

# The Priority of Alternative on-site Recovery Application as Cleaner Production Practice in SME Batik in Central of Java, Indonesia

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**Abstract**-This study aims to identify the most suitable alternative in the application of Cleaner Production (CP) based on the cost and benefit impact by presenting the result of survey-type research of two Small Medium Enterprise (SMEs) Batik; one located in the Pekalongan and the other located in Solo. The result of the study indicated that recycle wet wax which has been collected from the process of wax removing is the first priority. The second priority is reuse waste water from flushing process as long as two days. The third priority is reuse waste water from the dyeing process. The fourth priority is reuse waste water from washing process as long as two days. The fifth process reuses a droplet wax and the last priority is reuse waste water from wax removing process as long as three days.

**Keywords**- Cleaner Production; Recycle; Reuse; Reduce; SMEs Batik

## I. INTRODUCTION

Batik has been very famous as an important textile product made by Javanese, Indonesia. There has been a very long historical route of batik as a traditional and cultural heritage in Indonesia [1]. Batik is a fabric dyeing method using wax to create patterns and designs. This method makes use of a resist technique; applying areas of cloth with wax (a dye-resistant substance) to prevent them from absorbing colors when the cloth is dipped into dye. Not only as a dye-resistant substance, the wax which is applied also used to control colors from spreading out from a particular area to create motif when the dye is painted [2]. Two processes that represent the art of batik making are 'batik-tulis' (hand-drawn batik) and 'batik cap' (hand-stamped batik). Hand-stamped batik was developed in the middle of the 19th century by the Javanese, revolutionizing the batik production. The hand-drawn batik is produced by painting the wax on the cloth using a traditional tool called the canting; whereas the hand-stamped batik is produced by stamping the wax on the cloth using a copper stamp to make the batik design. The other technique combines both the canting and the stamp in order to produce more creative designs [3].

The process of making batik produces large amounts of effluents with a high concentration of pollutants which required extensive treatment before discharged into the environment. Referring to research that conduct by Suhartini et al. [4], the concentration of pollutants in wastewater originating from the process of making batik starting from the highest concentration to lowest concentration is the BOD (366.45 kg/day), COD (620.4 kg/day), and TSS (83.9 kg/day). In addition, a process of making batik also releases fat oil = 0.0000108 kg/day, CNH-N = 0.0004431 kg/day, and PH = 0.0045694 kg/day. The process of making batik produces large amounts of waste because of material-usage. Reference [5] found that the significant inefficiency is related to the usage of wax, dyestuff and water. The portion of wax and dyestuff cost dominate the total production cost of three companies that the author researched. Un-reusable wax reached 60%, dyestuff losses from 0.07% a year until 54.58% a year, and water inefficiency approximately reached 80% a year.

To reduce negative impacts of the process of making batik which is created by large amounts of effluents and inefficiency in using a material, batik industries can adopt a Cleaner Production (CP) in their process of production. Cleaner production is not a new concept as in [6]. It has essentially been practiced since the first chemical processes were utilized in our industrial society. Referring to United Nations Environment Programme (UNEP) 1994 and Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC) 1998, CP is generally defined as the continuous application of an integrated preventive environmental strategy to processes, products, and services to increase eco-efficiency and reduce risks to humans and the environment [7]. Cleaner production encompasses a broad range of applications such as changes in manufacturing technologies and practices, changes in chemicals and other raw material inputs, and even changes in products and packaging [8]. The foundation of the CP concepts is to plan, examine, re-evaluate and maintain the production processes to highlight ways of improving productivity, while reducing its environmental impacts through four main activities which are also called 4Rs (Reuse, Reduce, Recycle and Reproduce), or including another one (Recovery). CP means is persistently used in industrial processes, raw materials and products designed from their inception to prevent pollution of air, water and land; in order to reduce waste, to minimize the risks of environment and human health, and to make efficient use of raw materials, such as energy, water and space [9].

Although CP encompasses a broad range of applications, each alternative application of CP which is chosen will have different cost and benefit impacts to the SMEs in batik industries because they should invest some equipment. Invest for some

equipment make one of the alternatives may be burdening the company cost more than the others but that alternative may be more profitable than the other alternative. Based on this condition, this research aims to identify the most suitable alternative in application of CP based on the cost and benefit impact. More detailedly, this research aims to: (i) determine the type and amount of waste that comes from an effluent and inefficient use of materials from any process of making batik; (ii) determine one or more alternatives in application of CP which can be used by SMEs to reduce effluent and increase efficiency in using a material; (iii) evaluate the alternatives that have been chosen based on cost and benefit analysis; and (iv) make a priority of alternative in application of CP in process of making batik.

## II. LITERATURE REVIEW

### A. The Concept of Cleaner Production and Some Related Studies

Cleaner Production is an environmental management concept that surged in the 1970s as a strategy for environmental improvement that is complementary to environmental regulation. It advocates a voluntary approach for reducing environmental waste while also reducing costs. An early paper on the subject (Baas, et al. in the year 1990) defines CP as the continuous application of integrated, preventive environmental strategy to both processes and products to reduce risks to humans and the environment. The concept assumes that contamination is a result of the “ineffective” use of raw materials, products or by-products [10].

There are a number of constraints in disseminating CP concepts among which SMEs have been identified. It is because the SMEs has many difficulties in recognizing environmental hazards and risks present in their business activities as in [11, 12, 13] and the direct environmental impacts of SMEs are often diffuse and difficult to measure as in [14, 15]. Reference [16] says that the disseminating of the CP concept among SMEs is constrained by a lack of resources, lack of knowledge, and the perception of SMEs that CP did not have an impact on the environment. Lack of knowledge has caused inability of SME operators to adequately identify environmental hazards and risks which are leading to a lowered perception of the need for such technical skills. Other studies showed that the disseminating of the CP concept among SMEs is constrained by these factors: (a) lack of vision and knowledge on the part of business managers as in [17], [18], [19]; (b) lack of internal resources such as investment capital as in [20, 21, 22]; (c) limited technical knowledge and information about viable cleaner practices and technologies as in [23, 24, 25]; little staff motivation for development and implementation of CP alternatives as in [26]; and (d) lack of availability of tailor-made tools and strategies for environmental improvement in SMEs as in [27]. Then, according to research conducted by Shi et al [28], the top three barriers to CP adoption by Chinese SMEs were found to be: (a) lack of economic incentive policies; (b) lax environmental enforcement, and (c) high initial capital cost. The researchers conclude that current governmental policy should give higher priority to lessening those external policies and financial barriers rather than internal technical and managerial barriers. The findings shed some new light on readjusting public policy in order to help to facilitate widespread CP implementation in SMEs in China.

