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Recycling Textile Waste For Craft Industries: An experimental approach to eco-friendly papermaking

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Abstract

The textile industry significantly impacts the environment through waste generation, contributing to landfill space in Malaysia. This research explores innovative solutions for using textile waste in handmade paper production. Objectives include identifying and classifying suitable textile waste types, evaluating natural and synthetic fibre extraction processes, and developing eco-friendly formulations. Employing a mixed-methods approach, the study emphasises experimental aspects and the 3R concept (reduce, recycle, reuse) for sustainability. Outcomes will promote recycling and repurposing textile waste in papermaking, highlighting the social and economic benefits of sustainable practices in the industry.

Keywords: textile; waste; handmade paper

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1.0 Introduction

The textile industry is one of the largest and fastest-growing sectors globally, playing a crucial role in economies but simultaneously contributing to a significant waste problem. Each year, millions of tons of textile waste are generated worldwide, posing a serious environmental threat (Tang, 2023). Textile waste primarily consists of discarded clothing, fabrics, and textiles from consumers and industries. (Stanescu M. D. (2021)). According to Huun, K. (2023), countries like China and the United States lead in textile waste generation, with a combined total of over 37 million tons per year. Unfortunately, much of this waste ends up in landfills, contributing to greenhouse gas emissions, water pollution, and soil contamination. The problem is further compounded by inefficient waste management systems and low recycling rates, particularly in countries with high textile consumption (Kasavan. et al., 2021).

In Malaysia, textile waste has become an increasingly pressing issue, with the volume of discarded textiles rising dramatically in recent years. Melaka Solid Waste Management and Public Cleansing Corporation recorded more than 40,000kg of fabric waste collected within 24 hours during the campaign of the "Largest Recycle Fabric Materials Collected in a Day"(Bernama, 2022). Moreover, Solid Waste Corporation and KlothCares mentioned that 31 per cent or 432,901 metric tonnes of total waste generated in Malaysia in 2021 was fabric waste (Bernama, 2023). The United Nations reported that the world produces an estimated 100 billion garments annually, of

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which 92 million tonnes end up in landfills. At least seven per cent of landfills comprise discarded clothing and textiles, and about one per cent of clothing is recycled. These findings indicate that textile waste recycling needs to be emphasised more than other forms of waste, such as plastics and paper.

Efforts to manage and recycle textile waste also remain limited despite the growing urgency of the problem. In contrast, there is potential for repurposing textile waste into sustainable products such as handmade paper or home décor, for which these practices remain underutilised. Public awareness of recycling opportunities and environmental stewardship is also low, as only a small percentage of textile waste is recycled despite the vast majority being recyclable (Bernama, 2023). This increasing burden of textile waste requires urgent attention, with a focus on sustainable practices, public education, and improved recycling systems. By addressing the environmental, economic, and social dimensions of textile waste, it can reduce its impact and promote a more sustainable and circular approach to the industry.

On the other hand, immediate action is required to address this environmental issue, necessitating the collaboration of all relevant stakeholders. Implementing the 3R concept—Reduce, Reuse, Recycle—at universities and other institutions of higher learning is essential for fostering environmental protection and supporting economic sustainability within communities through recycling. When integrated into teaching and learning, particularly in product design and fine arts, the 3R concept can facilitate a deeper understanding and appreciation of the value of recycled materials derived from textile waste.

Research focused on textile waste management, particularly fabric waste recycling through the 3R concept, offers a viable alternative for reducing textile waste and promoting a greener environment. According to Utabey et al. (2020), the 3R concept emphasises solid waste reduction by encouraging the reuse of items in domestic and office settings and the recycling of materials by reprocessing used goods into enhanced products. Developing innovative approaches for repurposing textile waste into new, functional products is imperative. Applying the 3R concept can introduce a fresh perspective on waste management, especially for economically valuable materials that can be recycled. One efficient application is the papercraft industry, where textile waste can be transformed into handmade paper and other craft products.

Therefore, this research explores the potential of recycling textile waste for producing handmade paper, contributing to environmental sustainability and innovative craft practices. The study aims to identify and categorise different types of textile waste suitable for repurposing, optimise the extraction processes for natural and synthetic fibres to meet the quality standards of the handmade paper industry, and develop environmentally friendly formulations to enhance the sustainability and functionality of eco-friendly handmade paper products. Additionally, the research offers the practical applications and economic feasibility of using recycled textile waste in handmade papermaking, promoting greater awareness and adoption of sustainable practices within the craft industry and beyond.

