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STUDY ON CLEANER PRODUCTION STRATEGY IN THE MEDIUM SCALE SAGO STARCH INDUSTRY: A CASE STUDY IN CIMAHPAR, NORTH BOGOR SUB-DISTRICT

Kajian Strategi Produksi Bersih Pada Industri Pati Sagu Skala Medium: Studi Kasus Di Cimahpar Kecamatan Bogor Utara

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ABSTRACT

Medium scale industries are gaining importance and their contribution to pollution problems cannot be ignored. One of medium scale industry having the potential to cause environment problems is centralized of medium scale sago starch industries. Medium scale industries typically have limited space for the installation of treatment system. In addition, often medium scale industries are only marginally profitable, so waste treatment investment may threaten their viability. This problem can be solved by applying cleaner production strategy. This research studies the potentials of cleaner production application and formulating alternatives of cleaner production strategy in order to develop centralized medium scale sago starch industry in Cimahpar. The cleaner production alternatives which are potential to be applied are good housekeeping, washing of sedimentation tank daily, water controling, and worker supervision. The investment of these alternatives is Rp 15 270 000 and pay back period (PBP) one year and two months. Analytical Hierarchy Process (AHP) analysis shows that technology is the most important factor to maximize sago starch production efficiency by applying cleaner production. The priority of cleaner production program from AHP analysis is socialization and training of cleaner production application, integrated waste management, and socialization and training of sago starch quality increasing procedures.

Key words: AHP; cleaner production; medium scale industry; sago starch

ABSTRAK

Industri skala menengah semakin penting dan kontribusinya terhadap masalah polusi tidak dapat diabaikan. Salah satu industri skala menengah yang berpotensi menimbulkan masalah lingkungan adalah industri tepung sagu skala menengah yang tersentralisasi. Industri skala menengah biasanya memiliki system pengolahan limbah yang terbatas. Selain itu, seringkali industri skala menengah hanya memiliki profit yang sedikit, sehingga investasi pengolahan limbah sering diabaikan. Masalah ini dapat diatasi dengan menerapkan strategi produksi bersih. Penelitian ini mengkaji potensi penerapan produksi bersih dan merumuskan alternatif strategi produksi bersih dalam rangka pengembangan industri pati sagu skala menengah yang terpusat di Cimahpar. Alternatif produksi bersih yang potensial untuk diterapkan adalah tata graha yang baik, pencucian tangki sedimentasi setiap hari, pengendalian air, dan pengawasan pekerja. Investasi alternatif ini sebesar Rp15 270 000 dan pay back period (PBP) satu tahun dua bulan. Analisis Analytical Hierarchy Process (AHP) menunjukkan bahwa teknologi merupakan faktor terpenting untuk memaksimalkan efisiensi produksi pati sagu dengan menerapkan produksi yang lebih bersih. Prioritas system produksi bersih dari analisis AHP adalah sosialisasi dan pelatihan penerapan produksi bersih, pengelolaan sampah terpadu, serta sosialisasi dan pelatihan tata cara peningkatan mutu pati sagu.

Kata Kunci: AHP; industri skala menengah; pati sagu; produksi bersih
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INTRODUCTION

Sago (*Metroxylon* spp) originates from the genus Metroxylon and the Palmae family is a wild sago plant that grows in Indonesia with an estimated land area of 7 million ha, spread over Sumatra, Java, Kalimantan and Papua. Sago which is a native plant of Southeast Asia can flourish in plains or swamps with abundant water sources. According to Oates (2002), sago plants can grow well at altitudes up to 1 250 m above sea level with rainfall of 500 mm / year. Sago processing includes extraction of starch found in the heartwood stems of the sago tree. Stages of sago starch extraction consist of cleaning the logs or stems of sago that have been cut down from rough fiber skin as thick as 2-4 cm, splitting the logs into several parts with a length of 40-70 cm. After that, the sago starch is dissolved and separated from the husk and drained. The development of the sago processing industry in Indonesia is spread on an industrial scale, whether large, medium or small. There are several large industries spread across Riau, Papua, Java and Sulawesi, while small sago industries are also spread evenly on Java, Maluku, Sulawesi and Papua.

