SILK WASTE GENERATION AND ITS PRODUCTIVE UTILIZATION – A REVIEW

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Abstract

Silk waste generation is a significant concern in the textile industry, with substantial amounts of waste generated at various stages of silk production, from cocoon reeling to fabric manufacturing. With the increasing demand for sustainable and eco-friendly materials, it is essential to explore productive utilization of silk waste to minimize environmental impact and add value to the supply chain. This paper reviews the sources of silk waste, its environmental implications, and innovative approaches for its utilization in sectors such as textiles, cosmetics, agriculture, biomedical applications, and thermal insulation.

Keywords : *Silk waste, cocoon waste recycling, reuse, reeling waste*

1.Introduction

Silk is a natural protein fibre renowned for its lustre, strength, and luxurious texture. However, the production of silk results in considerable waste, particularly in the form of by-products like pierced cocoons, silk filature waste, silk fibroin, and sericin. These wastes are typically underutilized, despite having high potential for value-added applications. This paper discusses the scope of silk waste, highlighting opportunities for sustainable utilization.

2. Silk Waste Generation: An Overview

Silk waste is produced at different stages of the silk production process, from cocoon harvesting to fabric weaving. The major sources include:

Cocoon Waste: Damaged, double, and pierced cocoons that are unsuitable for reeling.

Reeling Waste: Ends from silk reeling, such as cut threads, silk gum, and undrawn silk.

Throwing and Weaving Waste: Yarn breaks during throwing and weaving generate short fibres or “noil” waste.

Dyeing and Finishing Waste: Chemical residues and broken silk fibers post dyeing.

The volume of waste produced is significant, with estimates suggesting that around 20-30% of silk cocoons are discarded as waste during reeling and spinning processes.

2.1 CACOON WASTE:

Definition: Cocoon waste refers to the leftover materials that result from the reeling process, where the silk thread is unwound from the cocoon. This waste can include both full and damaged cocoons.

Sources: During reeling, not all cocoons are suitable for extracting long fibres. Damaged, misshapen, or partially defective cocoons, known as "reelers waste," cannot be used in the reeling process and are discarded.

Applications:

It is Used for spun silk production (shorter fibers are spun to make silk yarn). Waste from cocoons is also used in making silk powder for cosmetic and pharmaceutical purposes. It can be processed for bio-based products like feedstock or fertilizers.

2.2 REELING WASTE:

Definition: Reeling waste includes broken, tangled, or unusable silk filaments that accumulate during the reeling process.

Sources: As the cocoons are reeled, some fibers may break or get tangled, creating reeling waste known as "reeling ends" or "silk lapping." These are shorter fibers that are discarded during the production of silk yarn**.**

Applications:

Spun silk: Reeling ends can be used to make lower-grade silk products, such as spun silk, or blended with other fibers like cotton or polyester to make blended textiles.

Insulation material: In some cases, reeling waste can be repurposed as an eco-friendly insulation material in home construction or industrial applications.

2.3 THROWING AND WEAVING WASTE:

Definition: It refers to the material waste generated during the process of weaving silk yarns into fabrics. This waste typically includes yarn ends, fabric selvages (the edges of woven fabric), and defective sections of fabric.

Sources: Weaving waste is produced when silk yarns are woven on a loom, especially when the yarn breaks, when excess yarn is trimmed from the edges, or when a fabric has flaws that make it unsuitable for sale.

Applications:

Recycling into new textiles: Weaving waste can be recycled and reprocessed to create lower-grade silk textiles or mixed-fiber fabrics**.**

Small-scale textile products: Off-cuts and selvages are often used by designers and artisans to create smaller textile items like bags, scarves, patchwork quilts, and craft materials.

Handicrafts: Weaving waste can be repurposed in the handicraft sector for making accessories, decorative items, or even as padding in quilts and cushions.

2.4 Dyeing and Finishing Waste:

Dyeing and Finishing Waste

Definition: Dyeing and finishing waste includes waste generated during the chemical processes applied to silk fabrics after weaving, which are meant to improve the appearance, colour, texture, or durability of the fabric. This waste can include unused dye, chemicals, water used for rinsing, and damaged or defective fabrics that cannot be sold due to improper dyeing or finishing.

Sources: This waste is generated from:

Dyeing: Leftover dyes, water contaminated with chemicals, and runoff from rinsing fabrics post-dyeing**.**

Finishing processes: Leftover chemicals, defective fabrics, and trimmings that are generated during processes like printing, embossing, steaming, or applying finishes to enhance softness, sheen, or water repellence.

Applications:

Waste fabric reuse: Defective or damaged fabrics from the dyeing and finishing stages can be upcycled into smaller textile items or repurposed for accessories, crafts, or industrial uses such as insulation.

3. Environmental Impact of Silk Waste

The improper disposal of silk waste poses environmental risks. Landfilling or burning of silk waste leads to the release of greenhouse gases and pollutants, contributing to soil and air degradation. Moreover, chemical treatments during silk processing often result in hazardous by-products that can leach into water bodies, impacting aquatic ecosystems.

To mitigate these concerns, sustainable waste management strategies must be adopted, focusing on recycling, reusing, and repurposing silk waste in various industries.

4.Productive Utilization of Silk Waste:

Several innovative approaches have been developed to utilize silk waste effectively, transforming it from a liability into a resource.

4.1. Textile Industry

Silk Waste Yarn: Short fibers and reeling waste can be spun into silk waste yarn, used in various textile applications, including handloom fabrics and blended textiles.

Silk Noil Fabric: Noil, a by-product of throwing and weaving, is used to create rustic silk fabrics that are in demand for home furnishings and fashion.