2.0 Literature Review

The textile industry is vast and multifaceted, producing various products that serve various purposes, from clothing and home furnishings to industrial applications. The fibres used in textile production, both natural and synthetic, are often blended in varying proportions to create materials with specific qualities tailored to the intended use. These products can range from short-term disposable items to medium-term goods, such as clothing, carpets, and automotive interiors, which have a lifespan of several years, depending on the material and usage (Diah et al., 2012).

According to Rani et al. (2022), the use of synthetic textiles in fashion and industrial applications has increased significantly in recent years due to their advantages, such as durability and cost-effectiveness. However, these man-made textiles present a substantial environmental challenge, as they resist biodegradation and can persist in the environment for hundreds of years. Furthermore, the degradation of synthetic fibres releases harmful substances that contribute to environmental pollution. In light of these concerns, there has been growing research and industry initiatives focusing on the utilisation of textile waste to create handmade, eco-friendly products. For example, FabBRICK, an innovation by Clarisse Merlet, transforms discarded textiles into an insulating, structural, and aesthetically pleasing building material. FabBRICK can be used as standalone bricks, partition walls, or integrated components in various products such as chairs and tables, offering a sustainable alternative to traditional building materials (Reyyan, 2024).

Furthermore, traditional craft techniques are also being revisited to upcycle textile waste. Singh S. (2021) highlights that applying traditional Indian textile techniques to recycling and upcycling processes can significantly enhance the aesthetic value of repurposed materials. Minakshi J. (2018) reinforces this view, suggesting that textile waste crafts have the potential to produce items that are ecological, ethical, and highly personalised. These environmentally friendly and unique products offer consumers beautiful and exclusive alternatives to mass-produced goods. This growing interest in crafting with textile waste demonstrates how cultural traditions can be leveraged to address contemporary environmental issues while fostering creativity and sustainability. Anjali (2023) adds that upcycling can also be integrated into indigenous textile weaving practices, helping to preserve cultural heritage while fostering ecological responsibility. By incorporating the 3R concept (Reduce, Reuse, Recycle), designers and artisans can capitalise on this opportunity, transforming textile waste into new garments and accessories, such as macramé bags and dresses, that combine diverse techniques and styles.

As highlighted by Gvoka et al. (2023) in their study presented at the VI International Conference on Contemporary Trends and Innovations in the Textile Industry, textile waste recycling can reduce the reliance on virgin materials and mitigate the environmental footprint of the textile and packaging industries. The study underscores the potential of repurposing waste textiles into new packaging materials, such as bags, sacks, and paper products, by incorporating textile fibres into paper and cardboard. These materials exhibit superior mechanical properties, such as enhanced tensile strength and wear resistance, and offer opportunities for creative and eco-friendly packaging solutions. By embracing textile recycling in packaging, industries can contribute to a circular economy, promote

sustainability, and reduce waste. Therefore, this research aligns with this paper, which focuses on recycling textile waste into handmade paper, as both processes demonstrate the potential for repurposing discarded textiles into functional, sustainable materials that address pressing environmental concerns.

Various studies above highlight the potential of utilising discarded textiles in innovative ways, where waste fabrics are transformed into functional and aesthetically appealing products. For instance, the use of discarded fabric, a byproduct of textile production, has been effectively employed in craft training programs to empower communities by providing new sources of income (Bakri & Hasyim, 2024). Bakri (2024) added that involvement with communities also helps reduce waste and increase communities' income. Moreover, the integration of traditional craft techniques with modern recycling practices not only addresses textile waste management but also enhances the cultural and economic value of recycled materials (Minakshi, 2018; Singh, 2021). These initiatives demonstrate that textile waste, including fabric scraps, can be repurposed into eco-friendly products such as handmade paper, supporting broader sustainability goals while fostering creativity and economic resilience in local communities.