The growth of the medium scale sago industry turned out to cause problems on the environmental side. Inefficient use of energy and improper waste management can have an impact on environmental quality and wasteful use of energy. Liquid waste in the sago small industry generally does not currently have a liquid waste management installation, and there is no further utilization of the sago industrial solid waste. The absence of this sewage treatment plant forms the impact of environmental damage, according to the results of Haryanto and Siswari (2004), a small-scale sago processing business in the Cibuluh village area, Bogor, which has an effect on decreasing water quality in the Cimahpar village river body. As BOD levels from 51.73 ppm (inlet) rose to 187.89 ppm (outlets).

Cleaner production is the first choice in solving environmental problems by managing processes and managing waste. According to Bapedal (1997), clean production is a preventive and integrated environmental management strategy that is carried out continuously in the production process, products and services so as to reduce risks to humans and the environment. According to Afmar (1998), clean production is focused on efforts to prevent waste generation. By doing prevention from the beginning (source reduction), reducing the formation of waste (waste reduction), and the utilization of waste with the principles of recovery (recovery), reuse (reuse), and recycling (recycle), it will automatically increase the efficiency of the process. One step in increasing profits in the industry, especially the sago industry can be done through clean production. A review of clean production opportunities can be carried out to determine the potential that can be applied in the sago industry. Cleaner production can be implemented and become a solution to reduce environmental damage and increase the profit of industrial players because it can increase productivity and add economic value to the sago industry waste.

MATERIALS AND METHODS

Production Process Identification

The study was conducted at the medium scale sago starch industry center in Cimahpar, Bogor, which consists of 3 industries with a production capacity of 6 800-7000 kg of sago stems per day. The resulting product is dried sago starch. In addition to knowing the technology used, this stage is also to calculate the mass balance.

Analysis of The Application of Cleaner Production

The analysis was carried out based on field observations, interviews with industry players, and expert opinions. Observations and interviews were conducted in all industry members of the center, while the experts consisted of five experts. The purpose of this stage is to identify clean production strategies that have been implemented and those that are potential for further implementation.

Strategy Determination

The application of clean production is based on three aspects namely technology, finance (PBP), and policy. Policy priorities are analyzed using the AHP (Analytical Hierarchy Process), consisting of three hierarchies (infrastructure, actors, programs) using Expert Choice 2000 software. The strategy for implementing clean production is prepared by referring to the position of the sago starch small industry analyzed using SWOT.

RESULTS AND DISCUSSIONS

Production Process

Sago stems obtained from suppliers are 75-90 cm long sago stems which have been peeled off the bark. During the process of storing and transporting sago stems, contamination of impurities (solids, soil, rocks, etc.) causes the outer surface of the sago stems to become dirty and brown to black. Therefore, before sanding, the sago stems are stripped a second time to remove impurities. The stripping process is done by using a machete. This method can eliminate the need for water for washing. However, the consequences are causing the loss of sago stem mass so that it can reduce the yield of sago starch produced.

Sago stems that have been peeled, first chopped using axes and machetes. This is intended to simplify the grating process. After the sago stems are peeled and chopped into sago stalk chips, the grating process is carried out using a diesel-fueled grater. This process aims to enlarge the surface area and break down starch cells so as to facilitate the process of filtering and extracting starch. In addition to the sago stem chip, the grating process also requires input in the form of water which functions as a solvent.

The sago porridge that comes out of the sieve machine is then filtered using a vibrating screen that is driven by a diesel-fueled diesel engine. This aims to separate the starch solution from the pulp. During the filtering process, the addition of water is made through pipes placed on the vibrating screen. Starch solution containing a mixture of water, starch and other dissolved components needs to be deposited so that the starch is separated and settles at the bottom of the settling pond. There are 4 types of settling ponds that are used continuously. The deposition process is carried out for 2-3 hours. Furthermore, the sediment and water are separated by removing the water from the settling basin. After the water has finished the starch sediment is removed using a spoon and stored in a temporary storage tank.

Starch resulting from the deposition process is wet starch which must be dried in advance so that sago starch is obtained with a maximum moisture content of 13%. The drying process is carried out for 5-6 hours when the intensity of sun exposure is maximum or for 2-3 days if it rains. Wet starch is dried in the sun by using a rub and reversal is done by stirring using the hands. Sago starch produced from the drying process is coarse sago starch that needs to be sifted first. Rough starch resulting from the drying process has a non-uniform size. For this reason, sifting needs to be done first so that the size is uniform. Sifting is done manually using a 100 mesh sieve.

