Weeds as an environmentally friendly alternative dyes

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Abstract. Synthetic dye liquid waste is a problem in the batik industry. The data showed that there are 5 rivers in Pekalongan which are dark coloured and stinks due to the batik industry's liquid waste. The test result showed that the waste in upstream contains Chemical Oxygen Demand (COD) 230 mg/L and 157 mg/L in downstream, while the maximum COD threshold should only be 50 mg/L. Environmentally friendly colouring technology is currently needed in the business. Natural dyes can be an alternative to produce batik. Weeds or parasites are considered an alternative to natural dyes. Weeds are plants which the existence is not wanted by humans. This research was conducted by experimenting the application of extraction of weeds or parasites on batik fabric. The objectives of this study were, the direction of colour produced by weeds or parasites through the extraction process, and analysis of the colour lasting test.

1. Introduction
Batik is a reliable commodity from the craft sub-sector of the creative industry sector. This statement is supported by statistical data and survey results from the Creative Economy Agency which show that the Creative Economy sub-sector GDP is 15.70%. However, the industry has a problem in which the synthetic dye waste which is widely used in the batik industry causes health and environmental problems. According to data obtained from the Pekalongan City Environmental Agency (BLH), the Chemical Oxygen Demand (COD) content was recorded at 230 mg/L in the upstream of the river and 157 mg/L in the downstream, while the maximum COD threshold should only be 50 mg/L [1]. Liquid waste that comes in direct contact with human skin will cause itching, heat, dry and hard skin due to the chemicals contained in it. These chemicals are in the form of 7.0 mg/L chromium or heavy metals which can cause cancer [2]. Other studies' results reveal that the use of synthetic dyes is estimated to have reached 10,000.00.00 tons per year, thus producing a very large amount of dye waste and resulting in dangers to health and environmental balance [3]. However, increased public awareness on product safety and concerns on the sustainability and replacement of oil-based products explain the recent interest on natural dyes [4].

Natural dyes can be an alternative used by batik craftsmen in reducing the dangers of using synthetic dyes. Natural dyes are considered environmentally friendly, low toxic, and not harmful to batik craftsmen [5]. Natural dyes considered to be effective in minimize the use of chemical agents which in turn overcome pollution problems [6]. They can be produced from plants' parts such as roots, stems, leaves, bark and flowers. The sustainability aspect of using these plants becomes a consideration for environmental balance if the craftsmen want to use the dye continuously. Weeds or parasites are
considered to be an alternative for natural dyes. However, there has been a new discovery in this research, which is weed or parasite, that is thought to be an alternative for natural dye.

From being unwanted or considered as parasites that grow on plants, weeds become a natural dyes innovation that can provide positive impact for both the plant and the utilization of the weeds themselves. There has never been a study of the use of weeds as a natural dye for batik. So far, researches related to weeds only deal with substances or methods of eliminating weeds which are considered as parasites for plants. Experiments of weeds-produced dyes can be an alternative for batik craftsmen to produce good quality batik that is environmentally friendly without producing hazardous liquid waste that comes from synthetic dyes.

2. Literature Review

2.1. Batik
Batik is one of the identities of Indonesian that has been recognized by UNESCO on October 2, 2009 in Abu Dhabi as the Intangible Cultural Heritage of Humanity. The recognition of Batik is based on five criteria, namely: (1) contains oral traditions, expressions, and native language; (2) presents in the social tradition; and (3) has been a traditional craftsmanship. Batik is an original Indonesian textile which the motif is made by using resist (blocking the unwanted colour using tools) dye technique using hot wax as a colour barrier which is attached using a canting (a tool to apply hot wax in the Batik making-process) and a cap canting [7]. There are synthetic dyes and natural dyes in the batik colouring process. Natural dyes are pigment colour dyes obtained from plants, animals and mineral sources [8]. Review of the papers revealed that natural sources not only can offer a rich and varied source of dyestuffs, but also could be considered as safe, environmentally friendly and low-cost treatments with additional benefit of colouring in a single stage. Most of natural dyes have also inherent antimicrobial properties and could possess high medicinal activity [9]. Natural dyes for textiles are commonly obtained from the extraction of various parts of plants such as roots, wood, leaves, seeds or flowers.

