

Research Article

The Application of Cleaner Production of Batik Industry (Case of Pamekasan Regency, East Java, Indonesia)

Norita Vibriyanto*, Crisanty S Titik, and Arabela Sulfa Hoirina

Department of Economics, Faculty of Economic and Business, Universitas Trunojoyo Madura, Indonesia

ORCID

Norita Vibriyanto: <https://orcid.org/0000-0003-4459-910X>

Abstract.

Batik is a representation of the cultural identity that is produced and offers insight into the daily lives of those who create it. It has a positive impact on economic development in Indonesia, such as increased income and reduced unemployment. Therefore it is important to manage and maintain Indonesia's batik crafts. In the current era of globalization, there is awareness of the importance of sustainable development. It is crucial that all parties engage in initiatives aimed at achieving sustainable development such as the implementation of cleaner production practices. Cleaner production represents a proactive strategic program that is implemented with the objective of aligning sustainable economic development activities with environmental protection efforts. The objective of this study was to ascertain cleaner production in the batik industry with regard to sustainable development. This research used a qualitative methodology by triangulation to validate the data obtained from informants. The findings indicated that the batik production in Pamekasan never fully adopted the principle of cleaner production. This is because artisan Batik in Pamekasan considers that synthetic dyes are more profitable for the production of batik products and affordable for consumers.

Keywords: batik, cleaner production, sustainable development

1. Introduction

The Batik industry supports local economies such as create jobs and foster entrepreneurship (1,2), reducing unemployment (3–5), generate income (6,7) and economic growth (3,8). Batik is a significant part of Indonesia's cultural heritage, recognized by UNESCO as a Masterpiece of the Oral and Intangible Heritage of Humanity (9). Batik Day in Indonesia, celebrated on October 2nd, this day is marked by various activities and events that highlight the cultural and economic significance of batik in Indonesia. On Batik Day, Indonesians from all walks of life, including government officials, students, and private sector employees, wear batik clothing to show their pride

Corresponding Author: Norita Vibriyanto; email: norita.vibriyanto@trunojoyo.ac.id

Published: 19 February 2025

Publishing services provided by Knowledge E

© Norita Vibriyanto et al. This article is distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use and redistribution provided that the original author and source are credited.

Selection and Peer-review under the responsibility of the ICESIDE Conference Committee.



and support for this cultural heritage. Apart from October 2nd, everyone can wear batik on any occasion because batik is one of the “national costumes” in Indonesia that can be used on various occasions and by everyone. This is one of the reasons why the demand for batik will continue to grow in the future.

Batik embodies intricate designs and themes that reflect the nation's rich history and philosophical narratives (10). The motifs and patterns in Batik often carry deep symbolic meanings, representing various cultural, historical, and spiritual elements (11,12). East Java is one of the provinces in Indonesia that is famous for its batik characteristics with bolder, more lively and brighter patterns that show the people's style of life (13). Among all batik producing areas, Madura Island is one of the areas that actively promote the development of batik craft. Madura batik has many motifs, beautiful colors and a unique production process. Madura batik motifs include spearhead, rhombus, knitting, machete, and flora and fauna (14).

Pamekasan is one of the districts on Madura Island that is known for its batik industry. Batik of Pamekasan has good quality and characteristics. It was recognized as the regional center of East Java province at the national level in 2009 (15). There are 92 batik centers in Pamekasan Regency spread across 7 sub-districts. Batik centers can transform communities by improving living conditions (16) beside that batik centers play a crucial role in preserving cultural heritage by providing a platform for artisans to continue traditional practices and educate the public (17,18).