Status of Clean Production Application

Cleaner production aims to make it more efficient to use resources (raw materials, energy and water) and reduce waste and emissions at the source. There are five types of prevention in the framework of implementing clean production, namely product modification, input substitution, technology modification, good housekeeping, and on-site recycling (Berkel, 2010).

The sago industry in Cimahpar has implemented three of the five strategies above, namely technology modification, good housekeeping, and on-site recycling (Table 1). Modifications to technology include the use of production machines and a driving machine for several process units. The other two strategies have two functions, namely increasing efficiency and providing positive benefits to the environment (Weston and Stuckey, 1994). Cleaner production has also been proven to provide direct added value to the industry such as the sale of sago pulp and gross crude starch.

Table 1 Cleaner production options that have been applied to the sago starch industry.

Strategy	Activity
Good housekeeping	- Imposition of water for the production process - Washing the tub: once every three days - Maintenance of grating cylinders on a regular basis - Use of wall clocks in the factory (timely in application) - The use of a pedestal to collect the scattered starch granules - The use of head protection by drying workers - Product layout: in the order of the production process - The use of a shredder, gobegan machine
Modification of technology	- Use of the same diesel engine to drive the shredder and the gobegan engine at the same time - Use the rinse tub for the washing process

Cleaner production has not been able to be distributed evenly to all industries due to differences in financial capabilities and knowledge. Although many clean production activities have been implemented, there are still opportunities to increase production efficiency and improve the industrial environment.

Identify the emergence of waste and clean production implementation options

In the process of stripping the waste generated at this stage in the form of wood chips which contain a lot of organic material (biomass). So far, wood chips are only piled near the production room and burned if the amount exceeds the maximum capacity. So that the option of implementing clean production can be done by supplying raw materials (sago stems), preferably in the form of sago stems that have not been peeled, so there is no need to do stripping twice and minimize biomass (skin and stem flakes) that is wasted. It is necessary to make a shelter for the waste of sago stem flakes before other uses are made. Utilization of waste sago stem flakes as organic fertilizer that can be sold and produce added value for the sago starch industry. It is necessary to adjust the layout of the raw material loading section to minimize movement carried out by the operator.

In the process of chopping some of the sago stems are cut into small pieces which are scattered and not utilized. The option of implementing clean production that can be done is that the enumeration site should use a tarpaulin base, making it easier to collect sago stalks. Sago stem flakes are then collected using a shovel and put into the grating process (for large pieces of debris) and filtering (for small pieces of flakes).

In the process of dissolution of waste generated as loss products scattered around the shredder. So the clean production implementation option that can be done is the collection of shredded sago stems scattered around the shredder by using a shovel. Implementation of good housekeeping, by regulating the exhaust height of the diesel engine so workers are not exposed to smoke. Install smoke treatment equipment on the exhaust so that the exhaust fumes are cleaner. Raw water treatment is needed for grating and filtering. Don't use catfish. Applying good housekeeping by providing ear muffs for operators who work around the grating machine.

In the filtering process Waste generated in the filtering process in the form of wet pulp and starch solution that is wasted with wet waste because the screening process is less than optimal. This waste is directly discharged into a small river, without being accommodated and treated in a waste collection facility first. Option for implementing clean production that can be done is that it is

necessary to create a waste storage pond and waste treatment to separate the wet waste and the starch solution that is wasted. Furthermore, wet dregs can be used as animal feed, fertilizer, sauce making, pellets and media for the cultivation of fungi and worms. While the starch solution is recycled to the starch precipitation process. 2. It is necessary to optimize the filtering process so that it can minimize the starch solution that is wasted with wet dregs.

In the process of deposition of starch waste produced in the process of starch deposition in the form of liquid waste that contains a lot of organic material and loss products in the sedimentation tub due to the process of removing the less optimal starch deposition. The clean production option that can be done is to reuse water from the settling tank for the process of grating and filtering. Gather the remaining starch in the sedimentation tank using a spoon.

