogas was used by local communities for cooking. Retribution for biogas service is between IDR 15000 – 30000 for each house connection per month. Retribution fee is used for operation and maintenance the system and to provide pipe network to distribute the biogas. Tofu factory management is responsible for biogas distribution. Retribution is collected by the management for operation, maintenance, and connection cost. Complaint or any feedback from the customers is directed to the management. Minor or major problems in the treatment plants and distribution are reported by the management to the Agency while repair was conducted by the Agency [6]. Performance of the two factories is shown in Table 1.

Table 1. Performance of the two tofu factories.

No.	Item	Name of tofu factory	
		Proma	Sumber Baru
1	Labour number	24	15
2	Working time	09.00 – 13.00	07.00 – 17.00
3	The Need for Soybeans	700 kg	1000 kg
4	Waste discharge	8.33 m ³ /day	11.9 m ³ /day
5	Concentration of COD	8.723 mg/L	6.230 mg/L
6	Biogas production	38 m ³ /day	37 m ³ /day
7	Number of biogas users	46 houses	42 houses
8	Biogas needs	30 m ³ /day	36 m ³ /day
9	Capacity of <i>Gas Holder</i>	29 m ³	96,2 m ³
10	Pressure to <i>Gas Holder</i>	0.0064 kg/cm ²	0.00054 kg/cm ²

Biogas reactors are floating drum type in which biogas pressures are due to mass of floating cover. Biogas holder at Proma Tofu Factory is separated from the anaerobic treatment plant. The plant is made of fiber-glass of 7 mm thick of tube type with 3.5 meters' diameter of 3 meters high. Separated gas holder is prism shape with 2.9 meter side of 3.45 high to give gas volume of 29 m³. In Sumber Baru Tofu Factory, biogas holder is directly on top the wastewater treatment plant. It is a tube type with 6.3 m diameter of 2 m high. The dome is also about 6.3 m high of 1.6 m high to give a gas holder of 96.2 m³. Photos of the two gas holders of the factories are shown in Figure 2.



Figure 2. (a) Gas holder biogas of Tahu Proma Factory, (b) reactor and gas holder biogas Factory of Tahu Sumber Baru

Proma and Sumber Baru Tofu Factory need 700 kg and 1000 kg of soy bean per day with connected house connection of 46 and 42 houses. Asri Tofu Factory with higher raw material's need is very potential source of biogas for its local communities. The Factory at 17 Sutami Street of Jebeng Kidul Sub-district, Wono Asih District, at Probolinggo City uses 1400-1600 kg soy beans/day. The factory treated the wastewater using anaerobic filters and was coupled with biogas holders. The biogas, however, was not distributed to local houses yet. Houses at RT 05 RW 03 of Jebeng Kidul Sub-district is only 100 m apart from the factory. Local communities are mostly work as farmers, labors, traders, and some works as employers at local government and companies. Currently LPG and woods are used for the stove. Three to four LPG are used monthly which is equally to IDR 45000-65000. Biogas from Asih Tofu Factory would reduce monthly expenses to buy LPG and woods. Asri Tofu Factory location is shown in Figure 3. This study is aimed to access the biogas production from tofu factory to be used for domestic purposes as alternative energy like cooking.

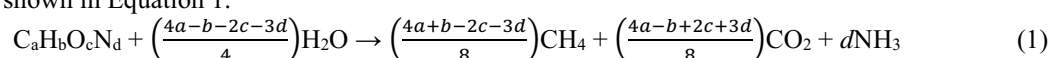


Figure 3. Asri Tofu Factory and its vicinity local houses

2. Materials and methods

2.1. Biogas production

Lettinga [7] mentioned that biogas was produced through the sequence of hydrolysis, acidogenesis, acetogenesis, and then methanogenesis. The overall biogas production according to Tchobanoglous [8] is shown in Equation 1.



Solid retention time (SRT) and hydraulic retention time (HRT) are two important parameters in anaerobic digestion process. Design criteria for SRT is shown in Table 2.

Table 2. Solid retention time in digester [9].