2.2. Extraction Process of Natural Dyes
Some extraction processes used in the pre-experimental process were: (1) fermentation (decay), which is soaking or rotting leaves or wood in water followed by certain processes. The fermentation process requires approximately 1 week to produce fermented paste; (2) the boiling process which is boiling the ingredients that will be used as natural dyes to produce the desired colour. All ingredients were boiled to get half of the solution (50% of the initial water volume) [10]. The dyes production should consider the weight of the material to be processed so that dye produced will be sufficient. The amount of natural dyes needed depends on the fabric area. The commonly used ratio is 1:10. For example, 1 kilogram of fabric will need 10 litres of natural dyes extract. Solution pH strongly affects dye extraction. Investigation on solution pH revealed the optimum pH of 12 [11].

2.3. Batik Colouring Process using Weeds
Weeds are plants which the presence is unwanted by humans. The weeds compete for life with the main crop. The weeds used in this study was the one found in longan. Figure 1 illustrates weeds in longan tree.
To become the alternative innovation for natural batik dyes, the weeds need to be tested. The weeds will go through a boiling process. The important steps of dyeing are: (1) dissolving the dye (migration); (2) forcing the dye solution to be absorbed into the material (absorption); (3) absorption of dyes from the surface into the material (diffusion-fixation) requires external assistance, such as: raising the temperature, adding other substances such as table salt, acids and others [12].

The dyeing process was done by using final mordant (post mordanting) method. The method consists of the following steps: (1) preparing the natural dyes using the extraction process (2) soaking the fabric to be dyed in weed extract solution for a few minutes, and turn the fabric back and forth until the dye solution is properly absorbed on the fabric; (3) drain and aerate the cloth; (5) the dyeing and drying process is done for approximately 7 times; (6) the dyed cloth was then put into to each mordant solution, that are tunjung (Ferrous sulphate) and alum.

2.4. Mordanting

Natural dyes mostly require a mordant to be fixed onto the fibre [13]. Mordanting is the treatment of textile fabric with metallic salts or other complex forming agents which bind the natural mordantable dyes into the textile fibres [14]. Mordant plays important role as colour enhancer thus makes the fabric colour long lasting. Mordant can also be considered as a chemical that helps in the absorption and fixation of natural dyes [15]. Mordanting process can be done in 3 ways. Pre mordanting is the process in which the fabric is immersed in the mordanting solution contains metal compound, followed by dyeing process. In simultaneous mordant (metachrom, monochrome) the mordanting agent is incorporated in the dyeing solution. It is therefore, the mordanting and dyeing processes is carried out in single step. The last mordanting process is post mordanting. The dyeing process was done prior to mordanting process [16]. Mordant is proven to provide colour strength in terms of colour sharpness and colour fastness [17]. The mordants used for dyeing using weeds were alum and tunjung (Fe (SO4)3). Tunjung is pale blue shaped crystal provides darker colour of natural dyes, while alum has the function to change the colour to be brighter.

3. Research Method

The research method used was the experimental research method. The experimental method was applied in the fabric dyeing process using extract of longan tree parasites with mordant tunjung and alum. The dyeing result was then tested for colour direction and colour fastness to washing. The test was conducted at the textile evaluation laboratory, Textile-Chemical Engineering Department, UII Yogyakarta. Each test was carried out in twice. The colour fastness was assessed using grey scale and staining scale. Gray scale is used to assess colour changes in the colour fastness test, while the staining scale is used to assess colour staining on the white fabrics.
4. Result and Discussion

The test result on the colour direction and colour fastness to washing is shown in Table 1 and Table 2.