Although there are a number of constraints in disseminating CP concepts among SMEs, study conducted by Phungrassami [29] demonstrated that the amount of water, energy saving cost and chemical saving cost could be lower by at least 90%, 7% and 8%, respectively because of application of CP by SMEs in Thailand. In line with Phungrassami [29], the study conducted by Rahman et al. [30] found that CP activities provide environmental improvement and they contribute to competitive advantage in Indonesian SMEs. This finding was concluded from the results of a CP implementation survey conducted among Indonesian SMEs. Out of 54 companies located at Pulogadung, 28 companies (51.85%) were applying CP in their environmental protection; 6 companies (11.11%) were applying 3R (reduce, reuse, recycle); 11 companies (20.37%) were going for reduce and reuse (2R) only; and 9 companies (16.67%) were practicing one R only in reducing their material usage in production line. Rahman, et al. (2009) also found that 54 selected SMEs have increased the productivity on manufacturing system (a saving of energy usage) and one of them (1.85%) had reduced 70% of their production cost by decreased rework, waste and energy saving contributed to the environment.

### B. The Process of Making Batik

There are three main batik techniques, i.e: hand-waxed (hand-drawn), hand-stamped, and the combination of the two [2]. Basically, without the process of preparation of the cloth, there are seven steps in the production process of making batik, i.e.: applying the first wax, applying the second wax (waxing prior to indigo steeping -“*nembok*”), dyeing the first colour (“*medel*”), removing the first wax (“*ngerok*”), applying the third wax (“*mbironi*”), dyeing the second colour (“*men yoga*”), and removing all of the wax from cloth (“*nglorod*”), as in [3], [31], [32].

Before the first step (applying the first wax), the cloth has to be specially treated in order to make sure that the wax adheres evenly to the surface and will not crack during the dyeing; as also to facilitate the penetration of the dye to those parts of the cloth left uncovered. Insufficient preparation of the cloth before dyeing would result in uneven, pallid colours. In the preparation process, the cloth is first washed to remove the original starch. Then it is soaked in vegetable oil. This process is called “*ngetel*” or “*ngloyor*”. To remove excess oil, the cloth is soaked in a solution of rice-straw ash and water. Nowadays, a caustic soda solution is preferred because it works more quickly. After washing and drying, the cloth is pounded with a heavy wooden mallet. By this process called “*ngemplong*”, the cloth is smoothed out, so that the wax flows evenly over it [31].

The following is a description of each step of the production process of making batik cap as in [3, 31, 32].

### 1) Applying the First Wax:

When the cloth is ready, the first application of wax is applied on both sides of the cloth using the canting (for hand-drawn batik) and the cap (for hand-stamped batik). The ‘cap’ is a metal stamp, usually constructed of strips of sheet copper, used in the Batik process to apply molten wax to the cloth surface. Smaller pieces of wire are used for the dots. When completed, the pattern of copper strips is attached to a handle. The cap is made precisely as it is to be stamped on both sides of the fabric; as a result both sides of the fabric are printed with identical and consistent patterns.

### 2) Applying the Second Wax (Waxing Prior to Indigo Steeping): Nembok

Then the second application of wax is applied. This process is called “*nembok*” in Javanese, originating from the word “*tembok*” meaning wall which literally describes what happens since the thick layer of wax that is applied to form a kind of wall of defences to keep the dye out. In this step, all those parts which are to remain white are now given a second layer of wax which has a different composition from the first and must be stronger and thicker.

### 3) Dyeing the First Color Medel:

After the second application of wax, the cloth is now ready for the “*medel*” or the first submersion into a bath of dye. This is the process to give the first colour to the cloth. When traditional dyes are used this process can take days as the cloth must be submerged and then air dried alternately for several times. With modern dyes once is enough, Naphthol and Indigosol (or another type of dye) are used instead of the vegetable dye (for traditional colours, this is the indigo blue dye). The blending of the chemicals with Ferro sulphate and lime, and the timing during the steeping itself are important factors.

### 4) Removing the First Wax: Ngerok

Once the cloth is dry, it undergoes the process of “*ngerok*” or the removing of the first application of wax from those parts that are to be dyed with a second colour. This is done by using a scraper or *cawuk*.

### 5) Applying the Third Waxing: Mbrioni

After removing the first application of wax, the following step is “*mbironi*” or the third application of wax to cover the parts of the fabric that have been dyed and leaving the parts to be dyed another colour open (this is giving the second colour to the cloth).

### 6) Dyeing the Second Colour or Soga Dyeing: Menyoga

After third waxing, the cloth is now ready for “*menyoga*” or the application of the second colour which in the traditional process was *soga* or the natural brown dye (it could be the other colour, not only brown). When using natural dyes this will again take days, whereas when modern dyes are applied the process will not be longer than half an hour.

### 7) Removing All of the Wax from Cloth: Nglorod:

When the cloth has been dyed as desired, the batik goes through the last stage of the process called “*nglorod*”, in which the wax is removed again by soaking it in boiling water.

All the processes can be described in the Figure 1.



Applying the first wax



Applying the second wax (waxing prior to indigo steeping) nembok



Dyeing the first color



Removing the first wax



Applying the third wax



Dyeing the second color



Removing all of the wax from the cloth

Fig. 1 The process of making batik

### III. METHODS

#### A. Steps of Research

In this research, there are five steps to determine some options of implementation of CP in the process of making batik.

##### 1) Step 1 – Determine Input and Output Data and Calculate Mass and Energy Balances:

To really find out what is happening in the operations, and where we need to construct some kinds of mass or energy balance to determine inputs and outputs and quantify them. Mass and energy balances are usually classed as an essential part of a structured approach to deal with an assessment [33]. Mass balance is an accounting of material entering and leaving a system. Fundamental to the balance is the conservation of mass principle, i.e. that matter cannot disappear or be created. Mass balances are used to design chemical reactors, analyse alternative processes to produce chemicals, in pollution dispersion models, etc. In environmental monitoring the term “budget calculations” is used to describe mass balance equations where they are used to evaluate the monitoring data comparing input and output data [34].

