

# The Ecological Impact of Tempeh Industrial Center in Sanan Village

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## ABSTRACT

Sanan Industrial Centre is one of the household industrial centers in Malang City. Waste produced in Sanan Industrial Center comes from two sources; they are from tempeh and cattle farmers industries. Fourteen tempeh industries utilize waste from tempeh as food and drinks for cattle. In comparison, other 149 tempeh industries do not use the waste from tempeh and choose to discharge them into rivers, which causes rivers to be polluted. Some industries utilize cow manure into biogas in Sanan Industrial Center. This research aims to calculate the availability and needs of soybean waste and wastewater as food and drinks for cattle, also to calculate the availability and needs of biogas. The analytical methods used are analysis of the availability and needs of soybean waste and wastewater, analysis of the availability and needs of biogas, and cluster analysis. The availability of untapped wastewater is 4,157 liters/day, and the needs of drinking water for cattle is 2,577 liters/day. The availability of untapped soybean waste is 3,541 kg/day, and the needs of food for cattle is 3,522 kg/day. The availability of energy in Sanan Industrial Center is 3,809 m<sup>3</sup>/day, and the needs of energy for cooking is 378.2 m<sup>3</sup>/day. There are 59 groups spread in Sanan Industrial Center for biogas distribution consisting of industries and cattle farmers.

**Keywords:** *Ecological impact, waste utilization, tempeh industry, biogas, analysis of the availability and needs, cluster analysis.*

## 1. INTRODUCTION

Industrial activities have positive and negative impacts. The positive impact of industrial activities is producing goods and services, increasing employment rates, which ultimately able to improve life quality. Meanwhile, the negative impact is producing waste and environmental pollution, which causes the environment to become dirty and polluted [1]. Based on Government Regulation No. 101 of 2014, waste is the remainder of a business and/or activity [2]. Waste is unused thrown material, which harms the community if it is not appropriately managed. Waste comes from the production process. The industrial waste produced can be in the form of solid, liquid, and gas [3]. Based on Minister of Manpower Decree No. 187 of 2016, wastewater is the remainder of a business and/or liquid activity identified from all industrial activities (production process waste, domestic waste, and utility waste) [4].

Malang, as a tourist city, has an environmentally sound vision. The Regional and Spatial Planning of Malang City states that every industry in an industrial center must be equipped with a waste treatment system that is adjusted to the waste type produced during the production process. It is prohibited from disposing of waste generated into environmental media, water, air, and soil as long as the waste has not met the required quality standards [5]. Based on the Spatial Planning of Malang City for 2010 – 2030, the strategic area determination of Malang City is by

developing household industrial center and non-pollutant small industries as a strategic economic area [6]. Malang has several household industries that produce superior products; one of the superior products of Malang is tempeh.

Sanan is one of the household industrial centers for tempeh and tempeh crackers found in Malang City. In the process of producing tempeh and tempeh crackers, several stages need to be done; they are the cooking of selected soybeans process, fermentation process, packaging, and labeling. Tempeh industry produces waste, namely liquid and solid waste. Solid waste comes from the soybean skin that floats during the washing process, while liquid waste is in the form of soybean wastewater and soybean soaking wastewater. Based on the result during the interview, liquid waste produced for 100 kg of soybeans is 40 liters. Solid waste and liquid waste are used as food for cattle. Energy used during the production process of tempeh crackers is from Liquefied Petroleum Gas. In the production process, temped produces a secondary product in the form of liquid waste. Based on the result, during field observation, 18 industries utilize wastewater as drinks for cattle. However, 182 industries do not use wastewater and immediately discharge them into rivers and sewers. Pollution is caused due to the large volume of waste and direct disposal to the environment without any prior processing. It causes rivers and sewers to become smelly and polluted. The tempeh industry is one of the household industries that produce a large-scale waste if it

is not managed correctly, and it will cause environmental pollution.

