The potential usage of recycled waste water in small scale tapioca industry in Bogor

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Abstract. Small scale tapioca industry in Bogor uses simple technology and equipment with a production capacity around 5 tons per day. The tapioca industry uses large amount of water to process the raw materials and to produce a large amount of liquid waste. The tapioca production consists of various processes, such as washing, extraction and settling process which produce a lot of liquid waste. This liquid waste contributes to the environmental pollution because it contains a lot of organic materials. The wastewater of tapioca industry generally has a high BOD, COD and TSS materials. The objective of this research is to calculate the potential waste water recycling in small scale tapioca industries in Bogor. Recycling this waste water can be done in two ways such as onsite recovery (reuse of waste water in the same process) and reuse (waste water uses for other process). Small scale tapioca industry in Bogor has an average production of 2.5 tons per day and produces liquid waste of 5070 litres/ton cassava. The identified potential usage of recycling waste water is recycling waste water for other process such as washing, milling, settling process and the conversion of waste into valuable product such as methane as a fuel. With this waste water recycling process, the tapioca industry will have a benefit in form of cost saving, and environmental benefit.

Keywords: small scale, tapioca industry, waste water, recycling

1. Introduction

Tapioca industry is one type of agroindustry that uses cassava as a raw material. The trade of fresh cassava in Indonesia is dominated by the tapioca industry used for the food industry [1]. Beside for food industry, tapioca is a raw material for some industries such as textile, paper etc. [2]. The tapioca industry has a great potential in penetrating domestic and international market [3].

The tapioca industry, based on the processing process, is classified into two groups. The first group is the large industry that uses modern machines with large capacity, strong capital and less labour while the second uses simple machines, small capital and uses more labour [4]. The industries that are mostly found in Indonesia are small industries which are included in the second group. This type of industries requires many workers to be more effective and efficient [5].

In the production of tapioca, this industry consists of a various process such as peeling skin of cassava, washing, milling, extraction, settling, drying and packaging. From the process, tapioca industry produces a lot of waste such as solid waste, liquid waste or gases that has a different
characteristics and pollution loads to the environment. The main type of waste during the processing of cassava are peels, solid waste and waste water [6].

Tapioca industry uses large amounts of water to the process. This causes this industry to produce a large amount of liquid waste. Each ton of cassava needs 6-9 m³ clean water [3]. Around 85% of clean water used for production process will become waste [7]. Some industries use large amount of water to washing equipment [2]. This liquid waste has the contribution to the environmental pollution because it contains a lot of organic materials.

Waste water from tapioca industry generally has a high BOD, COD and TSS content [4,2]. Some waste contain cyanide [2]. Waste water from tapioca industry has been identified to be toxic to the environment [6]. The tapioca industry produces 4-5 m³ / ton of processed cassava [8]. This large amount of liquid waste certainly requires a large cost for treatment. The installation of pollution control device can be 20-50% of the total investment cost [9]. This can be a big problem for tapioca industries, especially small-scale industries.

The purpose of this study is to evaluate the potential of the recycling of small-scale tapioca industry wastewater in Bogor. Recycling this waste is expected to provide benefits to the industry and the environment.

2. Methodology

2.1. Location and time
This research was conducted at tapioca small scale industry in administration area of Kadumangu village, Sub-district of Babakan Madang, Bogor-West Java from July until September 2019.

2.2. Data collection
Data were collected by observation, interview, documentation, and measurement of waste water from tapioca industry. To calculate the potential of tapioca industry waste recycling, some information related to the identification of the production process and the amount of liquid waste was taken. Identification of the production process is carried out based on field observations. The field observation included identifying activities related to production processes, raw materials used, additives, water, equipment used and the production cycle. Identification of potential waste from each stage of the process in the tapioca industry is needed to calculate the amount of waste. Information on the amount of waste will determine what kind of recycling can be done for tapioca waste water. There are two types of recycling, namely on-site recovery (recycling of waste used in the same process) and reuse (recycling of waste for use in other processes). Literature study is needed for the utilization of tapioca industrial liquid waste.

2.3. Data processing
The collected data from field (Tapioca Industry) and Laboratory analysis are then tabulated and calculated using Microsoft Excel 2016 for further analysis and discussion.

3. Result and discussions

3.1. Identification of tapioca production process
Small scale tapioca industry uses simple technology and equipment for the process with a capacity production around 5 tons per day [4]. The small-scale tapioca industry in Bogor is producing cassava with average of 2.5 tons per days. The lowest production is around 1 ton and the highest production is 5 tons per day. This amount varies depending on availability of cassava as a raw material to be processed. One of the weaknesses in the small-scale tapioca industry is the discontinuation of raw materials. This makes the production of tapioca unpredictable.
Tapioca industry usually produces two types of starch such as crude tapioca starch and refined tapioca starch. Small scale industries produce crude tapioca starch and sell it to other industries. The industry will process the crude tapioca starch into refine tapioca starch and improve the quality.

