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Research Article

RECYCLING HOSIERY WASTE AS A SUSTAINABLE STRATEGY FOR TEXTILE RESOURCE MANAGEMENT AND VALUE-ADDED PRODUCT DEVELOPMENT

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ABSTRACT

The hosiery industry generates significant quantities of waste in the form of damaged and rejected socks, gloves, waste yarn, waste fibres and sock rings. This study investigates innovative approaches to transform such pre-consumer textile waste into useful value-added products such as doormats and rugs, thereby reducing environmental impact. A survey and interrogation-based methodology was adopted to collect quantitative data from hosiery manufacturing units. Findings revealed that waste was produced at multiple stages of production, including fibre remnants, sock rings removed during finishing, and defective products rejected during quality checks. Recycling hosiery waste not only reduces environmental pollution but also contributes to economic sustainability by lowering the demand for virgin fibers and creating opportunities for employment and income generation.

Keywords: Hosiery waste, Recycling, Socks, Gloves, Textile sustainability, Value-added products.

INTRODUCTION

Industrialisation and rising consumption patterns have significantly increased textile waste generation at both industrial and household levels. Textile wastes are generally categorised as pre-consumer and post-consumer**.** Pre-consumer waste comprises fibre, yarn and garment remnants produced during manufacturing processes and is often considered "clean waste" because it is generated prior to reaching the consumer (Anbumani, 2007). Post-consumer waste refers to discarded garments and home textiles that are worn out or no longer in use, and require mechanical, thermal or chemical processing for recycling (Kumar, 2017). In the hosiery sector, a substantial proportion of textile waste arises from production of socks and gloves. Although such materials retain commercial value and can be recycled, a large portion is still directed to landfills adding to pollution, greenhouse gas emissions and resource depletion (Kadnikova *et al.,* 2018). Sustainable waste management, therefore, is essential to promote circularity in textile production and reduce pressure on virgin fibre extraction. Post-consumer wastes are called as non-re-workable waste and it is not possible to return this kind of waste into production process without any prior treatment. Depending on the type of waste material, textile wastes are recycled by mechanical, chemical and thermal methods. It consists of any type of garment or household textiles such as sheets or towels which are discarded by the consumers for the reasons that they are worn out, damaged, outgrown, or have gone out of fashion.

MATERIAL AND METHODS

Hosiery waste samples were collected from selected socks and gloves manufacturing industries and consisted of waste fibres and yarn generated during production, sock rings obtained during edge finishing, cut yarn removed from selvedge trimming and rejected or defective pairs of socks that were discarded during intermediate quality checks. All collected waste components were systematically segregated based on type, size and the stage of origin within the production cycle. This study followed a descriptive and survey-based research approach to assess the nature and quantity of hosiery waste generated in industrial units. The research was undertaken with the objectives of assessing the amount and type of waste produced in hosiery manufacturing units, examining the potential for recycling

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fibre, yarn and fabric waste, identifying strategies to reduce industrial waste load and developing value-added products from hosiery waste. Waste was conceptually defined as any material or product that can no longer fulfil its intended function and is discarded at the end of its lifecycle, contributing to environmental pollution, resource depletion, increased landfill demand and potential health hazards. Textile waste was categorised into pre-consumer waste generated during manufacturing, post-consumer waste arising from discarded garments and home textiles, and industrial textile waste produced as by-products during fibre, fabric and garment processing. Special emphasis was placed on hosiery waste due to its substantial environmental and economic implications. Literature suggests that polyamide used in socks and gloves is more difficult to recycle than polyester, resulting in a lower recycling rate; however, both pre-consumer and post-consumer hosiery waste can be recycled using mechanical or chemical methods to reduce dependence on fossil-based raw materials. Furthermore, industrial data on waste generation were collected daily and monthly from selected manufacturing units, recording quantities of fibre waste, selvedge and ring cuts, and rejected pairs of socks and gloves. Direct observations of the production line indicated that waste was generated throughout the manufacturing process, particularly during finishing operations and quality inspection.