One way to utilize cow manure is by processing cow manure into organic fertilizer, which is useful for fertilizing the soil and can be used as raw material for making biogas since cow manure contains bacteria that produce methane gas. These bacteria help in the fermentation process so that they can accelerate the process of biogas formation [7]. There are cattle farmers in Sanan Industrial Center who utilize cow manure for biogas. The amount of cattle in Sanan Industrial Center is 535 cows with 135 cattle farmers. Universitas Brawijaya inaugurated the biogas village in RT. 05 RW. 15 Sanan, Malang City. The biogas development starts from February 6, 2018, until the present. At present, three houses use biogas, one of which is the tempeh industry, with a total of 12 cows used for biogas. The biogas is distributed and utilized to the residents' house through pipes. Based on the result, during the interview with the Chairperson of RT. 05, the existing biogas can be used as fuel and petromax lamps for households.

Based on the interview with one of the cattle farmers, the existing cow manure is directly discharged into the river without any processes because no place can be used to process the cow manure. On the other hand, if the cow manure is let to be piled up and indirectly discharged into the river, it will cause disease. Cow manure that is directly discharged into rivers will cause environmental pollution and unpleasant odors. Since cow manure can produce energy in the form of gas, which is used for household and industrial activities, its utilization can reduce unpleasant odor, prevent the spread of disease and can replace the use of Liquefied Petroleum Gas. Therefore, this research was conducted to measure the availability and needs of resources used for biogas in the Sanan industrial Center. This research was carried out in the expectation that biogas could reduce waste pollution and reduce the use of Liquefied Petroleum Gas. The research problem is to find out the ecological impact of tempeh industrial center existence in Sanan Village. This research aims to identify and analyze the ecological impact of tempeh industrial center existence for the surrounding environment. In particular, this research was conducted by measuring the potential availability and needs of resources used for the availability of biogas in the Sanan Industrial Center, as it is known that industrial activities have an ecological impact. Definition of the ecological impact according to the explanation of Article 15 Paragraph 2 Letter b Law No. 32/2009 [8] concerning the impact and/or risk of Living Environment, from Chapter X Section 3 Article 69 states the prohibition of pollution, including dangerous and toxic objects (B3), entering waste into the environment media and so on. Meanwhile, household industries in villages still experience technical and social constraints in managing their waste. The existence of household industries is expected to have a positive impact on the surrounding community, but they must also manage the negative impact that will occur.

Biogas is one of the renewable energy resources produced from the process of decomposition of organic materials by

microorganisms in a rare state of oxygen (anaerobic). The primary source of biogas energy is cattle manure. Biogas can be burned like Liquefied Petroleum Gas, so it can be used as an alternative energy resource that is eco-friendly and renewable. Biogas can also provide secondary products in the form of compost, which can increase soil fertility and soil quality because it is very rich in organic sources. According to the research by Sri Wahyuni, a cow can produce a cow manure of 20 – 29 kg/day. Cows have the potential to produce gas production of 0.023 – 0.040 m<sup>3</sup>. Biogas, as an energy resource of 1 m<sup>3</sup> is equivalent to 0.46 kg of Liquefied Petroleum Gas [9]. Biogas can be used by humans to reduce waste and be eco-friendly energy as a substitute for Liquefied Petroleum Gas. Processing cow manure into biogas can reduce dependence on energy use, particularly Liquefied Petroleum Gas and can reduce environmental pollution.

## 2. ANALYTICAL METHODS

### *2.1. Analysis of the Availability and Needs of Soybean Waste and Wastewater Automata*

The supply-demand analysis is carried out to determine the availability and needs of wastewater that can be utilized by industry. Supply is the volume of wastewater produced by industry (liters/day), while demand is the need for water (liters/day) obtained from the number of cattle (a cow) multiplied by the need for drinking water for cattle (liters/day/cattle).

### *2.2. Analysis of the Availability and Needs of Biogas*

Analysis of energy supply and demand is one of *the* analytical tools that will be used to determine the availability of cow manure and how much the needs of energy for the community to cook. Supply can be applied as a supply of fuel energy resources from biogas by considering the availability of cow manure as a raw material for making biogas. The potential of gas produced uses 0.040 m<sup>3</sup>. Based on the result, during the interview, cow manure production is 25 kg/day/cattle. Demand means that the needs of energy resources for cooking are seen from the characteristic of fuel consumption by the community for cooking. Demand is the needs of energy resources that is seen from the characteristic of fuel consumption by the community. The formulation to calculate the needs of biogas energy needed by cattle farmers and non-farmers in Sanan Industrial Center can use the standard. The result of supply and demand analysis is used to determine the amount of availability and needs of energy.