##### 2) Step 2 – Calculate Environmental Performance Index (EPI):

Reference [35], [36], [37], and [38] say that EPI represents numerical measures, financial or nonfinancial, that provide key information about environmental impact, regulatory compliance, stakeholder relations, and organizational systems. EPI refers to the measurement of the interaction between the business and the environment [39]. EPI represents the quantification of the effectiveness and efficiency of environmental action with a set of metrics [40]. The indicators act as surrogates or proxies for organizational phenomena [41]. In this research, EPI is measured by this equation [42]:

$$EPI = \sum_{i=1}^k W_i P_i \quad (1)$$

$K$  = the amount of pollutants generated from the production process

$W$  = weight that indicates the level of danger of a pollutant compared to other pollutants

$P$  = difference between the amount of pollutants generated from production processes compared to the amount of pollutants allowed by government standard

The positive value of EPI indicates that amount of pollutant produced by the production process of batik complied with waste quality standards and safe for the environment. The negative value of EPI indicates that amount of pollutant produced by the production process of making batik did not comply with waste quality standards and harmful to the environment [42].

##### 3) Step 3 – Identify Some Alternatives of Implementation CP in the Production Process of Making Batik:

There are some alternatives of implementation of CP in the production process of making batik, i.e.: reduce, reuse, and recycling [43].

**Reduction of hazardous materials and chemicals:** Reduce is the principle concerned with input, aiming at reducing the input materials and energy in the production and consumption processes. It can also be called material reduction. In other words, it is essential to turn out the products using as fewer resources as possible, and to minimize waste [43].

**Reuse:** Reuse is the principle concerned with processing which requires the use of natural resources in every possible way. By reusing raw materials, by-products and used products, the lifespan of products and services can be prolonged and waste created in production processes can be minimized [43].

**Recycle:** Recycle is the principle concerned with output. By turning wastes to secondary resources, the waste requiring final disposal can be reduced and the consumption of natural resources can be reduced as well. Producers should try to use secondary resources as much as possible [43].

##### 4) Step 3 – Identify Feasibility of Each Alternative of Implementation of CP in the Production Process of Making Batik Based on Economic Criteria:

In this step, each alternative of implementation of CP that has been chosen to increase efficiency in using a material and reducing waste will be analysed in the contexts of net savings that can be obtained. Net savings are calculated by reducing benefits by the amount of investments (cost) made to make the process of reuse, recycle, or reduction (if any).

##### 5) Step 5 – Make a Priority of Alternative of Implementation of CP in the Production Process of Making Batik Based on the Result of Calculation in the Step 4:

In this step, priority of each alternative of implementation of CP was chosen based on Net Present Value (NPV) of net savings for one year. The alternative with the highest NPV of net saving for one year will become the first priority.

### B. Methods of Data Collection

This study presents the result of survey-type research by examining more closely to SMEs Agus Wijaya and SMEs Saud Effendy. Reference [44] says that survey is a tool that consists of a "self-reporting" of facts or opinions that can be applied to a homogeneous group, with at least one common characteristic, as belonging to the same industry. SMEs Agus Wijaya has been established since 1990 and located in West of Pekalongan. SMEs Agus Wijaya produced a hand-stamped batik with an average production of 1,200 piece of cloth per month. SMEs Saud Effendy has been established since 1985 and located in Solo. SMEs Saud Effendy also produced a hand-stamped batik cap with an average production of 2,500 pieces of cloth per month.

In that survey, the interview topics were designed to investigate issues solely related to both SMEs in order to collect more detailed information about the material and method which is used in the production process of making batik. The topics for the interviews were: (i) the detailed production process of making batik in both of SMEs; (ii) the type and amount of raw material, including dyes and chemical, used by each step of the production process of making batik (input); (iii) type and amount of waste resulted from each step of the production process of making batik; (iv) the colouring technique which was used by both of SMEs; (v) job allocation for each worker; and (vii) layout of the production process of making batik.

## IV. RESULTS

Both SMEs use cotton (mori prima) as a fabric for batik production. Mori prima is the less fine cotton to be used for either hand-drawn batik or hand-stamped batik. Although in general, both SMEs have a similar production process of making batik as described in the previous section, there were some modifications which were conducted by both of SMEs. SMEs Agus Wijaya conducted the first colour of dyeing in two steps. The first step was dyeing the cloth in bath dye and the second step was dipping the cloth in the diazo salt for locking the colour. Besides that, for their uniqueness, SMEs Agus Wijaya also did colouring process which was called "*colet*" besides dipping the cloth in bath dye. "*Colet*" is a method of colouring the cloth using a brush. *Colet* was conducted for dyeing the second colour. For removing the wax, SMEs Agus Wijaya is using soda ash as the ingredient; whereas, SMEs Saud Effendy is using tapioca flour as ingredients. The existence of a variation in the production process of making batik conducted in both of SMEs which becomes an object in this study is indicating that there are no generally accepted standards for the process of making batik. Each SME can make any differences to get the uniqueness.

### A. The Result of Determine Input and Output of each Stage of Process of Making Batik and the Result of Calculate Mass and Energy Balances

Based on the production process of making batik in each of SMEs, we can determine the type and amount of input and output and calculate the mass and energy balance of each step of the production process. Then, from this calculation, we can estimate the type and amount of waste which was generated from each step as in Table I and Table II.