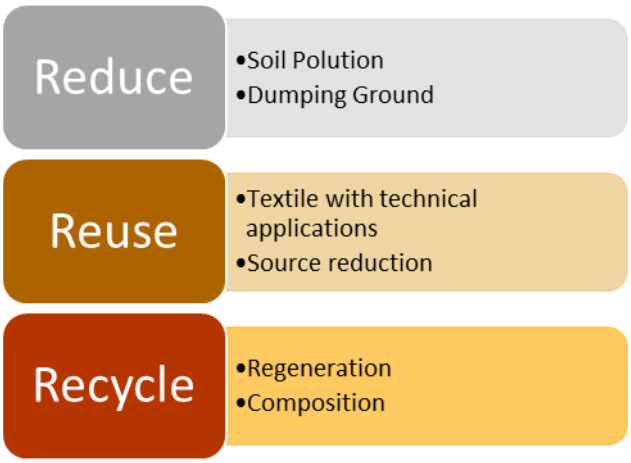
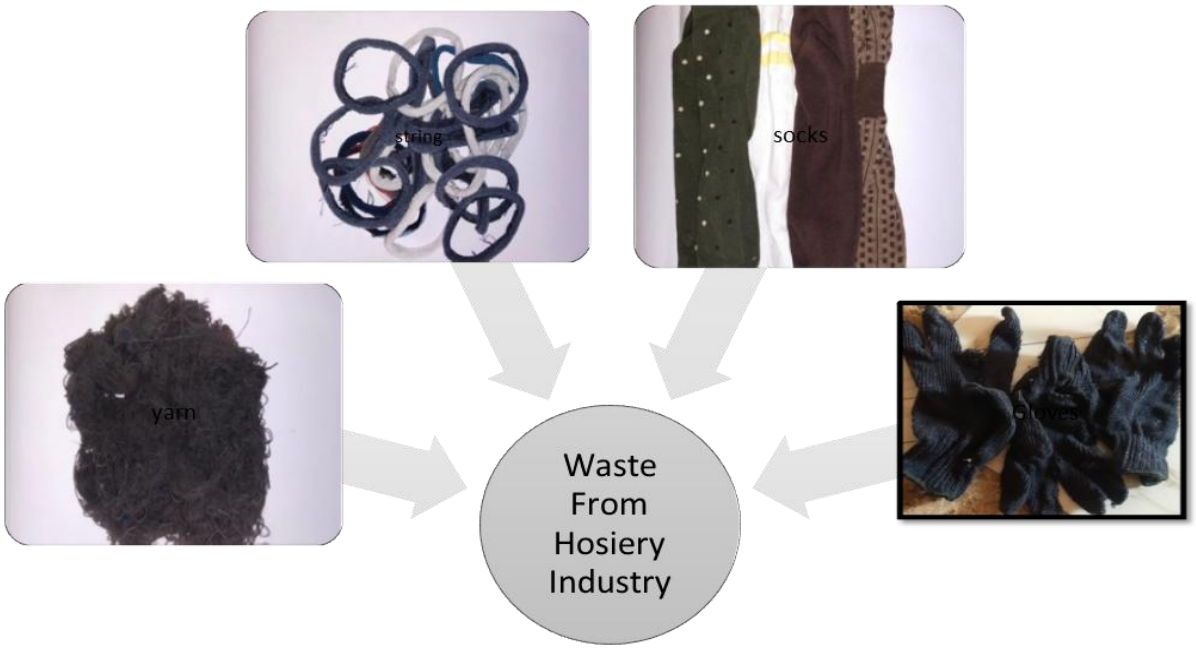


Figure 1. Flow Chart showing Waste management method.



RESULTS AND DISCUSSION

The production analysis confirmed that hosiery industries generate three predominant categories of waste: waste fibres**,** sock rings and cut yarn**,** and rejected pairs of socks or gloves. In socks manufacturing, cut fibre waste represented approximately 1–2%**,** sock rings accounted for the highest proportion at 30–40%**,** and rejected socks constituted 5–8% of total daily output**.** Gloves manufacturing also demonstrated considerable loss, with 1–2% wastage yarn and 10–20% rejected gloves recorded per day (Table 1). Production records revealed that mechanical hosiery machines generated 1182 units of socks, of which 85 pairs were rejected**,** 8.21 units comprised fibre wastage, and 2534 units were sock rings. Computerized hosiery machines produced 5481 units**,** with 242 rejected pairs**,** 2187.99 units of fibre wastage**,** and 11,446 sock rings. In addition to socks production, mechanical gloves machines recorded 1932 total units**,** 195 rejected gloves**,** and 18.25 units of fibre wastage. The cumulative findings emphasise that hosiery manufacturing consistently produces substantial amounts of recoverable textile waste across both socks and gloves units. Furthermore, the disproportionately high volume of sock rings and rejected articles highlights significant potential for value-added recycling initiatives. These results reinforce the need for structured textile waste management, as effective recycling can lower environmental burden and reduce the demand for virgin fibre, aligning with global sustainability trends in textile production.