Temperature (°C)	SRT _{min} (day)
18	11
24	8
30	6
35	4
40	4

HRT at Prima and Sumber Baru Tofu Factory is 2.7 and 5 days, respectively. Volume of digesters is shown in Equation 2.

$$\text{Volume digester} = Q_{\text{sludge}} \times \text{SRT design} \quad (2)$$

2.2. Coverage of biogas production

Biogas production in term of methane (CH₄) production is calculate as show below in Equation 3.

$$\text{Volume CH}_4 = \frac{Mr_{\text{CH}_4} \times \text{Organic mass}}{Mr_{\text{organic mass}} \times \text{density of CH}_4} \quad (3)$$

Energy produced by 1 m³ of biogas is equivalent to 0.48 kg LPG [10]. The number of houses in term of house connection is calculated based on Equation 4.

$$\text{Number of houses connected} = \frac{V_{\text{biogas}} \times 0.48 \text{ kg LPG} \times 30 \text{ days}}{3 \text{ kg LPG} \times \text{The number of LPG 3kg per month}} \quad (4)$$

3. Results and discussion

3.1. Biogas reactor design at Asri Tofu Factory

Biogas reactor is designed as in Sumber Baru Tofu Factory. It is tube type with reactor at the bottom and gas holder at the top (floating drum type). As mentioned in Table 2, SRT is 5 days with wastewater temperature of 30-42 °C. As maximum soy bean use is 1.600 kg per day with wastewater volume of 25 m³ then using Equation 2 the volume of reactor will be at least 125 m³. The reactor will be made of fiber of 7 mm thick with diameter of 6.3 m of 4 m high. The biogas at Asri Tofu Factory will be similar as in Sumber Baru Factory of floating drum type. It is a fiber glass type of 7 mm thick with a diameter of 6.2 m of 4 m high. Gas holder will be 6.3 m of diameter of 2 m high while the dome will be 6.3 m of diameter of 1.6 m high. Design of biogas is shown in Figure 4.

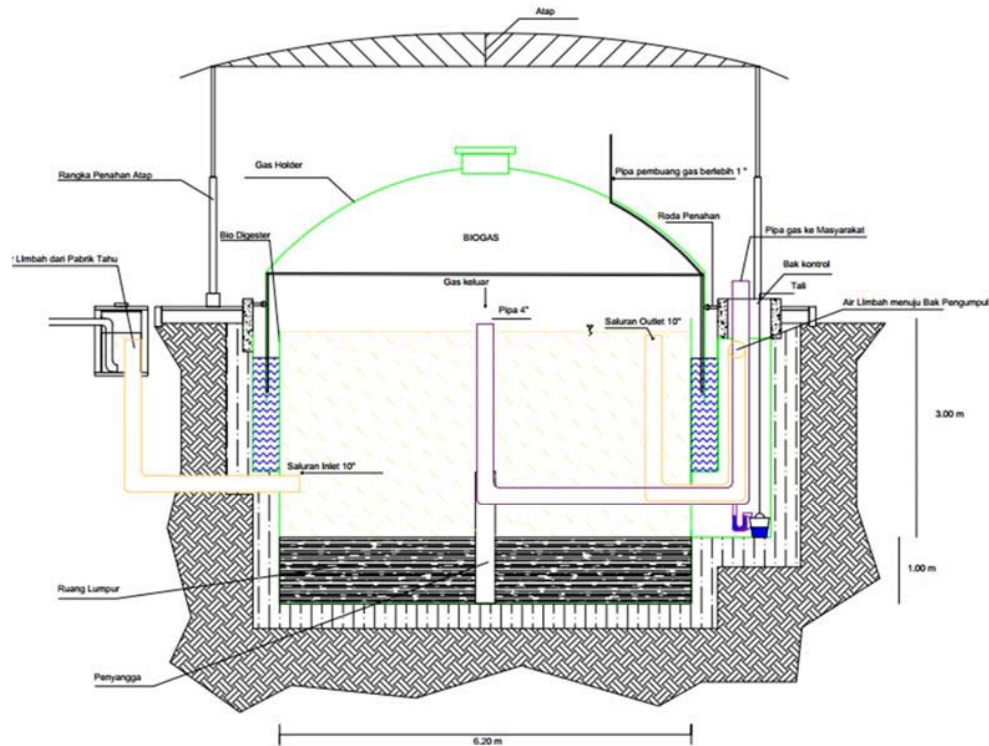


Figure 4. Biogas design of Asri Tofu Factory

3.2. Service coverage of biogas production

Biogas volume is designed based on equation (2). In this study, the design of Sumber Baru Tofu Factory is similarly applied to Asri Tofu Factory as wastewater characteristics of both factories were not comprehensive yet. Effluent COD of Asri Tofu Factory is similar to Sumber Baru Tofu Factory which are 6320 and 6230 mg/l, respectively. Using 1000 kg soy bean per day, Sumber Baru Factory produces 36 m³ biogas/day. Similarly, Asri Tofu Factory of using 1600 kg soy bean per day will produce biogas of 57.6 m³/day.