### 2.3. Cluster Analysis

Cluster analysis is used to categorize a group by having proximity between settlements. The categorize can be adjusted with proximity and statistics. Spatial cluster analysis is obtained by looking at the proximity between each settlement and other settlements, and then the cluster can occur. In categorizing settlements into a group or cluster will be using the Nearest Neighbor method. Nearest Neighbor analysis requires data on the distance between settlements and the closest settlements nearby, namely "closest neighboring settlements". This analysis is a method of quantitative geographic analysis that is used to determine the distribution pattern of settlements through GIS mapping.

Average Nearest Neighbor Analysis can analyze settlement patterns by knowing the area. By using ArcGIS, it is known that community settlements that form clusters are based on proximity, making it easier for biogas distribution.

The nearest neighbor ratio shows the distribution index of settlements. The resulting index will have results between 0 – 2.15. A value of 0 indicates that the pattern tends to have a clustered type, while approaching 2.15 has a uniform pattern (regular), whereas if it is in the middle of the value means it has a random pattern.

Observed Mean Distance is the distance that will be observed between points (parcel). This research used the results from Observed Mean Distance, which were seen to cluster the cattle farmers and industries.

## 3. DATA COLLECTION METHODS

Data collection methods are techniques used to collect data. The method designates a way through interviews, observation, and documentation. Data collection methods are the aspect that has a role in this research success. Data and information are needed in research to support the expected objectives of the research conducted. Data used in this research were collected through two methods; they are primary and secondary observation.

### 3.1. Secondary Observation

The secondary data collection method is a method of collecting data by studying scientific works, literature, reports, and other literature related to the issues discussed. The secondary observation in this research was obtained from literature studies related to the research.

### 3.2. Primary Observation

The primary data collection method is a method of collecting data through direct observation of existing conditions in the field. The primary observation can be in the form of field observation or interviews with predetermined respondents. The primary observation in this

research was conducted from field observation, interviews, and questionnaires.

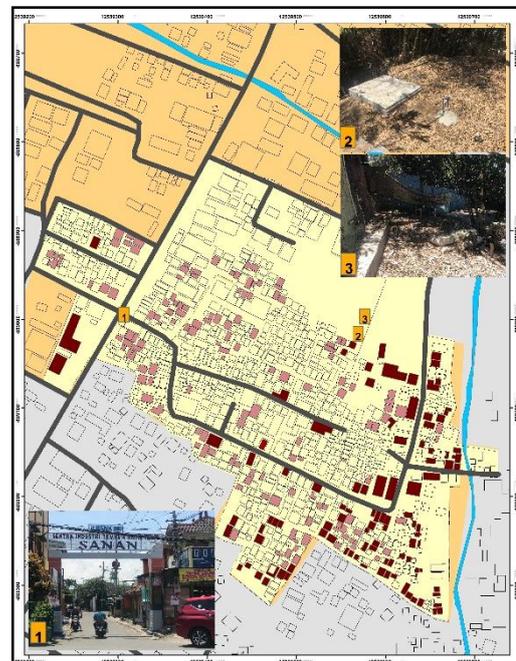
Field observation is direct observation and a systematic recording of issues related to the research activities being proposed. Data needed from field observation are tempeh industries spread, biogas distribution, and cattle farmers spread.

An interview is a method of collecting data utilizing question and answer, which is carried out systematically and based on the research objectives. Data needed from the interview are the number of industries, the amount of cattle farmers, tempeh industry production processes, and the resulting waste.

Questionnaires are data collection techniques through forms containing questions raised in writing to a person or group of people to obtain answers or responses and information needed by researches [10]. Data needed from the questionnaire is the amount of waste produced from tempeh production processes, fuel used for cooking, costs incurred for cooking using the fuel, the number of cattle owned, and the amount of cow manure produced.

## 4. RESULTS AND DISCUSSION

Sanan Industrial Center is included in Purwantoro Urban Village, Malang City. The majority of Sanan residents are tempeh artisans who had passed down since a long time ago and did not know when the tempeh production began. Sanan is a household industry area in Malang, which consists of 3 hamlets (RW), namely RW 14, RW 15, and RW 16. Sanan industrial Center has a land area of 14.4 Ha.



