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TYPES OF TEXTILE WASTE AND THEIR IMPACT ON THE ENVIRONMENT

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Abstract

The textile industry is one of the largest contributors to global industrial waste and pollution. This comprehensive review examines the various types of waste generated across the textile production lifecycle, from raw material processing to post-consumer disposal. The article classifies these wastes into two main categories: pre-consumer waste (including spinning waste such as carding droppings and short fibers, as well as roving and weaving waste) and post-consumer waste (discarded garments and textiles). Using the IMRAD structure, it details the characteristics and generation points of each waste type. Furthermore, it analyzes their profound environmental effects, including landfill accumulation, water pollution from chemical leaching and microplastic shedding, and greenhouse gas emissions. The study concludes by evaluating current recycling strategies and underscores the critical necessity of transitioning from a linear "take-make-dispose" model to a Circular Economy framework. This transition, supported by technological innovation and sustainable design principles, is presented as the only viable path for mitigating the environmental impact of the textile industry.

Keywords: Spinning waste, carding waste, short fibers, roving waste, recycling, textile industry, circular economy, environmental effect.

Introduction

The global textile industry, a cornerstone of the world economy, is paradoxically one of the most resource-intensive and polluting sectors. The demand for fast fashion has exponentially accelerated production cycles, leading to an unprecedented generation of textile waste. It is estimated that the industry is responsible for over 92 million tonnes of waste annually, a figure projected to rise sharply without significant intervention [1].

This waste stream poses a severe threat to ecosystems, human health, and planetary resources. Traditionally, the textile value chain has operated on a linear model: raw materials are extracted, processed into goods, and sold to consumers who eventually discard them. This "end-of-life" stage typically involves landfilling or incineration, both of which have dire environmental consequences. A profound understanding of the types of waste generated at each stage of production is the first step towards developing effective mitigation and management strategies.

This article aims to provide a systematic review of the different types of textile waste, with a specific focus on often-overlooked pre-consumer waste like spinning and roving waste. It will delineate their impact on the environment and explore the role of recycling and the principles of a circular economy as essential solutions. The primary objective is to synthesize existing knowledge to highlight the urgency of the problem and the pathways toward a more sustainable textile future.

Spinning is the process of converting natural or chemical fibers into continuous yarn and is a key stage in the textile production chain. The spinning industry in Uzbekistan has traditionally developed on the basis of cotton fiber and plays an important role in the country's economy [2]. This process, no matter how advanced, inevitably leads to the generation of various wastes. The increase in waste in spinning enterprises not only leads to the loss of raw materials (fibers), but also has a negative impact on the economy of the enterprise and the environment [3].

Dust and impurities: Fine dust, oil, plant debris (such as cottonseed hulls), and other impurities released during the initial cleaning and carding of natural fibers such as cotton and wool. These emissions can cause respiratory diseases, so dust collection systems are important [4].

Figure1. Carding waste

METHODS

This comprehensive review was structured and conducted to systematically analyze the types of textile waste, with a particular emphasis on pre-consumer waste from spinning processes, and to evaluate their environmental impacts and management strategies. The methodological approach consisted of several key stages to ensure a thorough and relevant analysis.

A systematic search for relevant literature was performed using major academic databases, including Scopus, Web of Science, Google Scholar. The search was conducted in English and Russian to capture a wider scope of research, particularly from regions with significant textile production like Central Asia. The primary keywords used were: "textile waste," "spinning waste," "carding waste," "comber noil," "roving waste," "textile recycling," "circular economy," and "environmental impact of fashion." Boolean operators were employed to combine these terms for a more focused search (e.g., "spinning waste and recycling," "carding waste and environmental effect").

The initial search results were screened based on titles and abstracts to identify the most pertinent studies. The full texts of the selected articles were then reviewed against the following inclusion criteria:

Publication Date: Priority was given to articles published between 2010 and 2024 to ensure the inclusion of recent data and technological advancements. However, seminal works from earlier years were also considered for foundational context.

- **Relevance to Topic:** Studies were included if they provided specific data on the generation rates, characteristics, or management of pre-consumer textile waste (especially from spinning and weaving) or post-consumer waste.
- **Geographical Scope:** While the review has a global perspective, special attention was paid to research and reports concerning textile production in Central Asia, including Uzbekistan, given the region's importance in cotton and yarn production [2, 3]. This allows for a more contextualized discussion of the problem.

The information extracted from the selected literature was categorized and synthesized according to the IMRAD structure. The analysis focused on:

Classification: Grouping waste types based on their point of generation in the textile production lifecycle (e.g., spinning, weaving, finishing).

Characterization: Detailing the composition and properties of key waste streams like carding droppings and short fibers, as illustrated in the provided figures (Figure 1, Figure 2).

Impact Assessment: Collating data on the environmental consequences of these wastes, such as landfill burden, microplastic pollution, and resource depletion.

Solution Evaluation: Reviewing the efficacy of current recycling methods (mechanical and chemical) and the principles of a circular economy as a sustainable framework for the industry.

