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Recycling of Cotton Textile Waste for Nonwoven Products

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Abstract

The rapid growth of the textile and apparel industry has resulted in a significant increase in textile waste worldwide. Cotton, one of the most widely used natural fibres, contributes a considerable portion of this waste during various stages of production and consumption. Recycling cotton textile waste into nonwoven products offers an environmentally sustainable solution to reduce landfill waste and promote circular economy practices in the textile sector. Nonwoven fabrics produced from recycled cotton fibres can be used in several applications such as insulation materials, agro-textiles, medical textiles and packaging. This article discusses the sources of cotton textile waste, recycling methods and the production of nonwoven fabrics from recycled cotton fibres. The study highlights the advantages, challenges and potential applications of recycled cotton nonwoven products in sustainable textile manufacturing.

Keywords: Cotton textile waste, recycling, nonwoven fabrics, sustainable textiles, circular economy.

1. Introduction

The textile industry is one of the largest manufacturing sectors in the world, but it also generates a large amount of waste during fibre production, fabric manufacturing, garment construction and post-consumer disposal. Cotton is the most widely used natural fibre in the textile industry due to its comfort, breathability and biodegradability. However, large quantities of cotton waste are generated in the form of spinning waste, cutting waste, yarn waste and discarded garments.

With the increasing popularity of fast fashion and high consumption of clothing, the volume of textile waste has increased dramatically. A significant portion of this waste ends up in landfills, causing environmental problems such as soil contamination, greenhouse gas emissions and inefficient resource utilization. Recycling textile waste is therefore essential for sustainable textile production and environmental protection (Kushwah and Naik, 2020).

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Cotton textile waste can be classified into pre-consumer waste and post-consumer waste. Pre-consumer waste includes fibre waste generated during spinning, weaving, knitting and garment manufacturing processes, while post-consumer waste refers to used garments and household textiles discarded by consumers. Recycling these materials can significantly reduce the environmental impact of textile production.

Nonwoven fabrics produced from recycled cotton fibres have gained considerable attention because they require shorter fibres and can be manufactured through simple mechanical processes. The conversion of cotton waste into nonwoven materials provides an effective method for utilizing textile waste while producing value-added products for industrial and technical applications.

2. Sources of Cotton Textile Waste

Cotton textile waste originates from several stages of textile production and consumption. The main sources include:

2.1 Spinning Waste

During yarn manufacturing, fibre waste is produced during opening, carding, combing and drawing processes. These wastes include short fibres, neps and droppings.

2.2 Fabric Manufacturing Waste

Weaving and knitting processes generate yarn waste due to breakage, defects and leftover materials.

2.3 Garment Manufacturing Waste

Garment production generates cutting waste, which consists of fabric scraps left after pattern cutting. This type of waste is often clean and suitable for recycling.

2.4 Post-Consumer Textile Waste

Discarded garments, home textiles and worn-out clothing represent a significant source of cotton waste. Recycling these materials requires sorting and processing before they can be reused. The increasing amount of textile waste generated globally has become a major environmental concern. Effective recycling strategies are necessary to reduce waste and promote sustainable resource utilization (Hazarika and Kalita, 2024).

3. Methods of Recycling Cotton Textile Waste

Several methods are used to recycle cotton textile waste into usable fibres or materials. These methods include mechanical, chemical and biological recycling processes.

3.1 Mechanical Recycling

Mechanical recycling is the most commonly used method for recycling cotton waste. In this process, textile waste is shredded and converted into fibre form using mechanical

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equipment such as tearing machines and openers. The recycled fibres can then be used to produce nonwoven fabrics or blended with other fibres to manufacture yarns.

Mechanical recycling is widely used because it is cost-effective and does not alter the chemical structure of the fibres. However, the process may reduce fibre length and strength due to repeated mechanical processing (Rahman *et al.,* 2023).

3.2 Chemical Recycling

Chemical recycling involves breaking down cotton fibres into cellulose or other chemical components using solvents or chemical treatments. These components can then be regenerated into new fibres or materials.