**Figure 1** Tempeh industries spread in Sanan Village

### 4.1 Production Process in Sanan Industrial Center

Soybeans used as tempeh raw materials are imported soybeans from the United States since they are readily available, cheaper, better, and bigger than other types of soybeans. Then, the process will continue with the soybeans' boiling process until cooked. The old boiling system used wood as fuel, kerosene, and stoves, but since 2004 after the policies and subsidies, the industry now had used a new system by using Liquified Petroleum Gas, low and high-pressure type of gas stove. The place used as a boiling container also uses stainless as the material. Then the process continues with the soybeans cracking with a new system using a soybean cracking machine. After separating soybeans from their skin, then soybeans that have been separated from their skin are soaked for 18 hours. It aims to increase the acidity degree for the fungus to be easy to develop. If soybeans have been soaked, the next process will be the boiling process again to get soybeans perfectly cooked. Then, finally giving the yeast into soybeans that have been boiled. There are two yeasts used, which are rubbed yeast and powder yeast. Afterward, soybeans that have been given yeasts are going into the molding process. Soybeans are then flattened and covered using banana leaves or plastic that has been perforated. The fungus will be developed for around 24 hours or even two days.

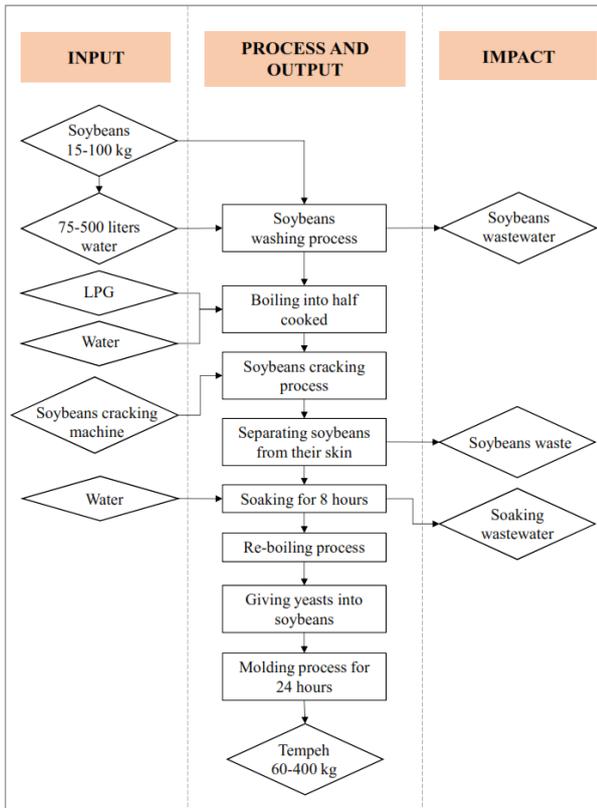


Figure 2 The production process diagram of tempeh industry

### 4.2. Waste in Sanan Industrial Center

There are two sources of waste produced from tempeh and cattle industries in the Sanan Industrial Center. The types of waste in the tempeh industry are solid waste and liquid waste, while in the cattle industry is solid waste. Waste produced by the tempeh industry is in the form of soybean waste and wastewater. Soybean waste is produced during tempeh production processes, which is at the stage of separating soybeans from their skin. The tempeh industry that has cattle will utilize soybean waste into food for cattle. Meanwhile, industries that do not have cattle will sell their soybean waste for the cattle farmer. Soybean waste, which is used as food for cattle, produces side products such as cow manure that can be used as biogas. On the other side, there is also wastewater; the remaining water comes from the soybeans boiling process. Similar to soybean waste, soybean wastewater is also used as a drink for cattle, but some industries do not utilize the wastewater from tempeh production. For industries that do not have cattle will directly discharge the wastewater from the boiling process into the river, in addition to wastewater, there is also wastewater not being utilized from the washing and soaking processes and directly discharged into the river.