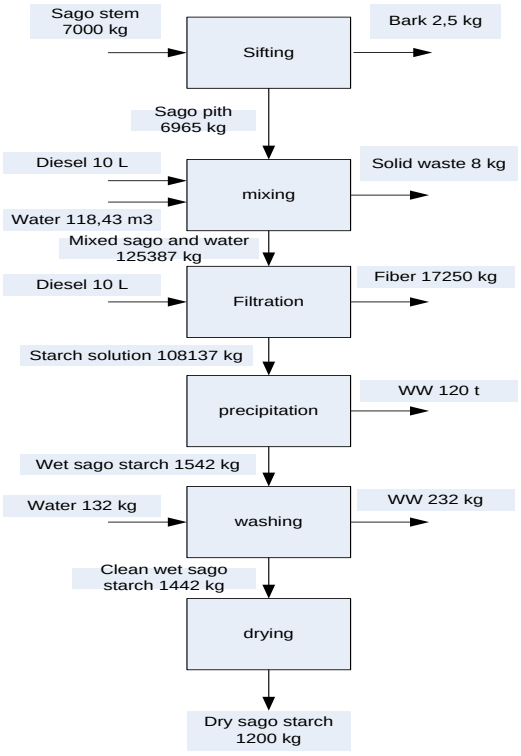

Fig. 1. Process of sago starch production and a wet matter mass and water mass balance (Yusuf et al. 2018)

Waste generated in the drying process is coarse sago starch which is blown by the wind at the time of reversal. For clean production options, you can use a scoop. Waste generated in the sifting process is in the form of floating sago starch. The option to apply clean product is that the sifting place must be cleaned first, so that the floating and scattered sago starch can be collected and packaged. Workers who carry out sifting must use a mask.

The possibility of the emergence of waste at the packaging stage is caused by starch which is shed when put into the package. The clean production option that can be done is that the sifting place must be cleaned first, so that the flying and scattered sago starch can be collected again and packaged. Workers who carry out sifting must use a mask. Use tools such as a funnel to make it easy to put starch in a sack.

Technology Aspects of Clean Production Application

Good housekeeping is intended to improve the efficiency of water use and prevent material loss. Cleaner production activities include implementing good production methods (GMPs), monitoring water use, and monitoring workers. In order to achieve these objectives counseling needs to be done so that the knowledge and awareness of industry players is better.

Washing up the tub should be done every day or after the production process is complete. Remnants of starch attached to the tool will affect the quality of the next sago shift starch, especially the parameters of the degree of whiteness and odor. Kusarpoko (2003) which states that the process of contamination of waste by microorganisms can occur after 12 hours. According to Ercin et al. (2012), the content of sugar and other nutrients causes microorganisms to ferment and produce alcohol and odor-causing organic acids.

Improvements to the production process can also be carried out such as mechanical washing using a propeller that is rotated by a machine. The aim is to increase water use efficiency and productivity. However, this method requires further design to adjust to different production capacities so it requires a large investment.

Washing two stages using liquid waste recovery treatment processes and other processes. This method can be done with the condition that the water does not contain harmful pollutants and microorganisms because it can reduce the quality of the sago starch produced (Liu *et al.*, 2013). The obstacle in implementing this method is that water quality monitoring is difficult at the small industry level.

The choice of making a centralized reservoir and wastewater treatment center is based on Kurniarto's (2006) research conducted in the small sago starch industry. The study concluded that the management of sago starch small industry waste in Cimahpar that should be carried out is a mechanical absorption WWTP where operational management is carried out by the government (kelurahan), and employers help by paying development fees and levies per month for IPAL treatment.

Centralized environmental control is based on Sofyar's (2004) research, which is a policy model for small industrial centers with similar wastes that is designed as a whole in handling waste. The options for making a centralized wastewater collection and treatment plant and centralized environmental control can be used as an alternative to a clean production program. The application of cleaner production to the sago starch industry includes worker counseling, water use monitoring, labor supervision and washing of settling tanks (Table 2). These choices have the highest priority based on consideration of ease of application and level of importance.

Financial Aspects of Clean Production Application

Financial aspects in the form of estimated costs and possible savings and profits from the application of cleaner production and management of the industrial environment can be seen in Table 3. High priority activities (***) are used as the basis for calculating Pay Back Period (PBP).

If the repair activities with important priorities (***) are carried out, and it is assumed that:

1. The selling price of sago starch is IDR 7 000 / kg (based on the lowest selling price), and
2. Sago starch is produced per month as much as 12 tons (minimum production per month), then the total cost of repair activities with an important priority is IDR 15 270 000. The total cost consists of:
3. Worker outreach costs for reimbursement of lost work time of IDR 120 000
4. Investment for the purchase and installation of gobegan equipment as much as IDR 15 000 000
5. The cost of washing starch sink for 1 month IDR 150 000, obtained from the cost of water and washing equipment for the settling tub. Meanwhile, the savings from monitoring water usage per month amounted to IDR 100 000 obtained from the assumption of saving the use of pumps per month. Profit per month from

Table 2 Analysis of the costs of applying clean production and managing the industrial environment.