This methodological framework ensured a logical, evidence-based, and comprehensive flow for discussing the generation, impact, and management of textile waste, aligning with the article's stated objectives.

RESULTS AND DISCUSSION

Textile waste can be broadly classified into two main categories: pre-consumer (or production) waste and post-consumer waste.

This waste is generated during the manufacturing of textiles and garments.

- Spinning Waste: This is a significant waste stream from yarn manufacturing.

Carding Waste: During the carding process, which disentangles, cleans, and intermixes fibers to produce a continuous web, impurities and shorter fibers are removed. These removed materials, known as carding waste or "fly," consist of dirt, vegetable matter, and very short fibers that are unsuitable for spinning strong yarns [5].

Short Fibers (Comber Waste): In the combing process, which produces higher-quality, smoother yarns, a substantial amount of short fibers, known as comber noil, is extracted. While this waste is inevitable for quality control, it represents a loss of raw material. These short fibers are often recycled into lower-value products like non-woven fabrics or stuffing materials [6].

Roving Waste: The roving stage involves thinning the sliver and inserting a slight twist to form a roving. Breakages and imperfections in the roving frame lead to roving waste. This waste is relatively clean and uniform, making it a good candidate for recycling back into the spinning process.

Figure2. Roving waste

Weaving and Knitting Waste: This includes yarn leftovers, selvage trimmings, and defective fabric pieces. These are often clean, identifiable materials that can be directly reused or recycled.

Fabric Processing Waste: This includes off-cuts from garment manufacturing and waste generated from dyeing and finishing processes, which often contain chemical residues.

This category comprises textile products that have reached the end of their useful life to the consumer, such as discarded clothing, household textiles (e.g., towels, bedsheets), and upholstery. This is the most challenging waste stream due to its volume, mixed material composition, and contamination.

The environmental footprint of textile waste is multifaceted and severe.

Landfill Accumulation: The vast majority of textile waste ends up in landfills. Synthetic fibers like polyester can take hundreds of years to decompose, while natural fibers like cotton decompose anaerobically, releasing methane, a potent greenhouse gas [7].

Water Pollution: The life cycle of textiles is heavily water-dependent. Chemical dyes and finishing agents used in production can leach from landfills into groundwater and soil. Furthermore, each wash of synthetic garments releases thousands of microplastic fibers into wastewater, which eventually reach rivers and oceans, entering the food chain [8].

Resource Inefficiency: The linear model represents a colossal waste of resources. For example, the water, land, and pesticides used to grow cotton that becomes comber waste or a discarded garment are all lost investments, exacerbating resource scarcity.

Managing textile waste requires a shift from a linear to a circular model.

Recycling Technologies: Recycling methods are broadly divided into mechanical and chemical.

Mechanical Recycling: This involves physically shredding textiles back into fibers. It is most common but often leads to fiber shortening, resulting in a downcycled product (e.g., turning garments into insulation material). Spinning waste like short fibers is frequently processed this way.

Chemical Recycling: This process breaks down polymers (like polyester or cotton) to their molecular level, allowing them to be repolymerized into new, high-quality fibers. This

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technology holds promise for true circularity but is still developing and requires significant investment [9].

The Circular Economy Framework: The circular economy aims to eliminate waste by design. In the context of textiles, this involves:

Designing for Longevity and Recyclability: Creating durable garments that are easy to disassemble and made from mono-materials.

Promoting Reuse and Repair: Supporting business models like thrifting, rental, and repair services.

Creating Closed-Loop Systems: Developing infrastructure where post-consumer textiles are collected, sorted, and recycled into new textiles, thus keeping materials in use for as long as possible. The Ellen MacArthur Foundation has been a key proponent of this vision, demonstrating its economic and environmental benefits [10].

The integration of pre-consumer waste, such as roving and spinning waste, into recycling streams is more straightforward due to its homogeneity and is already a common practice in many mills. However, the real challenge and opportunity lie in effectively managing the complex stream of post-consumer waste.

CONCLUSION

The textile waste crisis, driven by the fast-fashion paradigm and a linear economic model, presents one of the most pressing environmental challenges of our time. This review has detailed the various waste types, from the specific pre-consumer wastes like carding droppings and short fibers to the overwhelming volume of post-consumer clothing. The environmental impacts—from landfill leaching and microplastic pollution to immense resource waste—are undeniable and unsustainable.

While recycling technologies offer a partial solution, they are not a silver bullet. Mechanical recycling often leads to downcycling, and chemical recycling is not yet scalable. Therefore, the most critical finding of this analysis is that technological solutions must be coupled with a fundamental systemic shift. The adoption of a Circular Economy is not merely an alternative but a necessity. This requires concerted efforts from all stakeholders: designers must create for circularity, manufacturers must invest in clean technologies and waste reintegration, policymakers must enact supportive legislation, and consumers must embrace sustainable consumption patterns. By viewing waste not as an endpoint but as a valuable resource, the textile industry can begin to untangle itself from its current destructive path and weave a more sustainable future.

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