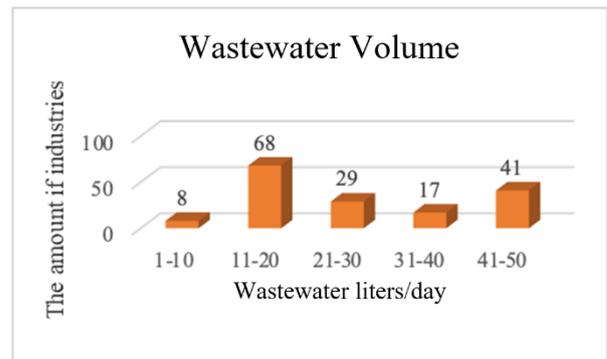


Figure 3 Volume chart of soybean waste

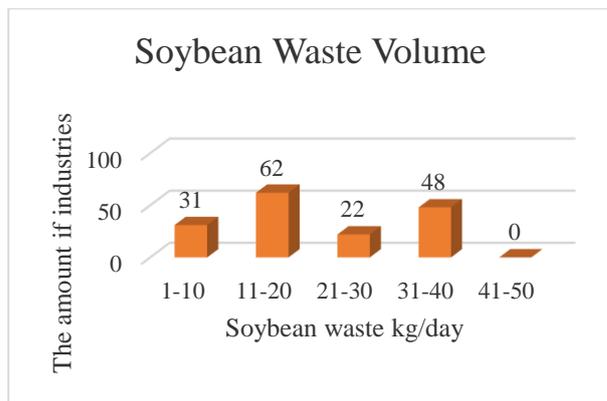


Figure 4 Volume chart of wastewater

From Figure 3, it can be seen that the most volume occurred of soybean waste produced by the tempeh industry is 11 – 20 kg/day. While figure 4 stated that the

most volume occurred of wastewater produced by the tempeh industry is 11 – 20 liters/day.

Cattle used in this research focus on beef cattle. Waste produced from tempeh production processes, soybean waste, and tempeh production wastewater is used as food and drinks for cattle. The existing cow manure is currently not utilized by the community and directly discharged into the river. It causes an unpleasant odor around the rives, and the river becomes polluted. The available cowshed located alongside the river makes it easy for the cattle farmers to discharge the cow manure into the river directly. It is contrary to the fact that the available cowshed will become dirty and have an unpleasant odor if the cow manure is not directly discharged into the river since there is no place for processing the cow manure.

The most volume occurred of cow manure is 50 – 150 kg/day, with a total of 96 cattle farmers. Waste produced by the tempeh industry can be used as food and drink for cattle. At the same time, cow manure produced by the cattle can be utilized as biogas to substitute Liquified Petroleum Gas for the tempeh industry.

### **4.3. The Availability and Needs of Soybean Waste and Wastewater**

#### *4.3.1. The availability of wastewater as drinks for cattle*

Fourteen tempeh industries utilize wastewater as drinks for cattle. Those tempeh industries that utilize wastewater from the tempeh production process also have cattle; therefore, they can utilize the wastewater into drinks for cattle. However, on the other side, 149 other industries have not utilized wastewater since they do not have cattle; because of that, the wastewater produced is directly discharged into the river. Based on the calculation of the wastewater availability that can be utilized as drinking water for cattle is a total of 583 liters/day. In comparison, the needs of water for cattle to drink is a total of 3,160 liters/day. Therefore, the availability of wastewater from 14 tempeh industries is not enough based on that calculation to meet the drinking water needs for cattle. The following is a comparison of the availability of untapped wastewater and drinking needs for cattle.

**Table 1** Comparison of wastewater availability and drinking water needs for cattle

The availability of untapped wastewater	4,157 liters/day
The needs of drinking water for cattle	2,577 liters/day

Based on Table 1, it can be seen that the availability of untapped wastewater can help the lack of drinking water needs for cattle by utilizing wastewater to be utilized as drinks for cattle.

#### *4.3.2. The availability and needs of soybean waste as food for cattle*

Fourteen tempeh industries utilize wastewater from the tempeh production process into drinking water for cattle, in addition to that those industries also utilize soybean waste into food for cattle. Based on the calculation, the result shows that the availability of soybean waste in 14 tempeh industries in total is 428 kg/day, while the needs of soybean waste as food for cattle is around 3,950 kg/day. Therefore, the availability of soybean waste is insufficient for the needs of food for cattle based on the above calculation result. To fill the lack of needs of food for cattle, other tempeh industries that have not utilized soybean waste should start to utilize their soybean waste in order not to make them wasted. Based on the calculation, it is known that there 149 other industries that have not utilized their soybean waste, which is in the amount of 3,541 kg/day. The following is a comparison of the availability of untapped soybean waste with the needs of soybean waste to be made into food for cattle.