In this era of globalization, sustainable development is an issue that is attracting the attention of parties around the world. Sustainable development is development that responds to the needs of the present without reducing the ability of future generations to fulfil their needs. All parties must participate in the effort to achieve sustainable development. Businesses are no exception. For businesses, environmental issues can be incorporated as a positive factor in business strategy, not as an obstacle, but as an effort to improve the cost structure of products and/or services. Environmental management strategies that are preventive, integrated and continuously applied to all activities, from upstream to downstream, related to the production process, products and services, are needed to increase the efficiency of natural resource use, prevent pollution and reduce waste generation in order to minimize risks to human health and safety and environmental damage. Therefore, cleaner production is one of the ways to achieve sustainable development.

Cleaner production is a strategic program that is proactively applied to harmonize sustainable economic development activities with environmental protection efforts. Cleaner Production provides financial benefits, environmental benefits such as waste reduction and improves the company's image for the better (9). There are 5 main principles in the cleaner production strategy in the National Cleaner Production policy outlined in 1E4R (Elimination, Re-use, Reduce, Recovery and Recycle) (19). Elimination (prevention) is an effort to prevent waste generation directly from its source, starting from raw materials, production processes to products. Reuse is an effort that allows waste to be reused without physical, chemical or biological treatment. Recycle is an effort to utilize waste by processing it back to the original process through physical, chemical and biological treatment. Recovery/reclaim is an effort to take materials that still have high economic value from a waste, then returned to the production process with or without physical, chemical and biological treatment.

Industry that adopting cleaner production often see substantial economic benefits. The benefit are reduced or saving costs (20) for materials, energy, and water, and lower expenditures related to waste treatment and disposal, involve low investment costs with quick payback periods (21), enhance the competitiveness of batik by aligning with global standards and improving their marketability (22,23) because of industry have positive image.

2. Methods

This type of this research is qualitative research. Qualitative research is research that seeks meaning about a phenomenon, event, or human life by being directly or indirectly involved. The focus of qualitative research is a research method used on natural objects, and the researcher is the key instrument. Data collection techniques are triangulated, data analysis is inductive, and qualitative research findings emphasize meaning rather than generalization. The research was conducted in Pamekasan Regency, East Java. The location selection was conducted purposively with the consideration that Pamekasan batik creative industry was recognized as the regional center of East Java province at the national level in 2009. The types of data used in this research are secondary and primary data. Secondary data was obtained from the Industry and Trade Office and related agencies.

Research informants consisted of main informants and supporting informants. While primary data obtained from interviews with informants. The main informants in this

study are batik industry players. Supporting informants came from the Department of Industry and Trade. Data collection was carried out by interviewing the main informants and supporting informants. Researchers also used the direct observation method by conducting a direct review of the intended object. In addition further data collection, namely documentation, is carried out to collect secondary data from various sources. The purpose of this data collection is to obtain data in accordance with the research topic, so the data collection techniques used are interviews and documentation.

3. Result and Discussions

Cleaner Production (CP) is a proactive environmental strategy aimed at increasing efficiency and reducing risks to humans and the environment by minimizing waste and emissions at their source rather than treating them after they have been generated (24,25). It involves the continuous application of integrated, preventive environmental strategies to processes, products, and services (25,26). Cleaner Production is a comprehensive approach that integrates environmental strategies into industrial processes to enhance efficiency, reduce waste, and support sustainable development (24,25,27). Cleaner production in the Indonesian batik industry refers to the implementation of environmentally friendly practices aimed at reducing waste and pollution during the batik production process. This approach is particularly significant given the traditional use of chemicals in batik dyeing, which has historically led to substantial environmental pollution (28,29). The 5 main principles of cleaner production refer to 1E4R (19).

3.1. Elimination

The concept of elimination in cleaner production within the batik industry primarily focuses on reducing or completely removing harmful substances and waste generated during the production process. This approach aims to minimize environmental impact while maintaining economic and technical feasibility. The strategy of elimination such as replacing synthetic dyes with natural dyes to reduce chemical pollutants in wastewater (29,30). Natural dyes are colorants derived from natural sources such as plants, minerals, and sometimes insects. Natural dyes are generally abundant and can be sourced from local environments. These dyes are typically extracted using methods like heating with water solvents or microwave-assisted extraction. These dyes are considered eco-friendly as they are biodegradable and reduce the environmental impact compared

to synthetic dyes(31–33). For instance, dyes from leaves and bark are often boiled to release the pigments. The extracted dyes are then applied to fabrics, often requiring a fixator to bind the color. Common fixators include alum, calcium oxide, and ferrous sulfate, which help improve color fastness and durability.