The tapioca production process covers of peeling, washing, grating, extraction, settling, drying and packaging. The peeling process is to remove the cassava skin and the rotten parts of the cassava. This process will produce a lot of solid waste form cassava peels. Some small industries accept cassava that has been peeled. This peeling process produces cassava peel around 30% of the amount of raw material. From 1000 kg cassava, 300 kg of peel could be produced and becomes waste [6].

After the peeling process, then comes the washing process. It should use a constant flow of water [2]. The peeled cassava is washed using water to remove soil remnants and other impurities. This process produces wastewater in large quantities.

It is then continued with the grating process. This process takes around 3-4 hours / ton. In this process, water is added to facilitate the grating process. The next process is extraction. This process aims to separate starch and cassava pulp (onggok). In this process water is added to extract starch and drain the cassava pulp.

Starch liquid that has been extracted will go through the settling process, while the cassava pulp is separated. Cassava pulp is a by-product of the tapioca industry and will be dried first before sold to other industries. Cassava pulp is also a by-product of the tapioca industry which is found in large quantities. Cassava pulp produced is around 30% of the total raw material processed. Cassava pulp (onggok) is not easy to dry because it has a high moisture and starch contents [10].

The extraction process will generally produce a 30 cm thick of sediment [2]. After that, the sediment or tapioca starch must be dried. Drying is a process to evaporate water content to obtain dry tapioca starch. In small scale industry, drying process usually uses sunlight and not artificial dryer. The product of small-scale tapioca industry is crude tapioca starch. From 1000 kg cassava peeled, it produces 265 kg crude tapioca starch. Production process of a small-scale tapioca industry can be seen in figure 1.

![Figure 1. Production process of a small-scale tapioca industry.](image-url)
3.2. Identification and characteristics of liquid waste

There are three categories of waste from cassava processing such as peel of skin cassava as solid waste, cassava pulp (onggok) as a byproduct from extraction process, and liquid waste from settling process. Solid waste in the form of cassava peel is usually used for animal feed. Cassava pulp (onggok) is usually sold to other industry as an additional ingredient in the production of sauces. The liquid waste from settling process can see in figure 2.

![Liquid waste from settling process](image)

Figure 2. Liquid waste from settling process.

Tapioca production process uses large amounts of water. The volume of waste water reaches 12-15 times the volume of cassava processed [5]. For small industries, this waste water is usually discharged directly to the environment. Small scale industries in Bogor dispose their waste directly to river and cause high load of pollution to the river [11]. Wastewater from tapioca industry contains high organic matter. When discharged into the environment it can cause a pollution. Tapioca industrial liquid waste also has specific properties such as creamy, smelly, and turbid in the presence of suspended solids and having a pH that tends to be acidic [4].

Waste water from tapioca industry comes from various production processes. The most is produced from washing process and the settling process. Wastewater from tapioca industry must be handled properly so it will not pollute the environment. From 1000 kg cassava, 5070 L waste water is produced.

The characteristic of waste water depends on quality the cassava [2]. The factors affecting quality of tapioca liquid waste are large volume, the content of pollutant, and the frequency of waste disposal [5]. The type and composition of the liquid waste depend on the processing method and type of technology used [6].

Based on regulation from Ministry of Environment of Republic Indonesia number 5/2014 (Appendix V) the parameters of quality standard of industrial waste water of tapioca industry are BOD, COD, TSS, Cyanide and pH. The effluent quality standard is presented in table 1[12].

| Parameters | Maximum Level (mg/L) | Maximum Pollution Load (Kg/ton tapioca) |
|------------|----------------------|----------------------------------------|
| BOD        | 150                  | 4.5                                    |
| COD        | 300                  | 9                                      |
| TSS        | 100                  | 3                                      |
| Cyanide    | 0.3                  | 0.006                                  |
| pH         | 6-9                  | -                                      |
|            | Maximum Waste discharge | 30 m³/ton product tapioca              |

Source: Ministry of Environment of Republic Indonesia number 5/2014 (Appendix V)
Waste water from tapioca industry has a high BOD, COD and TSS content [4]. The waste water is also low in pH because the waste water still contain a starch content [2]. The effluent of small-scale tapioca industry is presented in table 2.

| Parameters | Value (mg/L) | Regulatory Discharge limit (mg/L) |
|------------|--------------|----------------------------------|
| BOD        | 187          | 150                              |
| COD        | 643          | 300                              |
| TSS        | 3065         | 100                              |
| Cyanide    | 2.92         | 0.3                              |
| pH         | 4.26         | 6-9                              |

*Ministry of Environment of Republic Indonesia number 5/2014 (Appendix V)*

3.3. Waste water recycling

Waste management is not only through the processing process, but also activities to reduce the amount of waste produced. One way is by recycling the waste produced and the utilization of waste for other processes that can increase added value. To study the concepts and technologies for the wastewater recycling process, there are several things that must be considered, first is reliability of the treatment process, removal of suspended particles and turbidity, and special treatment [13].