**Table 2** Comparison of soybean waste availability and food needs for cattle

The availability of untapped soybean waste	3,541 kg/day
The needs of food for cattle	3,522 kg/day

Based on Table 2, it can be seen that the availability of soybean waste that has not been utilized is sufficient to help the storage of needs for soybean waste as food for cattle, in order to make the untapped soybean waste becomes beneficial.

### **4.4. The Availability and Needs of Biogas**

Cattle found in Sanan industrial Center are cows. The cow is beef cattle. Cow manure production in Sanan Industrial Center is approximately around 25 kg/day/cattle. Afterward, they are converted into biogas energy by using a standard 0.040 m<sup>3</sup> of potential gas produced per kg of cow manure. Industries in Sanan uses Liquified Petroleum Gas for cooking, so it is needed to compare the use of Liquified Petroleum Gas with the energy consumption ratio of biogas and other cooking fuel resources per 1 m<sup>3</sup>. 0.46 kg per 1 m<sup>3</sup> is used as a comparison for biogas compared with Liquified Petroleum Gas. Multiplying the number of existing cattle and the amount of cow manure by the standard of 0.04 is used to find out the availability of biogas. The results obtained after calculations show the availability of biogas in Sanan industrial Center, based on the amount of cow manure as much as 13,375 kg/day can produce biogas potential for cooking needs every day at 29.3 m<sup>3</sup>/day and for the availability of energy that is equal to 3,809 m<sup>3</sup>/day. Each industry has different energy needs depending on the use and production processes of tempeh and tempeh crackers. In this case, the alternative energy supply can also use biogas, one of the things to be underlined is the adequacy of energy supply from cattle owned by each

tempeh industry. Based on the calculation, the energy needs for cooking are approximately 378.2 m<sup>3</sup>/day.

#### **4.5. Biogas Distribution**

Cluster analysis which aims to categorize cattle farmers and industries into groups for gas distribution as seen from the proximity of cattle farmers to surrounding industries used in Sanan Industrial Center to find out the gas distribution. Based on the result of the nearest neighbor analysis, it obtained a z-score of -60.7 and a p-value of 0.000000. The z-score is less than 2.58, and the p-score is less than 0.02, which means it can be concluded that the settlement pattern is clustered. The nearest neighbor ratio shows the number of 0.01, which means the settlements spread in Sanan Industrial Center are clustered because it has a value of less than 1.00.

The gas distribution in Sanan Industrial Center is seen based on the proximity of cattle farmer houses to industry places. Based on the result of spatial cluster analysis, the maximum distance of gas distribution is 7.22 meters from the cowshed.

The grouping of cattle farmers and non-farmers is used to determine the availability of energy from cattle waste to meet the energy needs of non-farmers from each group.

Based on the calculation of the availability and needs of energy for cooking, the remaining energy owned from each group can be known. There are 59 groups spread across Sanan industrial Center. The following is a map of the availability and needs of energy from each group.

### **5. CONCLUSION**

1. Waste in Sanan Industrial Center produced from 2 sources, and they are from tempeh and cattle industries. Types of liquid and solid waste for tempeh industries and solid waste for cattle farmers. Tempeh industries that have cattle at the same time utilize waste from tempeh production processes as food and drinks for cattle.
2. Fourteen tempeh industries utilize waste produced from tempeh production processes as food and drinks for cattle. The availability of untapped wastewater is 4,157 liters/day, and the need for drinking water for cattle is 2,577 liters/day. For the availability of untapped soybean, waste is 3,541 kg/day, and the needs of food for cattle is 3,522 kg/day.
3. In Sanan Industrial Center, the availability of energy is 3,809 m<sup>3</sup>/day, and the needs of energy for the cooking process is 378.2 m<sup>3</sup>/day.
4. There are 59 groups spread in Sanan Industrial Center for biogas distribution consisting of industries and cattle farmers.

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