Batik artisans in Pamekasan Regency still use synthetic dyes because the resulting colors are brighter and there are more options. Additionally, batik made with natural dyes requires a longer dyeing process. The use of synthetic dyes remains a favorite among batik artisans in Pamekasan, as the majority of their consumers prefer bright and clear colors. This is in line (34) that synthetic dyes offer a vast variety of colors and ensure consistent color results, which is crucial for meeting market demands and maintaining product quality. Beside that synthetic dyes are easier to obtain compared to natural dyes, which can be limited by seasonal availability and regional constraints.

Additionally, batik artisans choose the fast coloring method since they usually send their finished products to the traditional market in order to sell them at least twice. Based on (35) the dyeing process with synthetic dyes is typically faster and more straightforward, reducing production time so that synthetic dyes are often more cost-effective than natural dyes. The lower cost of synthetic dyes helps Batik artisans manage production expenses and offer competitively priced products. The traditional market referred to 17 Agustus market, recognized as the largest traditional hand-drawn batik market in Indonesia, which was officially established on October 24, 2019. They will update the Batik products on Thursdays and Sundays, as those days are market days that will be busier with buyers compared to other days.

3.2. Reuse

In general, batik artisans the wet wax collected from the pelorodan process (wax removal) can be recycled and reused in subsequent batik production cycles. In the same way, the wax drippings that fall during the stamping process are collected and reused, so it can be minimizing waste. After the batik is boiled, the wax will separate from the fabric and float on the surface of the water. This happens because the wax, which is a type of fat, has a lower density than water. Once the water has cooled, the wax will solidify and can be collected.

Batik wax waste is blended with materials like gum rosin, paraffin, and lard to create modified waxes. These blends are tested for their latched power (ability to adhere to fabric) and resistance to cracking and alkaline solutions, ensuring they meet quality

standards for reuse in batik production. These methods not only help in reducing the environmental impact of batik production but also lower production costs by minimizing the need for new wax materials. The reuse and recycling of batik wax are integral to promoting sustainable practices within the industry (30,36,37)

3.3. Reduce

Reduction aims to minimize waste and resource consumption. In the Batik industry, this can be achieved by reducing the use of synthetic dyes by substituting them with natural dyes. However, batik artisans have not yet adopted natural dyes, even though they have received training on utilizing local resources as alternative materials to replace synthetic dyes. The existence of several stages to obtain colors from natural materials becomes a hindrance for artisans to use natural dyes, leading them to continue relying on synthetic materials. This results in a significant amount of waste generated from batik production, both solid and liquid. However, generally, the waste produced is liquid, which comes from washing and dyeing processes, and is disposed of directly without any prior treatment. The total volume discarded is estimated to be around 1 cubic meter per group of artisans each day. Typically, the liquid waste generated from batik production is directly dumped into the ground, drainage, or rivers, which can have detrimental effects on the local environment. This is particularly concerning for the soil and water quality in the area. It can disrupt the ecosystem, especially by making the soil less fertile and causing polluted water to flow into rivers, thereby affecting both the river ecosystem and the health of communities that still rely on river water for their daily needs.

Although the majority do not yet have wastewater treatment facilities, there are some batik artisans who have started using mini wastewater treatment installations because they received assistance and training in liquid waste processing, which included the creation of reactors equipped with super-adsorption materials from community service activities conducted by educational institutions. The application of physical adsorption principles for wastewater or batik washing in the form of a decolorization reactor connected to an adsorbent matrix column. The waste produced by artisans will be collected in a reactor with a capacity of 250 liters. Subsequently, based on the principle of gravity, the waste will flow through a column containing adsorbent, resulting in a filtrate that is free of dye. The principle of gravity will replace the use of electrical energy to draw wastewater into the column and will operate continuously. The use of

mini Wastewater Treatment Installations has an environmentally friendly nature, allowing the batik production process to be more optimal.