Table 1. Laboratory Test Result (Colour Direction and Lasting Test)

| Sample Code | Test number | Colour Lasting Test Score | Colour Direction Test Score | L’ | A’ | B’ | dE’ab |
|-------------|------------|---------------------------|-----------------------------|----|----|----|-------|
| Standart    | 0          | -                         | 98.62                       | 0.15 | -0.20 | 0.00 |       |
| IT (tunjung)| 1          | 3 (average)               | 24.51                       | 0.48 | 9.61  | 74.75 |       |
|             | 2          | 3 (average)               | 26.82                       | 0.23 | 7.86  | 72.25 |       |
| IK (alum)  | 1          | 3-4 (good)                | 62.78                       | 9.70 | 40.83 | 55.31 |       |
|             | 2          | 3-4 (good)                | 68.55                       | 8.40 | 37.11 | 48.62 |       |

Description:
L’ : Lightness
A’ : Red-Green Axis Saturation
B’ : Blue-YellowAxis Saturation
dE’ab : Total of Light Reflection
dE’ab : \((L'^2 + a'^2 + b'^2)^{1/2}\)

The result of fastness test after the 2 sample cloths were washed showed the range of “average” and “good”. The sample using tunjung mordant results in a score of 3 which was categorized as average, while the sample using alum mordant results in a score of 3-4 which was categorized as good. This means that the use of alum mordant made the colour on the dyed fabrics resulted in better colour fastness than that of tunjung mordant. The colour of the fabric before and after the test using mordant alum were very different. Fabric colour after washing was much lighter than that of before. On the other hand, under the variation of alum mordant, the colour produced before and after test were not much different. Better colour fastness would be obtained if the cloth is immersed longer during the dyeing process. The immersion can be done 15 times with a duration of 5-10 minutes. Previous studies have shown more optimal results for 30 minutes long immersion procedure [18].

Table 2. The result of the Cotton Cloth Dyeing on the Lasting Test

| Immersion Result | Test Result | Immersion Result | Test Result |
|------------------|-------------|------------------|-------------|
| Tunjung          |             | Alum             |             |

The colour direction or the colour difference test was done using the UV-PC Model ISR-2200 program. In variation of tunjung mordant, the result of the colour direction test showed lightness of 24.51 and 26.82, respectively, compared to the standard score of 98.62. It means that mordanting process using tunjung generated dark colour. The saturation score of the red-green and blue-yellow colour axis showed a higher result than the specified standard. The calculation of the fabric colour difference test on the sample using tunjung mordant resulted in a score of 74.56 and 72.25, respectively. The score was very high compared to the test score of 0.00, which means that the fabric sample test using tunjung mordant was very dark. In the previous research, the use of tunjung as a mordant in dyeing cotton fabrics
using ketapang leaf extract gives a darker colour effect and has the lowest brightness level than other mordant types [19]. Tunjung has iron cations that has high interaction with the dying. Consequently, when using tunjung mordant, the intensity of the colour produced is stronger [20].

The result of the colour direction test on the fabric sample using alum mordant showed lightness of 62.78 and 68.55, respectively, compared to the standard score of 98.62. It means that the cloth sample that used alum mordant was bright. The saturation score of the red-green and blue-yellow colour axis showed a higher result than the specified standard with the score of 9.70 (red-green) and 40.83 (blue-yellow). The calculation of the fabric colour difference test on the sample using alum mordant resulted in a score of 55.31 and 48.62, respectively. The score was very high compared to the test score of 0.00, which means that the cloth sample test using alum mordant was very bright. This is supported by the previous research which states that alum provides the lowest colour strength of all types of mordant methods [20]. The results revealed that the cloth sample that used tunjung mordant was darker than the one using alum mordant.

Tunjung mordant has been proven to strongly bind colours so that the resulting colour was darker. The dyeing process using alum mordant produced lighter colours than tunjung mordant. Tunjung colour binder is a salt containing Fe$^{3+}$ metal. Tannins condensed in the Fe$^{3+}$ salt solution will produce a blackish green colour [21]. This is in line with the result of the colour direction test using tunjung mordant which was darker than using alum mordant. The results of other research indicate that the darkest colour was obtained by cotton fabric dyed under ferrous sulphate mordant [6].

5. Conclusion
Weeds are potential materials for fabric dye. Using different mordants will result in different colour directions. Tunjung mordant produced the darkest colour compared to alum mordant. The colour fastness to washing test showed the result of “average” for tunjung mordant and “good” for alum mordant. This means that the application of alum mordant in the dyeing process generated better colour fastness than that of tunjung mordant.

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