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Cleaner Production Strategy for Improving Environmental Performance of Small Scale Cracker Industry

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Abstract

Cracker industry is one of thriving small-medium food industries in Yogyakarta Special Province. The cracker processing plant produces wastewater that potentially contaminates the environment. Wastewater coming from the washing of production equipments has the BOD and COD concentration that exceed the treshold of quality standard due to it containing high organic matter. This paper proposes a cleaner production strategy with environmental, economic and technical benefits for small scale cracker industry. Implementation of good housekeeping by improving the worker thoroughness in the production process and cleaning the scrap on the production equipment before washing improves the environmental performance in terms of biological oxygen demand (BOD), chemical oxygen demand (COD) by 76.67% and 84%, respectively.

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Keywords: cleaner production; cracker; environment; good housekeeping

1. Introduction

Cracker is a crispy snack that is often used as a complement to Indonesian foods. It is made from cassava starch mixed with flavorings such as shrimp, fish, sugar, or salt. Crackers are produced by gelatinization of starch with water in the steaming process. Homogeneous dough is then formed, steamed, sliced and dried (Siaw, 1985). There are many

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types of crackers because the food so easily mixed with other ingredients. Crackers production can be performed by large and medium industries and even small industries since the manufacturing process is very easy. Small scale crackers industry have been known to pollute the recieving water caused by wastewater discharged directly without any treatment, so the water is black and smells foul (Abdulgani, 2013). The number of cracker industry in Yogyakarta Special Province, Indonesia were 249 units in 2013 and tends to increase every year.

Small and medium enterprises (SMEs) are often not fully aware of the environmental impact of their activities. In fact, most of them think that their activities do not have any impact on the environment. They find that their customers were absolutely uninterested in their environmental behaviour, therefore they consider that the impact of their activities could be neglected. SME are very sceptical of the benefits to be gained from making environmental improvements. In fact, legislation has been pointed out as the most important driver for environmental improvements (Hillary, 2004). Wastewater treatment in small industry is constrained by technical and cost factors, so the prevention of the waste through cleaner production (CP) strategy becomes crucial. According to United Nations Environment Program (UNEP), CP is an integrated preventive strategy applied to processes and products in order to increase efficiency and reduce risks to human beings and environment by continuously taking actions to prevent pollution in every activity relating to processes, products, and services. It is achieved through reducing the use of resources, judicial use of energy, reducing emission and wastes, recycling, etc. CP itself is not a solution to all environmental problems, but it reduces the dependence on end of pipe solutions, generates less harmful wastes.

Many works show that CP is effective tool for improving environmental performance in some agro-industry such as milk processing (Ozbay and Demirer, 2007), poultry slaughterhouse (Kist et al., 2009), and fish processing (Thrane et al., 2009). They applied CP opportunities such as automated water management, change equipment, off-site reuse, chemical change, etc. However, none of these studies focus on small scale agro-industry, which very limited due to the lack of initiation, expertise and financial limitations. One of the opportunities used in the application of CP is good housekeeping (GHK). GHK associated with a number of practical steps, simple, does not require any investment (no investment) or little investment (low investment) that can be taken by enterprises and on their own initiative to improve their operations and enhance organizational procedures and workplace safety. The objective of this paper is to develop cleaner production strategy for small scale cracker industry in order to offer GHK opportunities for wastewater.

2. Methods

The implementation of CP strategy was demonstrated on small-scale crackers industry 'Subur' located in Bantul Regency of Yogyakarta Special Province. The research was based on the CP methodology prescribed by UNEP. The methodology was carried out in five phases as follows:

Phase 1: Planning and organization. At this phase, the participation and commitment of the owners and workers were confirmed because they determine the success of CP implementation.

Phase 2: Pre-assessment (qualitative review). This phase is carried out to know basic information about the enterprise. This phase is conducted to acquire qualitative review including a description of the company and identification of all stages of the production process. The review was acquired by interviewing the owners and workers as well as conducting walk-through inspection.