3.4. Recycle

Wax mixed with liquid waste, when subjected to filtration, sedimentation, and collection, still have the potential to be processed or recycled into other products, for example, as raw material for aromatherapy candles. However, it is still rare for artisan Batik in Pamekasan Regency to recycle it into aromatherapy candles. Converting mori cloth waste into scarves and rags, can enhance resource efficiency (38). The use of leftover mori fabric is simply left as is, with no efforts made to create other batik-based products. Nevertheless, the leftover mori fabric from the production process is not substantial and sometimes there is hardly any leftover at all.

3.5. Recovery

The use of wax is a distinctive feature that sets batik products apart from other textile products wax serves as a color barrier. Wax which still have the potential to be collected again, are processed for recovery to be reused in the batik-making process. The recycling of wax is usually done for an average of 5 uses. This can help batik artisans reduce operational costs or raw materials in the batik production process .

4. Conclutions

Based on the five main principles of cleaner production refer to 1E4R batik production in Pamekasan never fully adopted the principle of cleaner production. This is because artisan Batik in Pamekasan considers the synthetic dyes are more profitable for the production of batik products and affordable for consumers.

Acknowledgement

This research has been supported by grants from LPPM Universitas Trunojoyo Madura of Beginner Research Scheme 2024 so the author would like to say thank you. We are especially indebted to anonymous reviewer of this publication for many valuable comment and suggestions.

References

- [1] Nurwandi L, Abdulhak K, Sumantri E, Ardiwinata JS. Building a learning society in the design field for batik craftworkers in Indonesia. *Int J Innov Creat Chang* [Internet]. 2019;7(9):262–77. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85078273818&partnerID=40&md5=18d88546fd27f23c944ef289e6e72fa2>
- [2] Bakri A, Achmad SH, Kamalrudin MB, Yusop N, Rahayu ST, Sidek SB, et al. Challenges and potential development of LAWEYAN batik industry. *Opcion* [Internet]. 2018;34(85):1331–40. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85062809267&partnerID=40&md5=c1923fe84d136ee5fc6f001dacb8c05d>
- [3] Al-shami SA, Damayanti R, Adil H, Farhi F, Al mamun A. Financial and digital financial literacy through social media use towards financial inclusion among batik small enterprises in Indonesia. *Heliyon* [Internet]. 2024;10(15). Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85199171785&doi=10.1016%2Fj.heliyon.2024.e34902&partnerID=40&md5=2e00e7ea61f65cf4feb3c6f7808022e1>
- [4] Hunga AIR. The paradox of the growing importance of the “putting-out” system in the development of the batik industry: A case study in the Sragen-Surakarta-Sukoharjo cluster of Indonesia. *Int J Interdiscip Organ Stud* [Internet]. 2013;7(2):1–12. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84884684928&doi=10.18848%2F2324-7649%2Fcgp%2Fv07i02%2F53446&partnerID=40&md5=c92619bfee0d22a7ce43671d1532bbe0>
- [5] Daud RRR, Md Nasir NA, Nawi NC, Al-Mamun A, Aidara S. Strategic Orientations and Absorptive Capacity on Competitive Advantage Among the Batik SMEs in Malaysia. In: *Lecture Notes in Networks and Systems* [Internet]. 2022. p. 705–24. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85135008617&doi=10.1007%2F978-3-031-08087-6_49&partnerID=40&md5=ba073cef6e97007783f7bef9b708e1dc
- [6] Mohd Noor NHA, Othman N, Sa’at NH. The formation of handicraft women entrepreneurs in malaysia: The roles of attitudes, family heritage and religious values. *Kaji Malaysia* [Internet]. 2021;39(2):153–78. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85118916587&doi=10.21315%2Fkm2021.39.2.7&partnerID=40&md5=e6202b0f1a16913df680f28a2cacf693>
- [7] Mohd Noor NHA, Othman N, Sa’At NH, Ismail R. Encouragement for the sustainability of women entrepreneurs in batik and songket businesses. *J Pengur* [Internet]. 2021;61. Available from: <https://www.scopus.com/inward/record.uri?eid=>

