Cleaner production options for reducing industrial waste: the case of batik industry in Malang, East Java-Indonesia

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Abstract. The aim of this research is to conduct cleaner production options for improving the environmental performance during the production of batik industry, the case of UKM batik, Malang, East Java. Batik industry is one of small and medium textile industry which has contribution to economic growth in Malang. However, during production the batik, it generates wastewater that has potential to decrease the environmental performance. Wastewater from Celaket batik industry has BOD, COD, TSS, and pH level is far larger than the threshold of water quality standard as a result of use chemical substance during the dyes processing. In order to prevent generating wastewater, this study utilized cleaner production options, such as substitution of input material.Substitution of input material for dyes process was implemented by replacement chemical dyes (e.g.indigosol, nafthol, rapid) with natural dyes (e.g. Indigofero Tintoria). Modifying of technology/equipment was conducted by developing wastewater treatment equipment to reduce waste of batik productionThe implementation of this strategy was carried out by changing input material from chemical dyes with natural dyes. The CP uptake could reduce significantly the environmental impact in term of reduction of COD, BOD, and TSS.

Keywords: batik industry, cleaner production, nature dyes, wastewater

1. Introduction

Batik Industry is one of the small and medium enterprises (SMEs), which have a significant contribution to economic growth in Indonesia. In 2002-2006 SMEs have contributed to gross domestic product (GDP) of Indonesia IDR 104,638 trillion and have employed 5.4 million per year. In the year 2006, the creative industry has exported IDR 82 billion or 9.13 % from total national export. On the other hand, the production of batik generates waste during the life cycle of batik product. Batik and textile industries produce of wastewater generating from the dye process. Also, batik wastewater contains synthetic ingredients, which are difficult to be degraded. Wastewater produced from batik or textile industries is generally a non-biodegradable organic compound, which can cause the environmental pollution, especially to the aquatic environment. Therefore, the main environmental problems for the batik industry or textile are the wastewater with high pollutant level [1]. Textile wastewaters generally contain surfactants, dyes, pigments, resins, chelating agents, dispersing agents, inorganic salts, heavy metals, biocides, etc. and therefore they are heavily loaded with chemical oxygen demand (COD), color and salt [2], [4]. Textile waste can cause significant environmental problems if they do not manage properly [5]. The most dyes commonly used in textile industry are red and golden yellow and remazol black [9]. In fact, during coloring process, only 5 % can be used these compounds while 95% will be released as a liquid waste to the environment. Moreover, the chemical dyes in nature are very difficult to be degraded because they are stable enough and for high concentrations these compounds are dangerous to the environment because they can increase the COD and BOD levels in water [1], [9].

The current method conducted in order to reduce industrial waste is end of pipe method. However, this method has some weakness, for example, this method has reactive response to pollutant and waste after they are produced, pollutant are controlled by waste treatment tools and methods. Therefore, Industries require an innovative method to prevent in generating waste. Currently, cleaner production is a preventive method for generating waste and this method has used widely in the world in order to minimize industrial waste. Cleaner production is a continuous application of an integrated preventive environmental strategy applied to processes, products, and services to increase overall efficiency and reduce risks to humans and the environment [1]. Furthermore, CP is a preventive method to generate waste from industrial activities. In the last decades, this method has been of main concern in the control environmental impact of industrial activities [3]. This pollution control method requires high investment and operational costs and causing to decline market competitiveness. Based on the cleaner production approach, Waste/pollution is a result of project, inefficiency, failure, use of resource and ineffectiveness in production processes [4]. Cleaner production method is associated with green production/industry, sustainable production and eco-efficiency [2]. United Nations Environment Programme (UNEP) defines cleaner production as "The continuous application of an integrated environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment" [5]. Therefore, the implementation of cleaner production can increase the economical, Technical, and environmental performance of industrial companies.