Activity of improvement	Cost (IDR)	Priority
- Worker counseling	120.000	***
- Monitoring water usage	0	***
- Use of mechanical washers	5.000.000	*
- Use gobegan tools	15.000.000	***
- Washing the starch filling tub every day	150.000	***
- Monitoring workers during the production process	0	***
- Making centralized liquid waste collection tanks	8.000.000	**

* = less important, ** = quite important, *** = important

increased yields on using gobegan tools IDR 970,000. Thus obtained:

$$\text{PBP} = \frac{15.270.000}{(970.000+100.000)} \text{ x } \frac{1}{12\ bulan} = \text{ 1 year 2 months}$$

Policy Aspects of Clean Production Implementation

An alternative proposed strategy for applying clean production is based on the results of the study of Frijns and Vliet (1999), Sofyar (2004), and Hidetoshi (2006), then adjusted to the conditions of the small industry of sago starch in Cimahpar. There are six alternative clean production programs in developing a small industrial center for sago starch in Cimahpar namely:

1. Providing capital incentives for clean production actors
2. Technology development and transfer
3. Information dissemination and training on clean production implementation
4. Integrated waste management
5. Provision of information about new technologies, market conditions and government policies
6. Socialization and training on ways to improve the quality of sago starch.

The net production program alternatives above were assessed for importance on a scale of 1-5. Based on expert assessment, three alternatives were obtained, namely socialization and training in the application of cleaner production, integrated waste management, socialization and training in improving the quality of sago starch with successive geomean averages 4.7312; 4.2809; and 4.2809. The selection of alternatives is based on the consideration of capital, technology and local government policy criteria, while the actors consist of small entrepreneurs, large entrepreneurs, regional governments and the community. The objective to be achieved in this analysis is to maximize the efficiency of sago starch production by applying clean production (Figure 2).

The development of the sago starch industry requires the introduction of technology (0.545), then capital factors (0.488) and local government policy (0.291). This is in line with efforts to implement clean production through technology modification. Capital and local government policies are needed to support technology development. The sago starch small industry is the party that most needs technology introduction (0.593) (Figure 3). The next rank were consecutive big businessmen (0.443), community (0.211) and government (0.189). Likewise for capital and policy factors, small industries are more in need when compared to large industries, local governments, and society.

Increasing the mastery of technology in small industries requires socialization and training in the application of clean production (0.429). The next

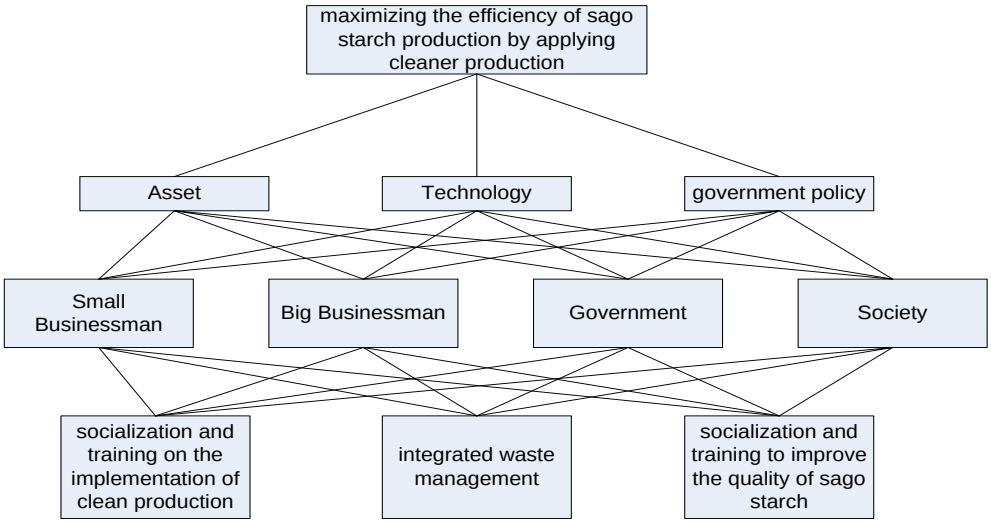

Figure 2 AHP structure of the development of a small industrial center for sago starch.