3.0 Methodology

This research is driven by the growing demand for sustainable "eco-friendly " in the context of environmental preservation and resource management. The study originates from the need to identify suitable alternatives to natural plant fibres in paper production, specifically focusing on using textile waste, a significant environmental pollutant. While textile waste poses a substantial ecological challenge, it also presents unique opportunities due to the diversity of fibres it contains. These fibres can be repurposed to form new layers, offering considerable potential for creating handmade paper. In support of the 3R concept (Reduce, Reuse, Recycle), this research employs a quantitative method by applying the experimental process to assess the feasibility of using textile waste in handmade paper production. The study is structured into two main phases, each focusing on different process aspects.

Table 1. Process phases

Phase	Project	Methods And Analysis	User
Phase 1 (Reduce, Reuse, and Recycle)	Identifying the potential of textile waste in handmade papermaking.	Experimental Studies	Textile users, Designers, Retailers and Manufacturers
Phase 2	Studying the extraction process of natural and synthetic fibres suitable for use in handmade paper manufacturing. Develop proper formulations, dye, and binder solutions that are eco-friendly and can be used for handmade craft paper.		Fine Arts Students

(Source: Yahaya et al., 2024)

3.1 Phase 1: Collection, Selection, and Extraction of Textile Waste

The first phase of the research involves the systematic collection and classification of textile waste from various sources, including end-users, fashion designers, clothing retailers, and industries that discard excess fabric or outdated clothing. The collected textile waste is meticulously sorted based on type, colour, and material composition to ensure that the raw materials are appropriate for further processing into handmade paper. This phase is crucial as it lays the foundation for the quality and consistency of the final product. Art students from the School of The Arts assisted in this phase, gaining practical experience through hands-on involvement in the collection and separation tasks, which were complemented by a series of lectures on material art research.

3.2 Phase 2: Experimentation and Production of Handmade Paper

In the second phase, the research shifts to the experimental production of handmade paper, focusing on fibre extraction, binding, and dyeing. This phase is dedicated to developing and refining environmentally friendly formulas and methods to ensure that the handmade paper meets high-quality standards while minimising environmental impact. The experimentation involves testing various techniques to identify the most effective and sustainable strategies for producing durable, aesthetically pleasing handmade paper from textile waste.

4.0 Findings

4.1 Materials

Fig. 1. Discarded Fabrics Waste.
(Source: Yahaya et al., 2024)

The selection of materials plays a critical role in the quality and environmental impact of the handmade paper produced. This study utilised a variety of textile fibres, including spandex, cotton, silk, and canvas, all sourced from discarded clothing items. These materials were chosen to reflect the project's commitment to sustainability by reusing textile waste. Lycra, a synthetic fibre known for its exceptional elasticity, was selected for its versatility in fabric-based applications. Cotton and silk, both natural fibres, were chosen for their inherent softness, breathability, and high absorbency, which contribute to the strength and durability of the paper. Canvas, a densely woven fabric typically made from cotton, was selected for its robustness and water-resistant properties, which enhance the paper's overall durability. Additionally, methyl cellulose was used as a binding agent due to its hydrophilic nature, which allows it to dissolve in cold water and form a viscous solution, thereby enhancing fibre bonding in the pulp. Its non-toxic, non-allergenic, and biodegradable properties make it an ideal choice for eco-friendly paper production.

4.2 Process

The handmade paper production process involves several meticulously planned steps, each designed to optimise material use and ensure a high-quality final product. The process is outlined as follows:

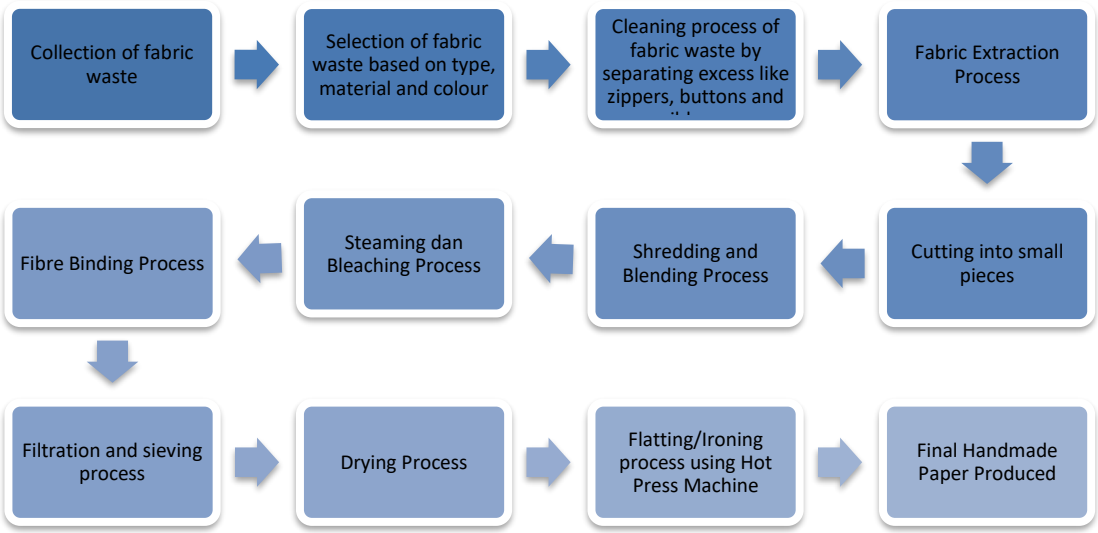


Fig. 2. The process of handmade papermaking.
(Source: Yahaya et al., 2024)

4.2.1 Fibre Preparation

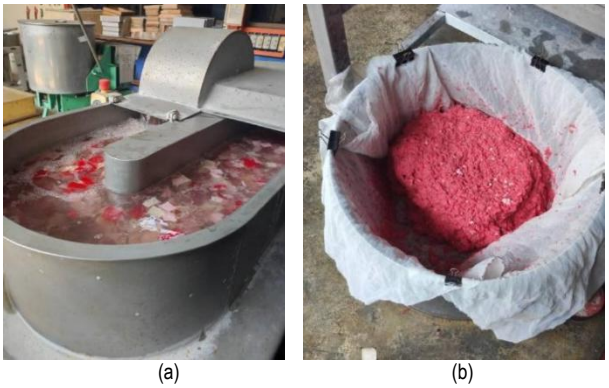
The process begins with the careful preparation of textile fibres. Selected fibres, such as cotton, silk, and canvas, are cut into small, uniform pieces using scissors. This size reduction is crucial for achieving a homogeneous pulp and producing smooth, high-quality paper.

(a) (b)

Fig. 3. (a) Fabrics cut into small pieces; (b) Weighing the fabrics.
(Source: Yahaya et al., 2024)

4.2.2 Pulp Formation

The cut fibres are then processed in a Hollander beater, designed explicitly for pulping cellulose-based materials. The beater's action effectively separates the fibres and mixes them with water to create a pulp slurry. The consistency of the pulp is a critical factor as it directly influences the texture and strength of the final paper product.



(a) (b)

Fig. 4. (a) Cut fabrics are processed in a Hollander beater; (b) Fabrics Pulp.
(Source: Yahaya et al., 2024)

4.2.3 Sheet Formation

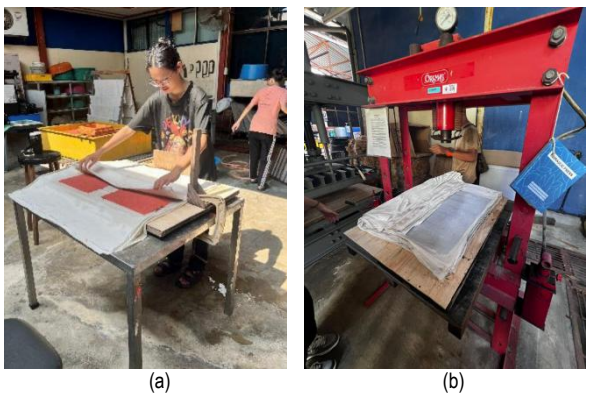
The pulp is poured into a vat containing a pre-prepared methylcellulose solution in the next stage. A deckle is used to draw out sheets from the pulp mixture, with the deckle's frame determining the size and thickness of each sheet. Excess water is carefully drained, and the wet sheets are transferred to an absorbent surface through a process known as couching. Precision is required at this stage to prevent the formation of air bubbles, which can compromise the smoothness of the paper.