- 2-s2.0-85115078433&doi=10.17576%2Fpengurusan-2021-61-06&partnerID=40&md5=eac9e6f7cd26b1942c4756d9c07978ae
- [8] Widyasari RK, Savitri MA, Wasilah DI, Widya SC. The implementation of new habit adaptations at the Go Tik Swan Batik workshop for the sustainability of a culture-based creative economy. In: AIP Conference Proceedings [Internet]. 2023. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85159668180&doi=10.1063%2F5.0113430&partnerID=40&md5=741529126373661672e9cb3220c448c7>
- [9] Tiwari RG, Agarwal AK, Jain V, Kumar A. Batik Classification in Indonesia: Exploring its Significance on Tourism and Economy. In: 2023 International Conference on Sustaining Heritage: Innovative and Digital Approaches, ICSH 2023 [Internet]. 2023. p. 119–24. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85190542923&doi=10.1109%2FICSH57060.2023.10482828&partnerID=40&md5=bda255f59677ec5692868537e00679e8>
- [10] Minarno AE, Soesanti I, Nugroho HA. Dataset of Batik Nitik Sarimbit 120. Data Br [Internet]. 2024 Aug 1;55. Available from: <https://doi.org/10.1016/j.dib.2024.110671>
- [11] Banindro BS, Sobandi B, Pandanwangi A, Mutmainah B, Hartono B. the Transition of Hindu Era Garuda Visual Element Into Islamic Era Batik Patterns in Java. New Des Ideas. 2024;8(2):467–89.
- [12] Yunus U, Tulasi D. Batik semiotics as a media of communication in Java. Cult Int J Philos Cult Axiolog. 2012;9(2):143–50.
- [13] Palupi MAR. Home Industry Batik Rolla Di Kecamatan Patrang Kabupaten Jember Pada Tahun 2010-2018. 2020;
- [14] Rakhmawati Y. Batik Madura: Heritage Cyberbranding. J Komun [Internet]. 2016; Available from: <https://journal.trunojoyo.ac.id/komunikasi/article/view/1840/0>
- [15] Amelia BS, Zakik Z. Pengentasan Kemiskinan Melalui Pengembangan Industri Kreatif Batik Di Kabupaten Pamekasan. Bul Ekon Pembang. 2023;4(1):83–9.
- [16] Suliyati T, Yulianti D, Subekti S, Handayani T. The Dynamics of the Community of Kampung Batik Semarang in Overcoming Slumness. In: E3S Web of Conferences [Internet]. 2019. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85075239934&doi=10.1051%2Ffe3sconf%2F201912509006&partnerID=40&md5=f5a0207b1e380a11e63abc15962155c1>
- [17] Sumartinah HR, Akbar AH, Sulistiastuti M. Sustainable Design Criteria for Batik Cultural Centre in Klampar, Madura. In: IOP Conference Series: Earth and Environmental Science [Internet]. 2024. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85195485077&doi=10.1088%2F1755-1315%2F1351%2F1%2F012013&partnerID=40&md5=da6cc5a9a50290d3b4493a866ab130d9>