Based on livelihood survey around Asri Tofu Factory then majority of the households use 3kg-LPG of 4 units per month. Based on Equation (3) then the number of households or houses can be served by the biogas system will be 60 houses. The closest community to the factory will be houses at RT 05 of RW 03. Pipe distribution for biogas is PVC type of 3 in as main pipe while 1 in diameter is for house connection. The farthest house can be connected is 300 m from the gas holders. Biogas pipe network in RT05 RW03 is shown in Figure 5.



Figure 5. Biogas pipe distribution network from Asri Tofu Factory

Retribution from each house is IDR 15000 per month for operation and maintenance; but another IDR 15000 is used for saving which can be used for many other purposes like extending pipe network and helping new house connection for connection fee. As compared of using 3 kg-LPG, it costs IDR 45000 to 65000 per month. Hence this biogas production reduces household monthly expenditure; excluding COD removal to water body and reduction of CH₄ emission to the atmosphere.

4. Conclusions

Biogas from Asri Tofu Factory can be utilized by 60 households of RT05 RW03 of Jrebeng Kidul Sub-district, Wonoasih District of Probolinggo City. This by-product of tofu factory helps to reduce household monthly expenditure for cooking energy. Besides, treating tofu effluent is not only reducing COD discharge to open body, but it also reducing CH₄ emission to the atmosphere as it used for cooking purposes.

References

- [1] Kaswinarni F 2007 *Kajian Teknis Pengolahan Limbah Padat dan Cair Industri Tahu Studi Kasus Industri Tahu Tandang Semarang, Sederhana Kendal dan Gagak Sipat Boyolali*. (Thesis) [Semarang (Indonesia)] Program Pasca Sarjana Ilmu Lingkungan Universitas Diponegoro
- [2] Wagiman 2007 Identifikasi Potensi Produksi Biogas dari Limbah Cair Tahu dengan Reaktor Upflow Anaerobic Sludge Blanket (UASB) *Jurnal Bioteknologi* **4**(2) pp 41-5
- [3] Potter C, Soepardi M and Gani A 1994 *Limbah Cair Berbagai Industri di Indonesia Serta Sumber Pengendalian Dan Baku Mutu* (Surakarta: EMDI- Bapedal)
- [4] Pamungkas A W 2017 *Perancangan Tipikal Instalasi Pengolahan Air Limbah Industri Kecil*

- Rumah Tangga (IKRT) Tahu di Kota Surabaya* (Essay) [Surabaya (Indonesia)] Program Sarjana Teknik Lingkungan – Institut Teknologi Sepuluh Nopember
- [5] Farahdiba A U, Ramdhaniati A and Soedjono E S 2014 Teknologi dan Manajemen Program Biogas sebagai Salah Satu Energi Alternatif yang Berkelanjutan di Kabupaten Malang *Asian Journal of Innovation and Entrepreneurship* **3(2)** pp 145-59
- [6] Gemardi A dan Marbun T K 2017 *Studi Pengelolaan Limbah Cair Pabrik Tahu Di Dinas Lingkungan Hidup (DLH) Kota Probolinggo* (Laporan Kerja Praktik) [Surabaya (Indonesia)] Program Sarjana Teknik Lingkungan – Institut Teknologi Sepuluh Nopember
- [7] Lettinga, Gatze and Haandel A C V 1994 *Anaerobic Sewage Treatment, a Practical Guide for Regions with a Hot Climate* (London: John wiley and Son)
- [8] Tchobanoglous G, Theisen H and Vigil S 1993 *Integrated Solid Waste Management* (Singapore: McGraw Hill)
- [9] Reynold 1996 *Unit Operations and Processes in Environmental Engineering* (Boston: PWS Publishing Company)
- [10] SGC 2012 *Basic Data on Biogas* (Sweden: Swedish Gas Technology Centre)