Phase 3: Assessment (quantitative review) includes measuring resource usage and waste generation throughout the process, identifying causes and solutions, and generating of GHK alternatives.

Phase 4: Feasibility analysis. Each alternative is further analyzed to determine the feasibility of the economic, technical and environmental.

- Economic feasibility study was carried out by calculating the amount of the investment or the costs and Net Present Value (NPV) for each GHK alternatives.

$$NPV = PV\ B - PV\ C \quad (1)$$

PV B = *Present Value Benefit*
PV C = *Present value Cost*

- Technical feasibility covers technical production processes, technology, human resources, and raw materials. Scale of technical feasibility assessment includes: 1 (difficult to implement), 3 (easy to implement), and 5 (very easy to implement) (Hakimi, 2006). Assessment was carried out by owner and workers.
- Environmental feasibility, the implementation of alternatives is feasible if they could reduce the wastewater concentration. According to Hakimi (2006), grade is given on a three-point scale: no impact on the environment (1), impact on the environment (3), and strongly impact on the environment (5).

Phase 5: Implementation and continuation. The selected GHK alternatives are further implemented in Subur industry to reduce the concentration and the amount of wastewater generated. The result of the GHK implementation was measured using the environmental performance parameter based on ministerial decree of the State Minister for Environment, the Republic of Indonesia No. 3 on 15 January, 1998 about the quality standard of wastewater for industrial area as follows:

$$APL = (CA)j \; x \; DA \; x \; f \quad (2)$$

APL = actual pollutant loading (kg/day)
(CA) j = concentration of parameter j (mg/L)
DA = discharge of the wastewater (L/sec)
f = conversion factor of 0.086

3. Results and Discussion

3.1. Profile of industry

Production capacity of Subur industry per day on average is 50,000 pieces of crackers using cassava starch of 300 kg. The number of workers is 11 people who are all male. Production runs daily from 5:00 to 15:30 pm with a break for 2 times that from 07:00 to 08:00 am and from 11:30 to 12:30 pm. Crackers frying starts at 15:30 pm processed by the sellers. Sales area of Subur crackers covers Yogyakarta and surrounding areas. Commitment from the owner of the Subur industry is shown by the agreed and approved implementation of CP strategy. Industry owner helps coordinate with the workers so as to facilitate the implementation of CP methodology. More recent works show that the decision of the SME owner-manager is the main reason to introduce any environmental management system (Zorpas, 2010) or even any waste management practice (Redmond et al., 2008). Therefore, to achieve a better implementation of environmental good practices in SME, the owner-managers should be informed about how to make appropriate changes in their business to take advantage of the benefits (Redmond et al., 2008).

3.2. The wastewater characteristics

The raw materials of Subur crackers are cassava starch, shrimp, fish, garlic, butter, salt, sugar, cooking oil and water. The production process consists of three parts: spice pastes making, dough preparation and crackers manufacture. Wastewater generated, 95% coming from the washing of machine and production equipment such as pans, mixers for making spice paste and dough, and roller machine. Wastewater as much as 515 liters per batch is directly discharged to environment without any treatment before. This wastewater has the BOD and COD concentration that exceed the treshold of quality standard determined by government of Yogyakarta Special Province (Table 1).

Table 1. Characteristics of “Subur” Wastewater

Parameter	Treshold (mg/L)	“Subur” wastewater (mg/L)
pH	6,0 – 9,0	6,1
BOD	75	250,9
COD	200	617,5
TSS	100	78,3

High levels of COD and BOD in excess of the quality standard is due to wastewater containing high organic matter. The characteristics of such wastewater could potentially occur in the agro-industrial as raw materials in the form of organic matter. The organic matter is decomposed by microorganisms that cause levels of COD and BOD in the wastewater become high. In addition to the raw materials, these high levels are due to the factor of human and work method. Workers are less thorough in taking the scrap of the dough on machine and production tools. These scraps would dissolve in the wastewater when washed. Method of cleaning is done by directly soaking or washing the machine without taking the scrap first. The more scrap on the tool, the more turbid water from the washing will be and the more water needed for flushing. Turbid wastewater indicates that the dissolved organic matter is high.