TABLE I THE TYPE AND AMOUNT OF WASTE WHICH WAS GENERATED FROM EACH STEP OF THE PRODUCTION PROCESS OF MAKING BATIK IN SME AGUS WIJAYA

| Process                                                                                                                   | Input                                          |                                                                                                                                                                                                                           | Output                                                                                                                                                                              | Waste                                                                                                                    |
|---------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| Application of wax (the first waxing, the second waxing and or " <i>nembok</i> ", and third waxing or " <i>mbrioni</i> ") | Raw material                                   | <ul style="list-style-type: none"> <li>Prima mori 40 m <math>\approx</math> 20 kodi</li> <li>Wax 5,000 grams</li> <li>Liquid Petroleum Gas (LPG) 0.67 kg</li> </ul>                                                       | Patterned cloth + wax that permeated in the patterned cloth as much as 4,800 grams                                                                                                  | Droplets of wax that trickled into the area around of the process of making batik as much as <b>200 grams</b> + emission |
| Dyeing the cloth                                                                                                          | Dyeing the first colour                        | <ul style="list-style-type: none"> <li>Patterned cloth + wax that permeated in the patterned cloth as much 4,800 grams</li> <li>Naphthol 60 grams</li> <li>Caustic soda 30 grams</li> <li>Clean water 16 liter</li> </ul> | Colour patterned cloth 40 m + wax that permeated in the colour patterned cloth as much as 4,800 grams                                                                               | Wastewater 16 liter that contains 60 grams dissolved Naphthol + 30 grams dissolved caustic soda                          |
|                                                                                                                           | Locking colour                                 | <ul style="list-style-type: none"> <li>Colour patterned cloth 40 m + wax that permeated in the colour patterned cloth as much as 4,800 grams</li> <li>Diazo salt 120 grams</li> <li>Clean water 16 liter</li> </ul>       | Colour patterned cloth 40 m + wax that permeated in the colour patterned cloth as much as 4,800 grams                                                                               | Wastewater 16 liter that contains 60 grams dissolved Naphthol + 30 grams dissolved diazo salt                            |
|                                                                                                                           | Washing the cloth after dyeing the first color | <ul style="list-style-type: none"> <li>Colour patterned cloth 40 m + wax that permeated in the colour patterned cloth as much as 4,800 grams</li> <li>Clean water 521 liter</li> </ul>                                    | Colour patterned cloth 40 m + wax that permeated in the colour patterned cloth as much as 4,800 grams                                                                               | Waste water 521 liter that contained some chemical hazards                                                               |
|                                                                                                                           | Colet (dyeing the second color)                | <ul style="list-style-type: none"> <li>Colour patterned cloth 40 m + wax that permeated in the colour patterned cloth as much as 4,800 grams</li> <li>Indigosol 80 grams</li> <li>Clean water 5 liter</li> </ul>          | Colour patterned cloth 40 m + wax that permeated in the colour patterned cloth as much as 4,800 grams + indigosol that permeated in the colour patterned cloth as much as 4.5 liter | 0.5 liter residual dye                                                                                                   |

|             |             |                                                                                                                                                                                                                                                                                                                                   |                                                                |                                                                                                 |
|-------------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| Wax removed | Wax removed | <ul style="list-style-type: none"> <li>• Colour patterned cloth 40 m + wax that permeated in the colour patterned cloth as much as 4,800 grams+indigosol that permeated in the colour patterned cloth as much as 4.5 liter</li> <li>• Clean water 60.28 liter</li> <li>• Soda ash 700 grams</li> <li>• Firewood 5.1 kg</li> </ul> | Batik cloth 40 m which contains indigosol as much as 4.5 liter | Wastewater 16 liter that contains 700 grams dissolved soda ash + wet wax 4,000 grams+ emissions |
|             | Flushing    | <ul style="list-style-type: none"> <li>• Batik cloth 40 m which contains indigosol as much as 4.5 liter</li> <li>• Clean water 480 liter</li> </ul>                                                                                                                                                                               | Batik cloth 40 m which contains indigosol as much as 4.5 liter | Wastewater 480 liter                                                                            |

TABLE II THE TYPE AND AMOUNT OF WASTE WHICH WAS GENERATED FROM EACH STEP OF THE PRODUCTION PROCESS OF MAKING BATIK IN SME SAUD EFFENDY

| Process                                                                                                 | Input                                                                                                                                                                                                                                                                    | Output                                                                                              | Waste                                                                                                            |
|---------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| Application of wax (the first waxing, the second waxing and or "nembok", and third waxing or "mbrioni") | Raw material <ul style="list-style-type: none"> <li>• Prima mori 40 m ≈20 kodi</li> <li>• Wax 5,700 grams</li> <li>• Liquid Petroleum Gas (LPG) 0.67 kg</li> </ul>                                                                                                       | Patterned cloth +wax that permeated in the patterned cloth as much as 5,500 kg                      | Droplets of wax that trickled into the area around of the process of making batik as much as 200 grams+ emission |
| Dyeing the cloth                                                                                        | Dyeing the first colour and second colour <ul style="list-style-type: none"> <li>• Patterned cloth +wax that permeated in the patterned cloth as much 5,500 kg</li> <li>• Polkazol 600 grams</li> <li>• Water glass 1.6 liter</li> <li>• Clean water 10 liter</li> </ul> | Colour patterned cloth 40 m + wax that permeated in the colour patterned cloth as much as 5,500 kg. | Wastewater 10 liter that contains 600 grams dissolved Polkazol                                                   |
|                                                                                                         | Washing the cloth after dyeing the first colour <ul style="list-style-type: none"> <li>• Colour patterned cloth 40 m + wax that permeated in the colour patterned cloth as much as 5,500 kg</li> <li>• Clean water 168.75 liter</li> </ul>                               | Colour patterned cloth 40 m + wax that permeated in the colour patterned cloth as much as 5,500 kg  | Waste water 168,75 liter that contained some chemical hazards                                                    |
| Wax removed                                                                                             | Wax removed <ul style="list-style-type: none"> <li>• Colour patterned cloth 40 m + wax that permeated in the colour patterned cloth as much as 5,500 kg</li> <li>• Tapioca flour 100 grams</li> <li>• Clean water 104.5 liter</li> <li>• Firewood 8,000 grams</li> </ul> | Batik cloth 40 m                                                                                    | Wastewater 100,6 liter that contains 100 grams dissolved tapioca flour + wet wax 3,000 grams+ emissions          |
|                                                                                                         | Flushing <ul style="list-style-type: none"> <li>• Batik cloth 40 m</li> <li>• Clean water 348.4 liter</li> </ul>                                                                                                                                                         | Batik cloth 40 m                                                                                    | Wastewater 354,8 liter                                                                                           |

### B. The Result of Calculate EPI Index

Then, to provide the information about environmental impact which is caused by each of SMEs, this research also calculates the EPI's value index of each SME as seen in Table III and Table IV. Although there are differences in input and output and type and amount of waste that resulted, both SMEs have negative values of EPI index. This condition indicates that both SMEs still have worsen an environment performance.

