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Recycling of Waste Clothing: Opportunities for Resource Conservation and Value Creation

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Abstract — The fast expansion of the textile and garment sector has greatly increased waste clothing creation, causing major environmental and resource management concerns. Most wasted clothing are disposed of by landfilling or incineration, leading to resource depletion, pollution, and greenhouse gas emissions. Waste clothes recycling has emerged as an efficient approach for encouraging resource conservation and fostering a circular economy. This study discusses important recycling technologies, including mechanical, chemical, thermal, and biological processes, and their potential for transforming textile waste into value-added goods such as regenerated fibers, composites, insulating materials, geotextiles, and construction items.The study also addresses how new technologies, like as artificial intelligence and the Internet of Things, can enhance the effectiveness of textile collection, sorting, and recycling. Additionally, the economic and environmental advantages of recycling are emphasized, including less carbon emissions, decreased landfill waste, resource conservation, and job creation. There is also discussion of current issues such contamination, insufficient infrastructure, mixed-fiber separation, and policy constraints. The analysis comes to the conclusion that effective waste clothing recycling presents important chances for value development, sustainable resource management, and the shift to a circular textile economy.

Keywords— Textile waste, Circular economy, Resource conservation, Sustainable manufacturing, Value-added products

I. INTRODUCTION

The textile and apparel business is one of the greatest worldwide manufacturing sectors, but its rapid growth has resulted in a huge increase in waste clothing due to quick fashion, changing consumer tastes, and shorter garment life cycles. Globally, nearly 92 million tonnes of textile waste are generated annually, with only a small amount being reused or recycled [1]. Most discarded textiles are transferred to landfills or burnt, producing environmental degradation, greenhouse gas emissions, and the loss of important raw resources [2]. Recoverable fibers found in waste clothing, including cotton, polyester, wool, and nylon, can be recycled to create new goods. In addition to conserving energy and water and lowering the need for virgin materials, recycling promotes the circular economy's tenets of prolonging the useful life of materials [3]. Depending on the kind and quality of textile waste, major recycling technologies include mechanical, chemical, thermal, and biological processes, each of which has unique benefits [4].

Value-added items such regenerated fibers, nonwoven fabrics, polymer composites, automotive components, insulation materials, geotextiles, packaging products, and building materials are being made from recycled textiles [5]. Recent breakthroughs in Industry 4.0 technologies, including artificial intelligence, robots, IoT, blockchain, and digital product passports, have significantly increased textile sorting, traceability, and recycling efficiency [6].Despite these advancements, mixed-fiber clothing, contamination, high processing costs, a lack of infrastructure for collection, and insufficient policy support remain obstacles to large-scale textile recycling [7]. Therefore, attaining sustainable textile waste management requires ongoing technical innovation, sensible legislation, and more stakeholder participation. In order to enhance resource conservation and sustainable circular textile systems, this article examines waste clothing recycling methods, value-added applications, economic and environmental benefits, current issues, and future research potential.

Figure 1. Classification of Waste Clothing

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Post-consumer, pre-consumer, and industrial waste clothing are the three main categories into which the Classification of Waste Clothing diagram divides textile waste. Pre-consumer trash is produced during the production of textiles and clothing, while post-consumer waste comes from homes after clothing has reached the end of its useful life. Production flaws and excess materials are the sources of industrial waste. Natural, synthetic, and blended fibers make up these waste streams. These fibers can be gathered, processed, and recycled into products with added value, enabling a sustainable circular textile industry and encouraging resource conservation.

II. LITERATURE REVIEW

According to recent research, recycling used clothing has become a viable way to promote resource conservation and value generation while tackling the growing environmental issues related to textile waste. Together, the examined literature shows that the fast-fashion business model and the textile and apparel industries' explosive growth have greatly increased post-consumer textile waste globally. Researchers constantly stress that traditional disposal techniques like incineration and landfilling lead to increasing greenhouse gas emissions, environmental contamination, and the loss of important resources. As a result, recycling used apparel has emerged as a crucial part of circular economy tactics meant to prolong material life cycles and lessen reliance on virgin resources [1]–[20].

Several recycling techniques have been developed to recover valuable materials from discarded textiles, according to the literature. Chemical recycling has received a lot of attention for recovering high-quality fibers from synthetic textiles, but mechanical recycling is still the most popular method because of its ease of use and reduced operating costs. Significant potential for energy recovery and environmentally friendly material processing has also been shown by thermal and biological recycling techniques. Numerous research come to the conclusion that textile composition, pollution level, processing cost, and planned end-use application all influence the choice of an acceptable recycling technology [1]–[10].

Researchers further report that recycled textile materials can be successfully converted into numerous value-added products, including regenerated fibers, nonwoven fabrics, polymer composites, automotive interior components, thermal and acoustic insulation materials, geotextiles, packaging products, construction materials, furniture padding, and industrial filtration media. These uses lessen the environmental impact of textile production while simultaneously increasing material use and opening up new business prospects. Textile-to-textile recycling has received special attention in recent studies as a viable strategy for creating a closed-loop textile production system [3]–[15].

In order to enhance textile waste collection, classification, traceability, and recycling efficiency, a number of studies also address the integration of circular economy principles with cutting-edge technologies like artificial intelligence, automated sorting systems, robotics, blockchain, Internet of Things (IoT), and digital product passports. Reverse logistics are optimized, contamination is decreased, material recovery rates are increased, and sustainable supply chain management is made easier by these digital advancements. Over the next few decades, researchers predict that technical development will be crucial to the industrialization of textile recycling systems [1], [3], [8], [11], [14], and [15].