4.2. Thermal Insulation Wear

Thermal Properties of Silk Waste: Silk waste fibers have been found to exhibit excellent thermal insulation properties. Due to the low thermal conductivity and natural crimp in silk fibers, they trap air, creating a layer of insulation. This characteristic makes silk waste an ideal material for thermal wear.

Silk Waste in Insulated Garments Silk noil and other waste fibers are increasingly being used in the production of thermal insulation wear, such as winter jackets, gloves, and outdoor gear. When incorporated into these garments, silk waste offers lightweight yet efficient insulation, comparable to other synthetic and natural fibers like wool and polyester.

Advantages of Silk Waste for Insulation:

Compared to traditional insulation materials, silk waste provides a sustainable and biodegradable alternative. It is hypoallergenic, breathable, and possesses moisture-wicking properties, making it highly suitable for use in outdoor clothing. Furthermore, silk waste's natural protein structure gives it a high resistance to temperature fluctuations, helping to regulate body heat in varying climates.

Current Research:

Recent studies have demonstrated that blending silk waste with other fibers, such as cotton or synthetic polymers, enhances the thermal resistance of the material, opening avenues for its use in high-performance thermal insulation gear. Research is ongoing to optimize the combination of silk with other eco-friendly fibers to create more durable and cost-effective insulated wear.

4.3. Cosmetics and Pharmaceuticals:

Sericin, a by-product of silk reeling, is a highly valued ingredient in the cosmetic industry for its moisturizing and antioxidant properties.

a. **Skin Care Products**: Sericin is used in creams, lotions, and serums to improve skin elasticity and hydration, helping to reduce wrinkles and fine lines. Sericin-based face masks provide anti-aging and skin-repair benefits.

b. Hair Care Products: Silk proteins are added to shampoos, conditioners, and hair serums to strengthen hair, reduce frizz, and enhance shine.

c. Soap and Body Wash: Sericin is used in luxury soaps and body washes for its skin-soothing properties and ability to lock in moisture.

4.4. Agriculture and Fertilizer Industry

Organic Fertilizers: Silk waste rich in nitrogen can be converted into organic fertilizers, enhancing soil fertility and crop yield. Studies show that silk waste compost improves plant growth and promotes sustainable agriculture.

Animal Feed: Dried silk pupae are a high-protein feed supplement for livestock, poultry, and fish. They offer a sustainable alternative to conventional animal feed, reducing feed costs for farmers.

Biocontrol Agents: Silk waste serves as a carrier for bio-pesticides, enabling the slow release of beneficial microorganisms to protect crops from pests.

4.5. Composites and Industrial Applications:

Bio-composites: Silk fibroin and other waste components can be incorporated into bio-composites for applications in automotive, aerospace, and construction industries. These eco-friendly materials offer strength, durability, and reduced carbon footprint compared to conventional composites.

Paper and Packaging: Waste silk fibers are used in producing specialty papers, packaging materials, and bioplastics, offering alternatives to synthetic products.

4.6 Applications in Medical Textiles

Sutures: Silk has been used for decades in sutures due to its high tensile strength and flexibility.

Wound healing: Silk-based scaffolds, dressings, and hydrogels are used to promote wound healing by providing a stable environment that supports tissue regeneration.

Tissue engineering: Silk fibers are used in the development of scaffolds for tissue regeneration, including skin, bone, cartilage, and ligament repair. The fibers provide mechanical support while cells grow and develop.

Vascular grafts: Due to its strength and elasticity, silk is studied for small-diameter vascular grafts, offering advantages over synthetic materials like polyethylene terephthalate (PET).

Drug delivery systems: Silk's ability to be chemically modified makes it suitable for use in controlled drug delivery systems, particularly for prolonged release of therapeutic agents.

4.7 Industrial and Technical Applications:

Silk waste is being increasingly used in high-tech industries due to its unique properties such as high tensile strength, thermal stability, and biocompatibility.

a. Filtration Systems: Silk non-woven fabrics are used as filters in water purification and air filtration systems. Their fine structure and natural absorbency make them suitable for removing contaminants.

b. Packaging Materials: Silk fibroin is processed into biodegradable packaging films, reducing plastic waste. These films are used in food packaging and pharmaceutical industries for eco-friendly alternatives to synthetic materials.

c. Acoustic and Thermal Insulation: Silk waste is used as an eco-friendly insulation material in construction for soundproofing and thermal insulation.

5. Challenges in Silk Waste Utilization

Despite the potential for productive use, several challenges hinder the widespread adoption of silk waste recycling:

Technological Barriers: Extracting valuable compounds like sericin and fibroin from silk waste is a complex and costly process requiring advanced technologies.

Market Awareness: Limited awareness of the applications of silk waste, especially in sectors outside textiles, slows its commercialization.

Standardization: Lack of standardized methods for silk waste processing affects the quality and uniformity of end products, posing a barrier to market acceptance.

6. Future Prospects:

To maximize the potential of silk waste utilization, there is a need for collaborative efforts among industry stakeholders, researchers, and policymakers.
Future research should focus on:

1.Developing cost-effective extraction methods for sericin and fibroin.

2.Expanding applications of silk waste in high-value sectors such as biomedical engineering, advanced materials, and thermal insulation wear.

3.Enhancing public and industry awareness of the environmental and economic benefits of silk waste utilization.

4. Implementing policy frameworks that encourage waste recycling and promote circular economy practices within the silk industry.

7. Conclusion:

Silk waste generation, while posing an environmental challenge, also presents an opportunity for resource recovery and value addition. Through innovative approaches in recycling and repurposing silk waste, industries can reduce their ecological footprint while opening new avenues for product development. The use of silk waste in thermal insulation wear demonstrates its versatility, offering a sustainable solution to meet the demand for eco-friendly, high-performance materials. The future of silk waste management lies in fostering cross-industry collaborations and advancing research into sustainable practices.

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