3.3. The good housekeeping alternatives

Based on the cause analysis of waste, the GHK alternatives were: 1) improving the worker thoroughness in the production process and 2) cleaning the scrap on the production tools before washing process. The feasibility of the implementation of these alternatives were evaluated from the economic, technical, and environmental aspects. Economic feasibility analysis showed that both alternatives feasible to be implemented. Then, followed by the technical and environmental feasibility analysis to determine priority (Table 3). Feasible alternatives that have a high priority would be effective for improvement of environmental performance.

Table 2. Net present value of good housekeeping alternatives

No	Alternative	Cost	Benefit	NPV
1	Improving the worker thoroughness in the production process	No cost	decrease the amount of water used = IDR 35,445	positive
2	Cleaning the scrap on the production tools before washing	No cost	decrease the amount of water used = IDR 79,92	positive

Table 3. Priority scale of good housekeeping alternatives

Alternative	Score			Priority
	Technical	Environmental	Total	
1	5	3	8	2
2	5	5	10	1

Both alternatives were implemented in routine production of Subur industry to measure their impact on the environmental performance (Figure 1). Through the implementation of these two alternatives, the rinsing process is done one time, which previously three times. Thus the amount of water used is also reduced.

Fig. 1. Scrap cleaning of production tools before washing

3.4. The Impact of good housekeeping on the environmental performance

Evaluating implementation of GHK for improving environmental performance was carried out by comparing the amount and concentration of wastewater before and after implementation. Measurements showed that the concentration of COD and BOD decreased to 122.97 mg/L and 74.6 mg/L, respectively. Moreover, these two parameters are conformity in quality standard of wastewater. The pH value of wastewater prior to implementation was already on the threshold standard (6.1). After the implementation, pH values closer to neutral that is 6.9. In addition, the parameters of the TSS (total suspended solids) also decreased to 60 mg/L. These decreases are due to the decrease of pollutant in wastewater so that suspended solids in the wastewater are reduced. After GHK implementation, overall value of the parameters has a value below the threshold so that it could be directly discharge into the environment. Through the implementation of GHK, water used to rinse is also reduced due to the reduced amount of scrap on the the tools. The amount of water required per batch is reduced 22.04% from 515 L to 401.5 L.

The amount and concentration of wastewater affect the pollution load into the environment. Analysis of environmental performance is done by calculating the actual pollution load using Formula 2. Improved environmental performance is known from the reduction of actual pollution load on each parameters as shown in Table 4.

Table 4. Environmental performance after implementation of good housekeeping

No	Parameter	Actual pollutant loading (APL)		Increasing of environmental performance ((a-b)/a)x100%
		Before Implementation (a)	After implementation (b)	
1	BOD	0,06 kg/day	0,014 kg/day	76,67 %
2	COD	0,15 kg/day	0,024 kg/day	84,00 %
3	TSS	0,02 kg/day	0,012 kg/day	40,00 %

4. Conclusion

End of pipe treatment strategy which has been known until this day, in fact has not been able to give competitive opportunity anymore because it has been too costly. GHK has been one of the easy and cheap techniques in cleaner production strategy. Industrial crackers in Yogyakarta Special Province dominated by small scale industries. They discharge the wastewater generated from washing of production equipment that exceeds the threshold of quality standard to the environment. Implementation of GHK by improving the worker thoroughness in the production process and cleaning the scrap on the production equipment before washing significantly improves the environmental performance in terms of BOD, COD, and TSS by 76.67%, 84%, and 40%, respectively. Moreover, the amount of water required for washing reduced 22.04%

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