Table 2 showing the findings from the gloves manufacturing industry revealed a consistent pattern of waste generation across production cycles. Daily and monthly production records showed that the industry generated waste primarily in the form of wastage yarn and rejected gloves**.** Quantitatively, wastage yarn accounted for approximately 1–2% of the total production**,** while rejected pairs of gloves contributed between 10–20% of the daily output**.** These observations indicate that a substantial proportion of gloves manufactured do not meet the acceptable quality benchmark during inspection and are discarded as waste. The high rejection rate suggests that optimisation in production accuracy and quality control could significantly reduce waste generation. Overall, the results confirm that gloves manufacturing contributes notably to industrial hosiery waste, highlighting the need for improved recycling strategies and better waste management interventions to minimise material loss and environmental impact. The recycling experiment demonstrated that hosiery waste can be effectively transformed into multiple value-added textile products. Based on the design development stage and usability evaluation, five functional and aesthetic household articles were successfully produced from the waste materials. The rejected socks and fabric strips were reused as stuffing and surface material to create soft toys**,** resulting in a teddy bear that offered both durability and visual appeal. Circular knitted scraps and coloured selvedge yarn were repurposed to produce a decorative table-top cover**,** highlighting the potential of hosiery remnants for creative interior applications. Additionally, a door mat was constructed from cut rings and braided fibre waste**,** which provided high surface grip and showcased excellent structural strength. A bottle cover was developed by combining stitched sock segments and elasticated waste**,** providing insulation, protection and aesthetic value. Lastly, woven and knitted strips of hosiery waste were integrated to produce a rug**,** confirming the suitability of the material for floor coverings and household textiles (Figure 3). The successful conversion of industrial hosiery waste into teddy bears, table-top covers, door mats, bottle covers and rugs (Figure 3a, b) demonstrates the strong potential for sustainable product diversification**,** waste minimisation**,** and income-generating opportunities**.** These findings support the principle that textile waste can function as a valuable raw material rather than a disposal burden, encouraging circularity within the textile and apparel sector.

Table1. Showing Quantification of Waste fibres, Socks Rings and Cut Yarn.

Total	production	Rejected pair	Wastage fiber	Cut Ring
Mechanical Machine	1182	85	8.21	2534
Computer machine	5481	242	2187.99	11446

Table 2. Mechanical Machine showing estimated Production. Rejected Paid and Wastage Fibre.

Total	Production	Rejected pair	Wastage fiber
Mechanical Machine	**1932**	**195**	**18.25**

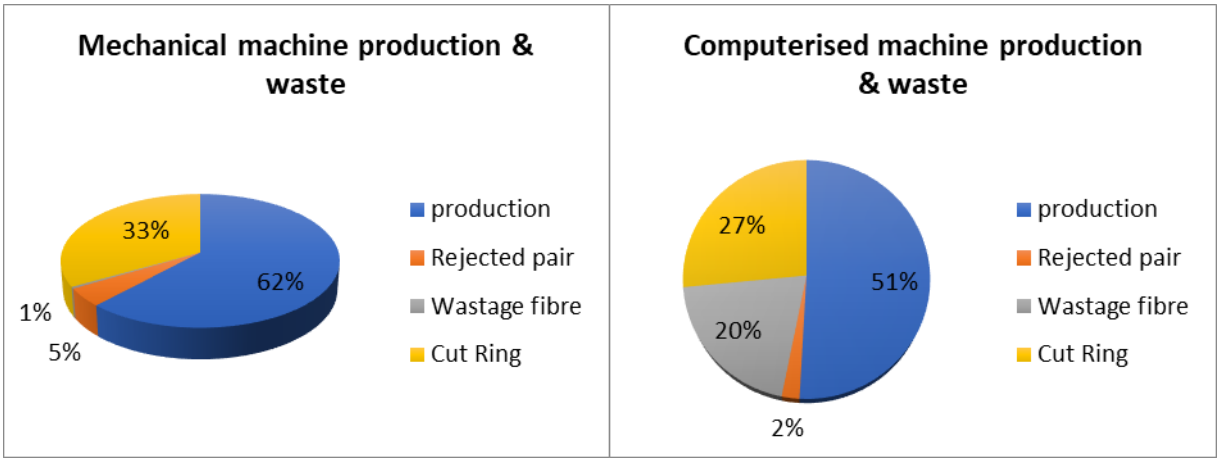


Figure 1. Pie chart showing Mechanical Production of waste and Computerized Machine Production.