Many researches show that CP is effective tool to improve the environmental performance in some SMEs such as milk processing [6], poultry slaughterhouse [3], and fish processing [7]. They implement CP strategies such as modified technology, change equipment, chemical change, automated water management, off-site reuse, etc. However, none of these studies focus on small industry, which are lack of education, expertise, initiation and financial limitations. One of the opportunities used in the application of CP is input substitution without investment or very low investment. Therefore, the object of this paper is to apply cleaner production option in order to improve the environment performance in terms of wastewater reduction. Therefore, this paper proposes cleaner production options to reduce waste from industrial activities, particularly for small and medium industries.

2. Research Method

2.1. The cleaner production concept

CP is relatively new approach to improve the environmental performance of process industries [5]. It describes a preventive approach to environmental management, which can be defined as *"the continuous application of an integrated preventive environmental strategy to processes, products and services to increase overall efficiency, and reduce risks to humans and the environment"* [5]. Moreover, according to UNEP (2001) CP can be implemented to: Production processes: Reducing energy, water and raw materials; eliminating dangerous raw materials and toxic; and minimizing waste during the manufacturing process and the quantity of toxicity of all emissions. Products: minimizing the environmental risk, health, and safety impact of products along the life cycles of product, from raw materials extraction, manufacturing and use, to the disposal of the product. Services: incorporating environmental concerns into designing and delivering services.

Furthermore, the aim of CP is to carry out more efficient for use of natural resources (raw materials, energy, and water) and to minimizing the production of wastes and emissions at the source [5]. The most common way to do such thing is through five prevention practices al. 1991 USEPA 1992 [8] those are: Substitution of input materials: using environmentally friendly (e.g. renewable) materials in products and processes. Substitute input materials by less toxic or by renewable materials or by adjunct materials, which have a longer service lifetime in production. Modification of the product: modifying the product characteristics in order to minimize the environmental impacts of the product during or after its use (disposal) and also to minimize the environmental impacts of its production. Modification of technology: changing the equipment's and technology to make the process more

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efficient and to reduce waste and emissions. Good housekeeping: adopting standardized /improved operation and maintenance procedures to avoid waste and emission, such as leaks, spills, etc. This may include improved worker training. On-site recycling: recovery and reuse of waste materials, water and heat at the company where they are generated.

2.2. CP procedure

CP options were conducted on small-scale Batik industry located in Malang. The research was based on the CP methodology prescribed by UNEP [5]. The method was implemented in five phases as follows:

Phase 1 : *Planning and organization*. At this phase, the owner and the worker have confirmed their participation and commitment to implement CP.

Phase 2 : *Pre-assessment (qualitative review).* This phase is carried out to know basic information about the enterprise. This phase is to acquire and identify all information for all stages of life cycle batik production. Review was conducted by interviewing the owners and workers. Also, inspection during the life cycle of batik industry has done.

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

Phase 4 : *Feasibility analysis.* Each CP option is evaluated to determine the feasibility of the economic, technical and environmental aspect. Economic feasibility study was carried out by assessing the amount of the investment and Net Present Value (NPV) for each CP option.

Phase 5 : *Implementation and continuation.* The selected Cleaner production options are further implemented in Celaket batik industry to reduce the concentration and the amount of wastewater generated. The result of CP option 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

3. Results and Discussion

3.1. Wastewater of Celaket Batik Industry

Celaket Batik Industry located in Malang, East Java is one of the small and medium enterprises producing traditional batik. The production process of batik consists of five steps: The first step, the wax is applied over the penciled-in outline of the pattern. The original cloth is white or beige. The second step, the cloth is dyed in the first dye bath. The area of the cloth where the wax was applied in step one will remain white. The third step, second application of wax is applied. In this case it is a dark brown color. The darker color helps to differentiate it from the first wax applied. The third step, the cloth is dyed in the second bath. In this case it is a navy blue. Any areas that are not covered by wax will become dark blue. The next step, all the wax that has been applied thus far is removed. Finally, the fabric is submerged in the final dye bath. The finished cloth after all of the wax has been removing. During the production of batik, it generates wastewater from all steps particularly from dye process. Batik Industry generate wastewater which 95% coming from the dyes process. Wastewater is generated by 200 liters per day for producing 4 m batik and it is discharged directly to environment without any treatment. In order to determine the quality of water, assessment of wastewater was conducted in laboratory. The result shows in Table 1 that wastewater has the BOD and COD and TSS level far larger than the threshold of quality standard determined by government of Malang, East Java (see Table 1).