(a) (b)

Fig. 5. (a) Mix with methyl cellulose and scraped cloth; (b) Pour a thin pulp layer onto the screen-covered frame.
(Source: Yahaya et al., 2024)

4.2.4 Pressing

Once the sheets are formed, they undergo pressing to remove excess water and ensure uniform thickness. The sheets are placed between layers of absorbent cloth and subjected to pressure in a hydraulic paper press. This step not only enhances the paper's strength but also shortens the drying time, thereby improving the overall energy efficiency of the process.



(a) (b)

Fig. 6. (a) Place between layers of cloths; (b) Press using hydraulic paper press.
(Source: Yahaya et al., 2024)

4.2.5 Drying

The pressed sheets are dried by carefully peeling them from the cloth and transferring them to a wooden board for air drying. This natural drying process typically takes one to two days, allowing the paper to develop its final texture and strength without additional chemicals.

(a) (b)

Fig. 7. (a) Transfer press sheets on wooden board; (b) Natural drying process.
(Source: Yahaya et al., 2024)

4.2.6 Finishing and Final Application

The final stage of the process involves inspecting and finishing the dried paper. Unlike industrial paper-making processes often involving bleaching and other chemical treatments, this study's handmade paper retains the original fibres' natural colour and texture. The results yielded a collection of 50 handmade sheets consisting of 45 A3-sized sheets and 5 B5-sized sheets. Each sheet exhibited unique variations, reflecting the natural irregularities of the fibres, which contributed to the overall aesthetic diversity of the collection. This variation not only highlights the artistic potential of handmade paper but also aligns with the study's broader objective of promoting eco-friendly alternatives in paper production. Furthermore, the decision to forego bleaching and chemical treatments demonstrates the viability of producing aesthetically appealing and functionally durable paper without compromising environmental sustainability. The findings from this phase underscore the potential for handmade paper to serve as a sustainable alternative to conventional paper, particularly in contexts where environmental impact and aesthetic quality are paramount. This collection of sheets, with its distinct textures and natural tones, serves as evidence of the success of a more environmentally responsible approach to papermaking, thus contributing to the body of knowledge in sustainable materials research and eco-friendly design practices.

Fig. 8. Handmade Paper with A2 size and B5 size sheets.
(Source: Yahaya et al., 2024)

5.0 Discussion

The production of handmade paper from synthetic fibres demonstrated the feasibility and numerous advantages of utilising alternative materials in sustainable crafts. This process encompassed several critical steps, including fibre preparation, pulp formation, sheet creation, and pressing, each of which played a pivotal role in determining the overall quality of the final product. The selection of synthetic fibres, such as lycra, cotton, silk, and canvas, provided a durable and flexible foundation for the paper, expanding its applicability beyond traditional uses and into innovative craft applications. Incorporating methyl cellulose as a binding agent was instrumental in ensuring the paper's structural integrity, underscoring the importance of selecting appropriate chemical agents in the papermaking process.

From a technical standpoint, the handmade paper exhibited desirable characteristics, including strength, elasticity, and a pleasing texture. These qualities resulted from meticulous execution at every stage of the process, highlighting the importance of precision in sustainable papermaking. The decision to utilise recycled materials, including discarded clothing and food packaging, was in direct alignment with the project's sustainability objectives. This approach not only contributed to waste reduction but also actively promoted the principles of the 3R concept—Reduce, Reuse, and Recycle—thereby reinforcing the project's commitment to environmental stewardship. This study effectively demonstrated how handmade paper can be employed innovatively, contributing significantly to the broader field of sustainable design. Moreover, integrating natural and recycled materials in the design process highlighted the potential for eco-friendly products to meet consumer demands for both sustainability and quality.

6.0 Conclusion and Recommendations

In conclusion, this study explored the potential of producing handmade paper from synthetic fibres and its application in creating functional and artistic products. Transforming recycled materials into handmade paper demonstrated the viability of integrating sustainable practices into the craft industry. The successful creation of a table lamp as the final product illustrated handmade paper's versatility and aesthetic potential, proving that waste materials can be effectively repurposed into valuable, eco-friendly items.

This study met its objective of combining artistic expression with environmental consciousness and provided a robust framework for future sustainable design and innovation explorations. The findings suggest that with careful material selection and process management, handmade paper can play a pivotal role in developing sustainable products, contributing to environmental stewardship, and promoting sustainable living. The work conducted in this study opens avenues for further research and development, encouraging the continued pursuit of innovative solutions that align with the principles of sustainability in craft and design industries.

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