TABLE III EPI'S INDEX VALUE FOR SME AGUS WIJAYA

| No           | Parameter      | Weight (%) *)<br>1 | Standard (Mg/liter) **)<br>2 | Result from obs. (Mg/liter)<br>3 | EPI<br>4=((2-3)/2)*1 |
|--------------|----------------|--------------------|------------------------------|----------------------------------|----------------------|
| 1            | BOD5           | 3.00               | 50.00                        | 12.00                            | 2.28                 |
| 2            | COD            | 3.08               | 150.00                       | 3,570.00                         | -70.22               |
| 3            | TSS            | 2.93               | 50.00                        | 630.00                           | -33.99               |
| 4            | Phenol         | 4.63               | 0.50                         | 3,459.00                         | -27.40               |
| 5            | Cr Total       | 4.63               | 1.00                         | 0.00                             | 4.63                 |
| 6            | Oil and grease | 3.63               | 3.00                         | 14.00                            | -13.43               |
| 7            | Sulfide        | 4.13               | 0.30                         | 0.00                             | 4.13                 |
| 8            | Ammoniac       | 3.33               | 8.00                         | 0.37                             | 3.18                 |
| EPI= -130.83 |                |                    |                              |                                  |                      |

TABLE IV EPI'S INDEX VALUE FOR SME SAUD EFFENDY

| No | Parameter | Weight (%) *)<br>1 | Standard (Mg/liter) **)<br>2 | Result from obs.(Mg/liter)<br>3 | EPI<br>4=((2-3)/2)*1 |
|----|-----------|--------------------|------------------------------|---------------------------------|----------------------|
| 1  | BOD5      | 3.00               | 50.00                        | 18.00                           | 1.92                 |
| 2  | COD       | 3.08               | 150.00                       | 713.00                          | -11.56               |
| 3  | TSS       | 2.93               | 50.00                        | 54.00                           | -0.23                |
| 4  | Phenol    | 4.63               | 0.50                         | 0.09                            | 3.79                 |
| 5  | Cr Total  | 4.63               | 1.00                         | 0.00                            | 4.63                 |

|                    |                |      |      |       |        |
|--------------------|----------------|------|------|-------|--------|
| 6                  | Oil and grease | 3.63 | 3.00 | 20.60 | -21.29 |
| 7                  | Sulfide        | 4.13 | 0.30 | 0.00  | 4.13   |
| 8                  | Ammoniac       | 3.33 | 8.00 | 18.14 | -4.22  |
| <b>EPI= -22.83</b> |                |      |      |       |        |

\*) The weight of each parameter of wastes (BOD, COD, TSS, etc.) refers to research conducted by Susanti [45]

\*\*) The value of the standard refers to Central Java Government Regulation No. 10/2004 about Wastewater Quality Standard for Textiles and Batik Industries

### C. The Result of Identifying Some Alternatives of Implementation CP for SMEs Batik

Based on the estimation of the amount and types of waste generated by SMEs Agus Wijaya and SMEs Saud Effendy, this study proposes a number of alternatives of the implementation of CP and waste treatment at both SMEs. This can be seen in Table V.

TABLE V ALTERNATIVE OF IMPLEMENTATION CP AT SME AGUS WIJAYA AND SME SAUD EFFENDY

| No Alt | Type of waste                                                           | Alternatives for the implementation of CP and waste treatment                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------|-------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1      | Droplets of wax                                                         | <b>Reuse droplets of wax which trickled into the area around of the process of making batik and has been becoming dry; this is done by:</b> | <ul style="list-style-type: none"> <li>Place the basket that has been lined with plastic around the place of the process of making batik to accommodate wax which has dropped during the process</li> <li>Reusing directly collected droplets of wax in the process of making batik</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 2      | Wet wax                                                                 | <b>Recycle wet wax which has been collected from the wastewater of the process of wax removing (nglorod); this is done by:</b>              | <ul style="list-style-type: none"> <li>Make a tub to catch the wax that released from the cloth; the tub is called kowen</li> <li>Recycle the wet wax by adding a mixture of materials such as Gondorukem, Kendal, and Paraffin. To recycle a wet wax, every 100 kg of wet wax is requiring gondorukem as much as 15 kg, paraffin as much as 7.50 kg and kendal as much as 1.50 kg. Gondorukem made of merkusi pines rubber; gondorukem is used in the wax mixture to keep the wax stay liquid longer and avoid the liquid wax from freezing. Kendal is animal fat obtained from cows or buffalo; kendal is used in the wax mixture to soften the wax, lower the boiling point and ease the peeling off process; whereas paraffin is white or light yellow, usually used in the mixture to provide water resistant substance to the cloth; paraffin is cheap compared to other substance with water resistant function</li> </ul> |
| 3      | Wastewater from dyeing process                                          | <b>Reuse waste water from dyeing process; this is done by:</b>                                                                              | <ul style="list-style-type: none"> <li>Adding a dye as much as 40% of the amount of the original need of a dye for Naphthol; adding 30% of the amount of the original need of dye for Indigosol; and adding 100% of the amount of the original need of a dye for Na Nitrite</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 4      | Chemical hazard (BOD5, COD, etc.) from wastewater of the dyeing process | <b>Reduce or replace the use of synthetic dyes with natural dyes; this is done :</b>                                                        | <ul style="list-style-type: none"> <li>Reduce or replace the use of synthetic dyes with natural dyes so the wastewater produced from the dyeing process will not contain harmful chemical substances</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 5      | Chemical hazard (BOD5, CoD, etc.) from wastewater of the dyeing process | <b>Reduce levels of dangerous chemicals being dumped into the environment to fit the specified quality standards; this is done by:</b>      | <ul style="list-style-type: none"> <li>Make a simple WWTP</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 6      | Wastewater from wax removing process                                    | <b>Reuse the water from wax removing; this is done by</b>                                                                                   | <ul style="list-style-type: none"> <li>Reuse the water from wax removing process as long as 3 (three) days before disposal</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 7      | Wastewater from washing and flushing                                    | <b>Reuse the water from washing and flushing process; this is done by:</b>                                                                  | <ul style="list-style-type: none"> <li>Reuse the water from washing and flushing process as long as 2 (two) days before disposal</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