- [18] Wang C-Y. Building a Network for Preserving Intangible Cultural Heritage through Education: A Study of Indonesian Batik. *Int J Art Des Educ* [Internet]. 2019;38(2):398–415. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85053726024&doi=10.1111%2Fjade.12200&partnerID=40&md5=4b8f213ceabad88d78be57fc5ec79de8>
- [19] Mohi L. Manfaat Penerapan Produksi Bersih Bagi Sentra IKM [Internet]. Kementerian Perindustrian Republik Indonesia. 2022. Available from: <https://www.kemenperin.go.id/artikel/20298/Industri-Makanan-dan-Minuman-Jadi-Sektor-Kampiu>
- [20] Tucci HNP, de Oliveira Neto GC, Rodrigues FL, Amorim M, Reis J. Cleaner Production with Economic and Environmental Assessment: A Case Study in an Aeronautical Workshop. In: *Springer Proceedings in Mathematics and Statistics* [Internet]. 2021. p. 397–407. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85115199457&doi=10.1007%2F978-3-030-78570-3_30&partnerID=40&md5=65b77f89f793e448b780626e67fe076d
- [21] Fauzi AM, Defianisa RL. Analysis for cleaner production implementation strategy in batik industry in Bogor. In: *IOP Conference Series: Earth and Environmental Science* [Internet]. 2019. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85072982414&doi=10.1088%2F1755-1315%2F325%2F1%2F012005&partnerID=40&md5=87f878850d7d381ecb84644d0cad7331>
- [22] Kusumawardani SDA, Kurnani TBA. Assessment tool to understand the readiness of Batik SMEs for Green Industry. In: *E3S Web of Conferences* [Internet]. 2021. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85104080834&doi=10.1051%2Ffe3sconf%2F202124902008&partnerID=40&md5=e6af2df064c0ae28987c9306fec87ab3>
- [23] Matos LM, Anholon R, da Silva D, Cooper Ordo nez RE, Gonçalves Quelhas OL, Filho WL, et al. Implementation of cleaner production: A ten-year retrospective on benefits and difficulties found. *J Clean Prod* [Internet]. 2018;187:409–20. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85047500285&doi=10.1016%2Fj.jclepro.2018.03.181&partnerID=40&md5=2abed73e283fa1ffac5215f62d5ba6c5>
- [24] Hamed MM, El Mahgary Y. Outline of a national strategy for cleaner production: The case of Egypt. *J Clean Prod* [Internet]. 2004;12(4):327–36. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-0344082152&doi=10.1016%2F0959-6526%2803%2900037-4&partnerID=40&md5=fcc195fd7874cf181e9c70a1365d9b78>

- [25] de Oliveira Jose JA, Gonçalves da Cruz AJ, Longati AA, Fidanza LB. Cleaner Production (CP). In: Life Cycle Engineering and Management of Products: Theory and Practice [Internet]. 2021. p. 13–44. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85161141266&doi=10.1007%2F978-3-030-78044-9_2&partnerID=40&md5=90512c6df6062a782f32b61eee3b3a18
- [26] Pacheco Martín D, López Bastida EJ, Schultz RK, Gil Unday Z. An overview of the concepts of cleaner production in the agroindustry. Univ y Soc [Internet]. 2021;13(6):176–82. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85120633002&partnerID=40&md5=ef7ab476f13c389155b14fd1f85d43bf>
- [27] Ma S, Zhang Y, Lv J, Ren S, Yang H, Wang C. Data-driven cleaner production strategy for energy-intensive manufacturing industries: Case studies from Southern and Northern China. Adv Eng Informatics [Internet]. 2022;53. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85133926843&doi=10.1016%2Fj.aei.2022.101684&partnerID=40&md5=a87e58503ef31202c6b78ec810f3e928>
- [28] Kusumastuti A, Achmadi TA, Phusavat K, Hidayanto AN. Assessment of producer's perspective on the production of environmentally friendly fashion products: a case study in Indonesian natural dyes batik craftsmen. Environ Sci Pollut Res [Internet]. 2023;30(60):124767–79. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85140613467&doi=10.1007%2F11356-022-23330-z&partnerID=40&md5=adc83dd9621c45d0f4f68f64a6d570ce>
- [29] Sirait M. Cleaner production options for reducing industrial waste: The case of batik industry in Malang, East Java-Indonesia. In: IOP Conference Series: Earth and Environmental Science [Internet]. 2018. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85042299523&doi=10.1088%2F1755-1315%2F106%2F1%2F012069&partnerID=40&md5=da215f6d74e4d4513f730a2c04b57858>
- [30] Susanty A, Puspitasari D, Rinawati DI, Monika T. Achieving cleaner production in SMEs batik toward innovation in production process. In: 2013 International Conference on Engineering, Technology and Innovation, ICE 2013 and IEEE International Technology Management Conference, ITMC 2013 [Internet]. 2015. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84962295813&doi=10.1109%2FITMC.2013.7352704&partnerID=40&md5=b4d20818a84af9361218a4465b447865>
- [31] Felaza E, Priadi CR. Implementation of cleaner production in a natural dye batik industry SME: A way to enhance biodegradability of batik wastewater? In: MATEC Web of Conferences [Internet]. 2016. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85012896555&doi=10.1051%2Fmateconf%2F>