alternative sequence is integrated waste handling (0.328), socialization and training on how to improve the quality of crude ioka. The socialization and training must be carried out because the average level of education of sago starch small industry players is relatively low which impacts on the understanding of industrial development. According to Kurniarto (2006), sago starch small entrepreneurs with higher levels of education will tend to have better perceptions of waste management and the environment when compared to small starch sago entrepreneurs with lower educational levels. The development of the concept of clean production is expected to lead to changes in awareness, knowledge, perspectives, attitudes and behavior of industrial implementers (Raka, 1999). The strategy that can be done is with a clean production training program for small starch entrepreneurs in Cimahpar.

Clean Production Implementation Implementation

The clean production implementation seeks to integrate the clean production strategy to develop a more efficient sago starch industry center in Cimahpar that is more efficient in terms of production and reduces environmental impact. In the development of a small industrial center for sago starch in Cimahpar, implementation steps are needed in accordance with the conditions and the environment. For this reason, knowledge is needed regarding the internal situation and external conditions faced by the small industry of sago starch in Cimahpar. Referring to the evaluation of external and internal factors formulated by Hidetoshi (2006), the position of the Bogor sago starch small industry is in the first quadrant of the SWOT matrix (Figure 3). A broader identification by Sofyar (2004) regarding the development of small production-based small business policies also places the position of small businesses in the first quadrant of the SWOT matrix. The first quadrant of the SWOT matrix shows that the implementation can use aggressive strategies while considering the constraints and available resources (Marimin, 2005).

The strategy for the development of the small sago starch industry in Cimahpar is as follows:

1. Clean production awareness and training by:
   a. increase entrepreneurs' awareness of environmental issues and increase motivation to be involved in maintaining environmental quality
   b. provide group assistance for consultation, problem solving, and supervision of the progress of the implementation of the clean production program.
2. Increasing production efficiency (minimizing energy and raw materials)

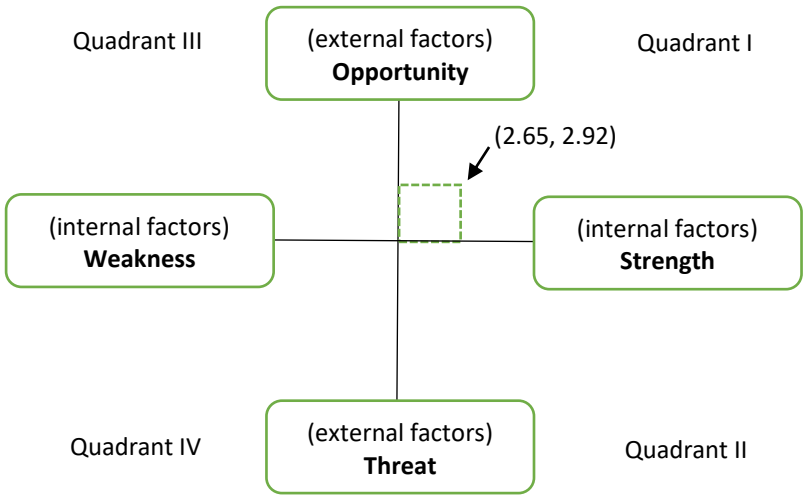

Fig. 3. Position of the medium industry of sago starch on the SWOT matrix

by improving process technology to increase yields and reduce losses.
3. Increasing the role of government in coordinating the involvement of the private sector, financial institutions, research institutions or universities, mass media, and the community to succeed in the clean production program
4. Enhancing the creativity of small-scale sago starch entrepreneurs in Cimahpar through the means of gathering citizens to take advantage of the Development Planning Meeting (Bogor City Department of Industry and Trade empowerment program) which is bottom-up.

CONCLUSIONS

The small industry of sago starch in Cimahpar uses large quantities of auxiliaries (water) and produces waste that has the potential to pollute the environment. The industry has applied the principles of cleaner production, but there are still many cleaner production activities that need to be applied.

Proposed alternative improvements through clean production include good housekeeping, daily staple bath washing, and worker monitoring. The proposed improvement requires a capital of IDR 15 270 000 with PBP (Payback Period) 1 year 2 months.

The small industry of sago starch greatly requires the introduction of technology to maximize production efficiency. This introduction should be carried out by means of socialization and training on clean production to industrial players.

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