Table 1. Characteristic of Celaket batik industry wastewater.

Parameter	Characteristic of batik waste water	Threshold (mg/L)
BOD	5226 mg/L	75
COD	20900 mg/L	200
TSS	2036 mg/L	100
pH	6-9	11.8

The high concentration of COD, BOD and TSS in the wastewater during the production batik is caused by containing high chemical substance and organic matters. The characteristics of such wastewater could potentially occur in batik 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, chemical substance during the dye process can increase the level of COD and BOD of water. Traditional batik industry, such as Celaket Batik Industry uses chemical dyes for coloring process. As a result, this process generates wastewater with high concentration of BOD, COD and TSS (see Table 1).

3.2. Cleaner production alternative

In order to reduce environmental impact in term of wastewater in producing batik, this paper utilized cleaner production. Cleaner production options, such as substitution of input material and modifying technology have reviewed (technical, economic and environmental benefit). Substitution of input material for dyes process was implemented by replacement chemical dyes (e.g.indigosol, nafthol, rapid) with natural dyes (e.g. Indigofero Tintoria). Modifying of technology/equipment was conducted by developing wastewater treatment equipment to reduce waste of batik production.

The feasibility of the implementation of this option was reviewed from the economic, technical, and environmental performances. Economic feasibility analysis showed that both alternatives feasible to be implemented. Feasible alternatives that have a high priority would be effective for improvement of environmental performance. This study was applied option 1 due to economic feasibility rate higher compared with option 2. Another reason is the option 1 easies to do due to limited time and lack of knowledge of the owner and employees of batik industry.

Table 2. Cleaner production option for reducing wastewater.

No	Cleaner Production alternatives	Strategies	Investment	Benefit	Economic feasibility (NPV)
1	Substitution of input material	Replecement chemical dyes (Remazol and Vinyl Sulphone) with natural dyes (e.g.IndigoferoTintoria)	IDR 2.610.000	Rp 3.378.000	Positive
2	Modification of technology/equipment	Development wastewater treatment on site	IDR 2.278.791	Rp 2.808.000	Positive

3.3. Implementation of subtitution of material input

The impact of applying substitution of input material strategy can be seen in table 3. The parameters of BOD, COD, TSS and pH decrease significantly after treatment with improvement around 85 %, 89%, and 98 % respectively (see Table 3). A decrease in the level of BOD, COD, and TSS show an increase in the water quality. Also, the use of natural dyes is not harmful to the environmental. In addition, waste of batik industrial generating from natural dye does not decrease the viability of soil bacteria

[10]. However, the improvement of environmental performance of batik industry requires more effort to meet the level of threshold for wastewater before release to environment.

Table 3. Characteristic of batik wastewater before and after CP treatment.

Parameter	Characteristic of batik wastewater before implementing CP	Characteristic of batik wastewater after implementing CP	Threshold (mg/L)
BOD	5226 mg/L	738.3 mg/L	75
COD	20900 mg/L	2930 mg/L	200
TSS	2036 mg/L	38.6 mg/L	100
pH	9	10.8	11.8

4. Conclusion

The implementation cleaner production has a significant contribution to improve the environmental performance during the production of batik. Batik industry generates wastewater with high concentration of BOD, COD that has potential to contaminate environment. In order to improve the environmental performance during the industrial activities, cleaner production option was implemented. Substitution of material input strategy has applied by replacement chemical dyes with natural dyes during the coloring process. The result indicates that the CP option (substitution of input material) significantly improves the environmental performance in terms of BOD, COD, and TSS reduction by 85%, 89%, and 98% respectively.

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