Chemical recycling techniques have gained attention because they allow the recovery of high-quality cellulose from textile waste. These regenerated fibres can be used to produce new textile materials, reducing the demand for virgin cotton fibres.

3.3 Biological Recycling

Biological recycling uses microorganisms or enzymes to degrade textile waste into useful substances. This method is still under research but has potential for sustainable waste management.

4. Production of Nonwoven Fabrics from Recycled Cotton Fibres

Nonwoven fabrics are textile structures produced by bonding fibres together without weaving or knitting. These fabrics are widely used in technical textiles due to their versatility and low production cost.

The production of nonwoven fabrics from recycled cotton waste generally involves the following steps:

4.1 Collection and Sorting

Cotton waste is collected from textile industries or post-consumer sources. The waste materials are sorted to remove contaminants such as buttons, zippers and synthetic fibres.

4.2 Shredding and Fibre Recovery

The sorted textile waste is shredded using mechanical equipment to convert fabric pieces into fibrous form. This process produces recycled cotton fibres suitable for nonwoven manufacturing.

4.3 Fibre Blending

Recycled cotton fibres may be blended with other fibres such as polyester, viscose or wood pulp to improve the mechanical properties of the final product.

4.4 Web Formation

The fibres are arranged into a web using carding or air-laying processes.

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4.5 Bonding

The fibre web is bonded using mechanical, thermal or chemical bonding methods. Common nonwoven production techniques include needle-punched, spun-lace and wet-laid processes.

Studies have shown that cotton textile waste can be effectively used to produce wet-laid and air-laid nonwoven materials. In some cases, recycled cotton fibres can replace up to 70% of virgin raw materials while maintaining good mechanical properties of the nonwoven structures (Grover *et al*., 2025).

5. Applications of Recycled Cotton Nonwoven Products

Nonwoven fabrics produced from recycled cotton fibres have a wide range of applications in technical and industrial sectors.

Table: Major Nonwoven Products from Recycled Cotton Textile Waste

Application Area	Nonwoven Product	Key Properties
Construction	Thermal insulation panels	Heat resistance, lightweight
Agriculture	Mulch mats, crop covers	Biodegradability, moisture retention
Medical sector	Surgical gowns, wipes	Softness, absorbency
Household products	Cleaning wipes	High absorbency
Automotive	Seat padding, acoustic insulation	Sound absorption

Source: Adapted from Grover *et al.* (2025); Wang *et al.* (2021); Rahman *et al.* (2023); Bhuiyan *et al.,* (2023)

6. Advantages

Recycling cotton textile waste into nonwoven fabrics provides several environmental and economic benefits:

- Reduction of textile waste in landfills
- Conservation of natural resources and energy
- Lower production costs compared to virgin fibres
- Promotion of circular economy in the textile industry
- Reduction of greenhouse gas emissions

Recycling textile waste therefore plays an important role in sustainable textile manufacturing and waste management.

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7. Challenges and Future Prospects

Despite the advantages of cotton textile recycling, several challenges still exist. One of the main limitations of mechanical recycling is the reduction in fibre length and strength, which may affect the quality of recycled products. Additionally, the presence of mixed fibres and contaminants can complicate the recycling process. Recent research has focused on developing advanced technologies for textile sorting, fibre recovery and fibre regeneration. These innovations aim to improve the efficiency and quality of recycled textile materials and support sustainable production systems. In the future, greater collaboration between textile industries, recycling companies and researchers will be essential to promote large-scale textile recycling and reduce environmental impacts.

Conclusion

Recycling cotton textile waste into nonwoven products offers a sustainable solution for managing the growing problem of textile waste. By converting discarded cotton fibres into value-added nonwoven materials, the textile industry can reduce environmental pollution and conserve natural resources. Nonwoven fabrics produced from recycled cotton fibres have numerous applications in agro-textiles, medical textiles, insulation materials and packaging products. Although certain technical challenges remain, ongoing research and technological advancements are improving the efficiency of textile recycling processes. The adoption of recycling practices in the textile industry will play a crucial role in achieving sustainable development and circular economy goals.

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