### D. The Result of Calculating the Cost and Benefit for Each Proposed Alternative

Economically, each proposed alternative for the application of CP will be analysed in the contexts of of net savings that can be obtained. Net savings are calculated by reducing benefits by the amount of investments (cost) made to make the process of reuse, recycle, or reduction (if any). In order to implement the first alternative (reuse droplet of wax), SMEs Agus Wijaya and SMEs Saud Effendy are required to invest some baskets and plastic approximately 33,000 IDR (5 baskets @ 5,000 IDR and eight plastic @ 1,000 IDR). On the other hand, as described in the Table I and Table II, the result of the observations suggests that the production process of making batik in SMEs Agus Wijaya and SMEs Saud Effendy as much as 40 m will produce droplets of wax not less than 200 grams. If all dry droplets of wax are reused in the process of making batik and process of making batik can produce 2,000 m/month, then in a month, craftsmen can save the use of wax as much as 10,000 grams or 10 kg (200 grams x 2,000 m/month/40 m). Value of gross savings is equivalent to 160,000 IDR/month (10 kg/ month x 16,000 IDR/kg). Thus, the net saving that can be generated in the first month of the implementation of reuse droplets of wax is 127,000 IDR/month (160,000 IDR/month less 33,000 IDR/month). In the following months, the net saving will be even greater (152,000 IDR/month) because SMEs Agus Wijaya and SMEs Saud Effendy do not need to purchase the basket every month (which need to be purchased every month just a plastic). The positive value of the net saving of alternative reuse droplets of wax indicates that the alternative is economically viable.

To implement the next alternative, recycle wet wax which has been collected from the wastewater of the process of wax removing (*nglorod*), both SMEs need to make “kowen” (a tub to catch the wax that released from the cloth) and purchase some gondoruken, paraffin, and kendal and also fuel to be used to reheat the wet wax. The cost of making “kowen” is about 3,000,000 IDR and cost of purchase of all that materials and additional fuel is about 803,400 IDR/week to 805,900/week. Its cost depends on the price of each of material on the market. If all the results of recycle of the wet wax are used again in the process of making batik, then each of SMEs can save on the purchase of wax as much as 132 kg/week until 135 kg/week. If the price of wax is 16,000 IDR, then the benefit is equal to 2,112,000 IDR/week until 2,160,000 IDR/week. Based on this condition, in the first month, both SMEs cannot make a positive net saving because the cost of making kowen and purchasing all that materials and fuel is still greater than the benefit of not purchasing a wax. Both SMEs will get a positive net saving after three months or in the fourth month. At that time, the net saving that can be generated from the implementation of recycled wet wax is equal to 1,308,600/week or 5,324,400 IDR/month until 1,354,100 IDR/week or 5,416,400 IDR/month. Although initially negative, the positive value of the net saving of alternative recycles in wet indicates that the alternative is economically viable.

From implementation the alternative of reuse wastewater from dyeing process, each SME will get benefit from the efficiency of using dye and water. For implementing this alternative, each SME must buy a bucket or plastic tub to hold the residual of water from the dyeing process. The cost of buying a bucket or plastic tube is about 250,000 IDR until 300,000 IDR (depend on the type and quality of a bucket or plastic tub), and the benefit from the efficiency of using dye and water is about 438,480 IDR/month to 864,000 IDR/month from the second month onward. This benefit is depending on the type of dye used. For the first month, SMEs can only gain a net saving as much as 138,480 IDR/month (438,480 IDR/month less 300,000 IDR/month) to 564,000 IDR/month (864,000 IDR/month less 300,000 IDR/month) if the SMEs use a bucket or plastic tube which is costing 300,000 IDR. The positive value of the net saving of alternative reuse wastewater from dyeing process indicates that the alternative is economically viable.

From implementation the alternative of reusing the water from the washing process, wax removing process and flushing process, each SME will get net saving from the efficiency of using the water. On SMEs Agus Wiyaja, respectively, this efficiency will cause the SMEs get net saving as much as 202,799.25 IDR/month, 31,285.38 IDR/month, and 186,400 IDR/month. On SMEs Saud Effendy, respectively, this efficiency will cause the SMEs get net saving as much as 115,725.25 IDR/month, 95,665.20 IDR/month, and 245,840.00 IDR/month. The positive value of the net saving of each alternative indicates that all alternatives are economically viable.

Unlike previous alternatives, reducing or replacing the use of synthetic dyes in order to reduce the chemical hazard in the wastewater is less economical because the implementation of this alternative does not give a positive net saving to the enterprise. The cost of making batik by using natural dyes is relatively higher than the cost of making batik by using synthetic dyes. It makes; net benefit from making batik by natural dyes less than net benefit from making batik with synthetic dyes. The other alternative to reduce levels of dangerous chemical hazard being dumped into the environment is making simple Waste Water Treatment Plant (WWTP). It is quite difficult to calculate the net saving of each SMEs because the process of making WWTP is usually collective (involve more than one SME) and the process of making WWTP usually gets some subsidy or assistance from local government.

#### E. Proposed Alternative

The NPV of net saving for one year of each alternative of implementation of CP becomes the basis for determining the priority of the proposed alternatives. The alternative with the highest NPV of net saving for one year will become the first priority. In summary, the NPV of net saving for one year from each alternative can be seen in the Table VI.