The wastewater with the large quantities can be recycled and reused for processing. Wastewater from tapioca industry has a high BOD, COD, TSS, cyanide and low in pH, so they need to treat these wastewater in the waste water treatment plant (WWTP) before re-using it for processing. The waste water recycling scheme for tapioca industry can be seen in figure 3.

Settling process produces the most amount of waste. Waste water from the settling process can be reused in washing, milling and extraction process [4]. Water usage in small scale tapioca industry is presented in table 3.

| Process  | Waste produced (L/ton cassava) | Used for                              |
|----------|-------------------------------|---------------------------------------|
| Washing  | 825                           | Waste water treatment Plant            |
| Grating  | 270                           | Recycling for washing process          |
| Settling | 3559                          | Recycling for washing and grating process |
One alternative technology that can be used to treat waste water from tapioca industry is what we call **constructed wetland**. Constructed wetland is an artificial waste water treatment system that consists of ponds that have been planted with aquatic plants [13]. This technology is a complex integrated system of water, plants, animals, microorganisms, and the environment [14]. The constructed wetland installation is designed as a process for purifying waste water in nature but with a controlled environment [15].

Constructed wetland is a type of a secondary treatment in wastewater treatment plant [13]. This technology uses a biological system using microorganism to remove the organic matter. Before treatment with constructed wetland we need to process the wastewater in primary treatment. Effluent from constructed wetland can be used for washing, grating and extraction process as a clean water. The scheme of wastewater treatment plant for tapioca industry can be seen in figure 4.

![Figure 4. The scheme waste water treatment plant for tapioca industry.](image)

Construction wetland can be used to treat a variety of wastewater including waste water from tapioca industry. There some benefits of constructed wetland e.g. simple process [16], less cost or low investment, low operation and maintenance cost and the output treated water can be used for processing [13]. The treatment by constructed wetland can remove of COD from 704 mg/L – 83 mg/L, BOD from 285 mg/L – 29 mg/L and and TSS from 371 mg/L – 6 mg/L [16]. Removal of pollutant process in constructed wetland consists of three processes such as physical, chemical and biological process. The physical process includes sedimentation, filtration and adsorption [17]. This physical process can reduce the concentration of COD BOD and TSS. The combination of chemical and biological through the microorganisms and plants can remove the dissolved COD and BOD [18]. Constructed wet land to treat waste water from tapioca industry has high treatment efficiency in terms of the biological oxygen demand (BOD₅), chemical oxygen demand (COD), cyanide and total settleable solids (TSS) [19].

One important aspect of waste recycling is calculating the price of clean water for potential use of waste recycling [20]. With recycling waste from settling process, the industry can save 3.5 m³ clean water per day or 84 m³/month with 24 working days. Standard progressive tariff of clean water for small scale industry (I1) in Bogor city is IDR 14,000 (1–10 m³), IDR 20,000 (10–20 m³) and IDR 23,000 (> 20 m³) [20]. Based on the progressive tariff, the tapioca industry can save IDR 2,012,000 per month.

Tapioca waste water contains high solid, BOD and COD value, acidic and cyanide. Due to the BOD and COD value, an attempt has been made to convert them into valuable product such as methane production as a fuel of power plant [2]. Wastes transformation is the possibility to create a value-added product. Cassava waste can be used as a biogas substrate [6]. The conversion of waste water into fuel not only does it recover the energy contained in cassava waste, but also eliminates human health problems such poisoning, headache, shortness of breath etc.

The biogas conversion from liquid waste tapioca can be estimated from the COD value. Based on the test in the laboratory, the COD value of the liquid waste is 643 mg/L. Biogas production can be estimated from the value of COD and its degradation rate, for every kg of COD degraded under anaerobic conditions, 0.39 m³ CH₄ can be produced at 35°C [22].

Based on the mass balance of tapioca process, from 1 ton of cassava, it produces liquid waste with load 6.43 kg COD or 24 kg of COD/ton cassava. With a degradation rate of 90% and a
conversion value of 0.39 m³ methane/kg COD [22], COD value convert to 2,257 L methane (CH₄). Then 67.6% methane [23] converts to 3,389 L of diesel fuel. For every ton of cassava processed, we can produce 1,695 L biogas. With this waste water recycling process the tapioca industry will have a benefit in form of cost saving and environmental benefit.

4. Conclusion
The tapioca production process covers peeling, washing, grating, extraction, settling, drying and packaging. From 1000 kg cassava, 5,070 L liquid waste is produced. Waste water from the settling process can be reused for washing, milling and extraction process. By recycling waste from settling process, the industry can save 3,500 L clean water per day or 84 m³/month with 24 working days or equivalent to IDR 2,012,000 per month.

The liquid waste of tapioca industry contains 187 mg/L BOD, 643 mg/L COD, 3,065 mg/L TSS, 2.92 mg/L cyanide and pH 4.26.1 ton of cassava produces liquid waste with load of 6.43 kg COD or 24 kg of COD/ton cassava and converting to 2,257 L methane (CH₄) and for every ton of cassava processed, we can produce 1,695 L biogas.

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