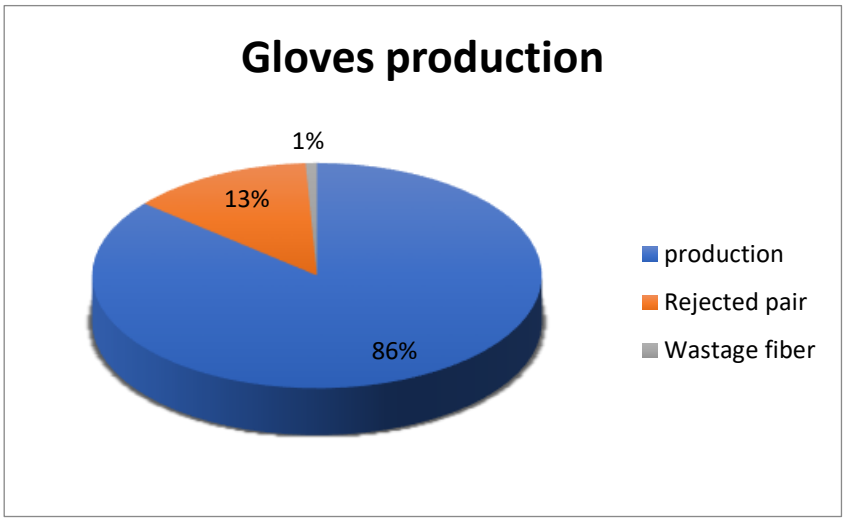


Figure 2. Pie chart showing gloves production in percent ration.

Figure 3 a. Soft Toys, Bottle Cover, Door mat, Rug made by Waste Socks.

Figure 3b. Door mat made by waste fibre.

Recycling hosiery waste plays a pivotal role in achieving sustainable textile production. Previous studies confirm that the reuse of textile remnants decreases pressure on landfill sites, conserves energy, minimises water use and reduces demand for dyes and virgin fibres (Jamshaid *et al*., 2021; Kadnikova *et al.,* 2018). Polyamide-based hosiery products are especially significant in this context because their recycling can reduce dependence on fossil resources (Textile Exchange, 2018 cited in GRABS). Transforming hosiery waste into household products such as doormats, quilts, rugs and mattress fillings supports circular economy principles while providing income to local artisans and small-scale industries. This aligns with the global textile recycling movement, which annually converts approximately 750,000 tonnes of post-producer waste into new raw materials (Textile Recycling Council, 2020). Textile waste management has become a major research focus due to rising industrial production and consumer consumption. Earlier studies reveal that both pre-consumer and post-consumer textile waste contribute significantly to environmental degradation if not recycled appropriately (Kumar, 2017; Shah, 2022). Various forms of textile waste, including fibre remnants, yarn residues, selvedge cuts and rejected garments, continue to accumulate during spinning, knitting, weaving and garment manufacturing processes (Anbumani, 2007; Oxtoby, 2013). Researchers have demonstrated that these wastes retain high reuse value, as they originate from high-quality raw materials that undergo limited wearing and ageing (Jamshaid *et al*., 2021). Geetharani and Kumar (2020) further confirmed that hosiery waste can be efficiently transformed into functional products, supporting sustainable practices in the textile sector. Waste recycling is not only environmentally beneficial but also reduces dependence on virgin raw materials; for instance, regenerating polyamide from hosiery residues significantly reduces fossil-fuel requirements and energy consumption (Kadnikova *et al*., 2018). Biotechnological approaches have also been explored to convert textile waste into value-added outputs, enabling greater economic returns from discarded fibre materials (Ashmitha, 2018). Online sustainability resources reiterate the importance of systematic waste handling in the textile industry, emphasising the transition from a disposal-based model to a recycling-based circular economy (Textile Recycling Association, 2023; Textile Recycling Association, 2024; Semantic Scholar, 2023). Given this global shift toward textile recycling, the development of household and lifestyle products from hosiery waste aligns strongly with current sustainability trends and circular design models.

CONCLUSION

Recycling hosiery waste is an essential strategy for promoting environmental and economic sustainability within the textile sector. Repurposing production waste into new materials reduces pollution and resource exploitation while simultaneously generating employment and supporting small-scale entrepreneurial activities. With proper planning and integration of recycling systems, the hosiery industry can transition effectively towards a circular production model.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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