TABLE VI PRIORITY OF ALTERNATIVE IN APPLICATION OF CP

| Alternative                                                                                 | Net saving (IDR/month)                         | NPV of net saving for one year<br>(i=6%/year)<br>(IDR/year) | Priority |
|---------------------------------------------------------------------------------------------|------------------------------------------------|-------------------------------------------------------------|----------|
| Reuse droplets of wax                                                                       | 127,000 – 152,000 (From the first month)       | 1,064,748.18 – 1,274,344.28                                 | 5        |
| Recycle wet wax which has been collected from the wastewater of the process of wax removing | 5,324,400 – 5,416,400 (From the fourth month)  | 36,214,930.35 – 36,840,686.04                               | 1        |
| Reuse wastewater from dyeing process                                                        | 138,480 – 564,000 (From the second month)      | 1,019,224.85 – 4,151,089.10                                 | 3        |
| Reuse the wastewater from the washing process                                               | 115,725.25 – 202,799.25 (From the first month) | 970,222.44 – 1,700,237.26                                   | 4        |
| Reuse wastewater from wax removing process                                                  | 31,285.38 – 95,665.20 (From the first month)   | 262,291.74 – 802,042.11                                     | 6        |
| Reuse wastewater from flushing process                                                      | 186,400 – 245,840 (From the first month)       | 1,562,748.51 – 2,061,084.19                                 | 2        |

Recycle wet wax which has been collected from the process of wax removing is the first priority. The second priority is reuse waste water from flushing process as long as two days before disposal. The third priority is reuse waste water from the dyeing process. The fourth priority is reuse waste water from washing process as long as two days before disposal. The fifth process reuses a droplet wax and the last priority is reuse waste water from wax removing process as long as three days before disposal.

## V. CONCLUSIONS

There were a number of wastes generated from the production process of making batik, i.e.: droplet wax from stamping process, wet wax from wax removing process, wastewater from the dyeing process, wastewater from wax removing process, wastewater from washing and flushing process and chemical hazards which are contained in wastewater. To reduce negative impacts of the wastes generated from the production process of making batik, the enterprise or SMEs in the Batik Industry can adopt some alternatives of CP in the process of making batik. Unless the alternative of reduction of using synthetic dyes with natural dyes, all alternatives of CP which were proposed in this study give positive net saving to both SMEs. Reduction of using synthetic dyes with natural dyes did not give positive net saving to the enterprise because the cost of making batik by using natural dyes was relatively higher than the cost of making batik by using synthetic dyes. This condition made gross benefit from making batik by natural dyes was less than gross benefit from making batik with synthetic dye.

A limitation of this research is the fact that its research focused specifically on two SMEs; one in Pekalongan and the other in Solo and thus the generalisability of the findings to other parts of SMEs batik is still questionable. In addition to that, only one case study was researched in a strict population of a number of SMEs batik in Pekalongan. The data collected here lacks statistical generalisability, but can be considered acceptable because the primary goal was exploration research-building rather than testing. Besides that, because the information gathering was done by deep observation and face-to-face interview, the information would have been richer. Academically, this research will make contributions in the following areas: i) examines some alternatives of CP in the production process of making batik; ii) examine the applicability of some alternatives of CP in the production process of making batik; iii) provide further insights into the match between the production process of making batik and environmental performance in order to achieve business sustainability in batik industries. For owners of SMEs, with the findings, they will be better able to allocate limited resources in order to achieve less waste and more efficient production process.

This research can be enhanced by increasing the number of SMEs from different areas as respondents. Future studies may also consider differentiating the samples of research based on different types of batik produced by the SMEs (hand-drawn batik, a mix between hand-drawn batik and hand-stamped batik) to obtain a more general conclusion about innovation efforts can be made based on the type of batik produced by SMEs.

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## REFERENCES

- [1] Hasanudin, "Batik Pesisiran: Melacak Pengaruh Etos Dagang Santri pada Ragam Hias Batik," Kiblat Buku Utama, Bandung, Indonesia.
- [2] S. S. Oparinde, "Batik as a cultural identity of the Yoruba: hand colouring techniques and applications, possibility of adaptations," *Journal of Arts, Science & Commerce*, vol. 3, pp. 31-41, April 2012.
- [3] Gunaryo, D. Sudarman, H.B. Wibowo, and P. Ambarita P., "Pengembangan Ekonomi Kreatif Indonesia 2025: Rencana Pengembangan Ekonomi Kreatif Indonesia 2009-2015," Report, Ministry of Trade of The Republic of Indonesia, Jakarta, Indonesia, 2008.
- [4] N. A. Suhartini, A. Mahbubah, U. Muid, Ciptomulyono, and M.L. Singgih, "Rancangan sistem pengukuran green productivity dan environmental management accounting untuk pengembangan usaha kecil menengah," in *Proc. Seminar Nasional Manajemen Teknologi XIII*, Surabaya, Indonesia, 2011, pp. A-25-1-A25-9.
- [5] I. Nurdalia, "Kajian dan analisis peluang penerapan produksi bersih pada usaha kecil batik cap (studi kasus pada tiga usaha industri kecil batik cap di pekalongan)," Master thesis, Diponegoro University, 2006.
- [6] T. Zosel, "Pollution prevention in the chemical industry," in Edgerly D. (ed) *Opportunities for Innovation: Pollution Prevention*, National Institute of Standards and Technology, Gaithersburg, USA, pp. 13- 25, 1994.
- [7] R. van Berkel, "Cleaner production for process industries: overview of the cleaner production concept and relation with other environmental management strategies," 2000, available: <http://search.informit.com.au/documentSummary;dn=905761086389730;res=IELENG>, accessed 31 January 2013.
- [8] J.S. Hirschhorn, "Why the pollution prevention revolution failed—and why it ultimately will succeed," *Pollution Prevention Review*, vol.7, pp. 11-31, winter 1997.
- [9] R. Hillary, "Environmental Management Systems and Cleaner Production," John Wiley & Sons Ltd, England, 1997.
- [10] B. van Hoof and T.P. Lyon, "Cleaner production in small firms taking part in Mexico's sustainable supplier program," *Journal of Cleaner Production*, vol.41, pp. 270-282, February 2013.
- [11] F. Tilley, "The gap between the environmental attitudes and the environmental behaviour of small firms," *Business Strategy and the Environment*, vol. 8, pp. 23-248, July 1999.
- [12] C. McKeiver and D. Gadenne, "Environmental management systems in small and medium businesses," *International Small Business Journal*, vol.23, pp. 513-537, October 2005.
- [13] D. Williamson, G. Lynch - Wood, P. Doikos, C. Halvadakis, A. Henry, N. Dunphy, K. Rais, and V. Korab, "A blueprint to support