- 2F20166205003&partnerID=40&md5=927f11d5ebbb5efcc87c73c38064dadf
- [32] Handayani W, Kristijanto AI, Hunga AIR. Are natural dyes eco-friendly? A case study on water usage and wastewater characteristics of batik production by natural dyes application. *Sustain Water Resour Manag* [Internet]. 2018;4(4):1011–21. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85088121236&doi=10.1007%2F540899-018-0217-9&partnerID=40&md5=9528a2d9a0ba9ef2033a7b2997790f8e>
- [33] Martuti NKT, Hidayah I, Margunani M, Alafima RB. Organic material for clean production in the batik industry: A case study of natural batik Semarang, Indonesia. *Recycling* [Internet]. 2020;5(4):1–13. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85094589051&doi=10.3390%2Frecycling5040028&partnerID=40&md5=c49d216722b3f619df01b7d2294ef7ad>
- [34] Rusdi S, Zakaria MY, Rifki Aditya NF, Chafidz A. Investigating the potential use of cassava leaf extract as a natural coloring substance for fabrics. In: *Materials Science Forum* [Internet]. 2020. p. 123–8. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85087021802&doi=10.4028%2Fwww.scientific.net%2FM5F.991.123&partnerID=40&md5=3ad6fa4cbc915cfccff653ba0bf084f0>
- [35] Ika Rinawati D, Puspita Sari D, Pujotomo D, Handayani Kasih P. Natural Dyes Product Design Using Green Quality Function Deployment II Method to Support Batik Sustainable Production. In: *E3S Web of Conferences* [Internet]. 2018. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85059616735&doi=10.1051%2Fe3sconf%2F20187304014&partnerID=40&md5=0ae9a4b0b3efc2a13cbf8127bb2643ec>
- [36] Kusumawati N, Muslim S, Kistyanto A, Arifiana D. Optimization of batik wax waste reutilization by blending method using gum rosin, paraffin, and lard on handmade batik fabric production towards zero waste management. *Res J Pharm Biol Chem Sci* [Internet]. 2016;7(2):58–65. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84962590693&partnerID=40&md5=973036c26215b4ea3e752c0df8ebd55d>
- [37] Muslimah E, Widyanti F, Anis M, Pratiwi I, Sufa MF, Fahmi AA. Recycled Wax Use in The Indonesian Batik Production Process: Eco-Efficiency Analysis. In: *AIP Conference Proceedings* [Internet]. 2024. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85187579061&doi=10.1063%2F5.0179981&partnerID=40&md5=766ba61fa6fc91525c5e27ca4b25bada>
- [38] Akbari T, Handayani R. Implementation of Cleaner Production Strategies for Batik Production Process in Banten Batik Center. In: *IOP Conference Series: Earth and*

Environmental Science [Internet]. 2022. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85173910892&doi=10.1088%2F1755-1315%2F1211%2F1%2F012010&partnerID=40&md5=be950eef9f36a6490e726157b5866320>