- environmental compliance among European SMEs," Report, Staffordshire University, UK, 2006.
- [14] R. Hillary, "Small and Medium-Sized Enterprises and the Environment," Sheffield, Greenleaf, UK. 2000.
- [15] D. Perez-Sanchez, J. Barton, and D. Bower, "Implementing environmental management in SMEs," *Corporate Social Responsibility and Environmental Management*, vol. 10, pp. 67-77, May 2003.
- [16] A. Vives, "Social and environmental responsibility in Small and Medium Enterprises in Latin America," *Journal of Corporate Citizenship*, vol.21, pp. 39-50, September 2005.
- [17] G. Hilson and V.Nayee, "Environmental management system implementation in the mining industry: a key to achieving cleaner production," *International Journal of Mineral Processing*, vol. 64, pp. 19-41, February 2002.
- [18] S. Studer, R. Welfor, and P. Hills. "Drivers and barriers to engaging small and medium-sized companies in voluntary environmental initiatives," Working Paper, The Centre of Urban Planning and Environmental Management, The University of Hong Kong, Hong-Kong, 2005.
- [19] L. Baas, "To make zero emissions technologies and strategies become a reality, the lessons learned of cleaner production dissemination have to be known," *Journal of Cleaner Production*, vol.15, pp. 205 -216, September 2007 .
- [20] J.B. Frijns JB and van Vliet, "Small-scale industry and cleaner production strategies," *World Development*, vol. 27, pp. 967-983, June 1999.
- [21] D. Hitchens, S. Thankappan, M. Trainor, J. Clausen, and B. de Marchi, "Environmental performance, competitiveness and management of small business in Europe," *Tijdschrift voor Economische en Sociale Geografie*, vol.96, pp. 541-557, November 2005.
- [22] C. Mitchell, "Beyond barriers: examining root causes behind commonly cited cleaner production barriers in Vietnam," *Journal of Cleaner Production*, vol. 14, pp. 1576-1585, 2006
- [23] G.Hilson, "Barriers to implementing cleaner technologies and cleaner production (CP) practices in the mining industry: a case Study of the Americas Minerals Engineering," *Journal of Cleaner Production*, vol.13, pp. 699-717, July 2000.
- [24] J. Grutter and H.P. Egler, "From cleaner production to sustainable industrial production modes," *Journal of Cleaner Production*, vol.12, pp. 249-256, April 2004.
- [25] R. van Berkel, "Cleaner production and eco-efficiency initiatives in Western Australia 1996-2004," *Journal of Cleaner Production*, vol.15, pp. 741-755, 2007.
- [26] L.J.Stone, "Limitations of cleaner production programmes as organizational change agents. II. Leadership, support, communication, involvement and programme design," *Journal of Cleaner Production*, vol. 14, pp. 15-30, 2006.
- [27] H. Jenkins, "A critique of conventional CSR theory: an SME perspective," *Journal of General Management*, vol. 29, pp. 37-57, June 2004.
- [28] H. Shi, S.Z.Peng, Y. Liu, P. Zhong. "Barriers to the implementation of cleaner production in Chinese SMEs: government, industry and expert stakeholders' perspectives," *Journal Cleaner Production*, vol.16, pp. 842-852, May 2008.
- [29] H. Phunggrassami, "Eco-efficiency as a decision tool for cleaner production: application for SMEs in Thailand," *Environmental Research Journal*, vol. 2, pp. 217-221, 2008.
- [30] M.N.A. Rahman, Hernadewita, B.M. Deros BM, and A.R. Ismail AR, "Cleaner production implementation towards environmental quality improvement," *European Journal of Scientific Research*, vol.30, pp. 187-194, 2009.
- [31] C. A. Sheares, "The Batik patterning technique in Southeast Asia," *The Heritage Journal*, vol. 4, pp. 97-129, 2009.
- [32] <http://www.winotosastro.com/batik/proses.html>.
- [33] R.P. Jack, "Cleaner production: overview and background," Teaching material of environmental management, 2012, available: <http://www.resourcesaver.com/file/toolmanager/O105UF1509.pdf>, accessed 31 January 2013
- [34] P. Barua, H. Zamal, and M.S.N. Chowdhury, "Nutrient mass balance for improved traditional coastal shrimp ponds of Bangladesh," *Journal of Marketing Science*, vol. 26, pp. 98-113, April 2011.
- [35] A.Y. Ilinitich, N.S. Soderstrom, T.E. Thomas, "Measuring corporate environmental performance," *Journal of Accounting and Public Policy*, vol.17, no.383-408, Winter 1998.
- [36] V. Veleva and M. Ellenbecker, "A proposal for measuring business sustainability: addressing shortcomings in existing frameworks," *Greener Management Int*, vol.31, pp. 101-119, July 2000.
- [37] K. R. Chinander, "Aligning accountability and awareness for environmental performance in operations," *Production and Operations Management*, vol.10, pp. 276-291, January 2009.
- [38] J.F. Henri and M. Journeault M., "Environmental performance indicators: an empirical study of Canadian manufacturing firms," *Journal of Environmental Management*, vol. 87, pp. 165-176, April 2008.
- [39] X. Olsthoorn, D.Tyteca, M. Wagner, and W. Wehrmeyer, "Environmental indicators for business: a review of the literature and standardisation methods," *Journal of Cleaner Production*, vol. 9, pp. 453-463, October 2001.
- [40] A. Neely, M. Gregory, and K. Platts, "Performance measurement system Design: a literature review and research agenda," *International Journal of Operations and Production Management*, vol.15, pp. 80-116, 1995.
- [41] Y. Ijir, "Theory of accounting measurement." *Studies in Accounting Research*, vol. 10, 1975.
- [42] N. Afida, "Peningkatan produktivitas melalui usaha waste reduction dengan pendekatan green productivity (case study: PT. Ecco Tannerty Indonesia)," Undergraduate thesis, Institute of Technology Sepuluh November, 1999
- [43] L. Shi and L. Xing, "Circular economy: a new development strategy for sustainable development in China," in *Proc. Third World Congress of Environmental and Resource Economists*, Japan, 2006.
- [44] B.B. Flynn, S.S. Sakakibara, R.G. Schroeder RG, K.A. Bates KA, and E.J. Flynn, "Empirical research methods in operations management," *Journal of Operations Management*, vol. 9, pp. 250-284, April 1990.

[45] D.I. Susanti, "Implementasi green productivity sebagai upaya untuk meningkatkan produktivitas dan kinerja Lingkungan," Undergraduate thesis, Institute of Technology Sepuluh November, 2006.

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