The literature notes a number of obstacles that still prevent the widespread adoption of waste textile recycling despite notable technological advancements. Major obstacles to effective recycling still include mixed-fiber clothing, complicated textile mixes, chemical finishes, dye pollution, poor collecting infrastructure, high processing costs, little consumer knowledge, and inadequate government backing. Furthermore, the shift to a sustainable circular textile economy is hampered by the lack of uniform recycling regulations and the scarcity of industrial-scale recycling facilities, especially in developing nations. To enhance resource recovery and sustainable textile waste management, researchers advise more robust policy frameworks, more producer responsibility, eco-design principles, investment in cutting-edge recycling technologies, and increased public involvement [2], [7]–[20].

Overall, the reviewed literature shows that recycling waste clothes reduces landfill trash, lowers carbon emissions, conserves natural resources, encourages sustainable manufacturing, and produces value-added products—all of which have significant positive effects on the environment, economy, and society. To create effective fiber separation technologies, boost recycling economics, increase material quality, and create integrated circular business models that can facilitate large-scale industrial deployment, more research is necessary. The combined results of these studies offer a solid basis for further investigation into value creation and sustainable waste clothes recycling in the context of a circular economy [1]–[20].

III. RECYCLING TECHNOLOGIES

In order to reduce environmental pollution and save natural resources, recycling methods are essential for turning used

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garments into reusable materials and value-added goods. The textile composition, fiber quality, degree of contamination, economic viability, and the planned final use all influence the choice of recycling process. Recent developments have greatly increased recycling efficiency by utilizing automation and creative processing methods. Mechanical, chemical, thermal, and biological recycling are the main methods used to recycle used apparel.

1. Mechanical Recycling

The most popular and well-established commercial technique for handling discarded clothing, especially textiles composed of natural fibers like cotton and wool, is mechanical recycling. Textile waste is gathered, sorted, cleaned, shredded, and opened into fibers without changing their chemical makeup. The recovered fibers are then used to make composite materials, yarns, nonwoven textiles, insulation, furniture cushioning, and car interiors.

There are a number of benefits to mechanical recycling, such as minimum usage of dangerous chemicals, low processing costs, and decreased energy consumption. It also considerably minimizes landfill trash and conserves virgin raw materials. However, repetitive mechanical processing limits the quality of recycled materials by shortening fiber length and decreasing mechanical strength. Notwithstanding these drawbacks, mechanical recycling continues to be the most cost-effective and eco-friendly method of managing huge amounts of textile waste.

2. Chemical Recycling

A cutting-edge method for recovering premium fibers from synthetic textiles like polyester, nylon, and mixed fabrics is chemical recycling. This technique uses solvents, catalysts, or hydrolysis processes to chemically depolymerize polymers into their original monomers. Fibers with qualities similar to those of virgin materials are created by purifying and repolymerizing the recovered monomers. Higher material recovery and better product quality are made possible by chemical recycling as opposed to mechanical recycling, especially for mixed-fiber textiles that are challenging to recycle mechanically. It greatly lessens reliance on raw materials derived from petroleum and promotes closed-loop textile recycling. However, chemical recycling is rather costly because it necessitates advanced machinery, a larger initial investment, and careful control of chemicals and process pollutants.

3. Thermal Recycling

Through regulated thermal processes like pyrolysis, gasification, and incineration, thermal recycling transforms non-recyclable textile waste into useful energy. The energy contained in textile materials is recovered during these procedures as heat, electricity, liquid fuels, or synthesis gas. For polluted, mixed, or low-quality textile waste that cannot be profitably recycled using mechanical or chemical procedures, thermal recycling is especially appropriate. Thermal recycling may produce greenhouse gases and other emissions if proper pollution-control measures are not used, even if it minimizes the need for landfills and recovers useful energy. As a result, once material recycling and reuse have been exhausted, it is typically regarded as the last recovery option.

4. Biological Recycling

Biodegradable textile fibers like cotton, wool, silk, and other natural materials are broken down by microorganisms, bacteria, fungi, and enzymes in biological recycling, a new and environmentally friendly technology. Textile waste can be biologically treated to create simpler compounds that can be recycled into compost, biofuels, bio-based chemicals, and other eco-friendly goods.

This method offers significant environmental advantages because it operates under relatively mild conditions, requires fewer hazardous chemicals, and produces lower carbon emissions than conventional recycling methods. However, due to slower processing rates, limited applicability to natural fibers, and relatively significant research and development needs, biological recycling is still in the early stages of development and has limited industrial-scale deployment.

5. Comparison of Recycling Technologies

Depending on the requirements of the product and the content of the textiles, each recycling process has specific benefits and drawbacks. For natural fibers, mechanical recycling is cost-effective, but it frequently lowers the quality of the fibers. Chemical recycling facilitates textile-to-textile recycling and yields high-quality regenerated fibers, but it necessitates higher investment and more advanced technology.

Although it only recovers a small amount of material, thermal recycling efficiently extracts energy from non-recyclable garbage. Although its commercial application is still in its infancy, biological recycling provides a sustainable substitute for biodegradable textiles. In order to maximize material recovery, reduce environmental impacts, and improve the production of high-value recycled textile products, future textile waste management is anticipated to integrate these recycling technologies with sophisticated sorting systems, artificial intelligence, robotics, and circular economy practices.

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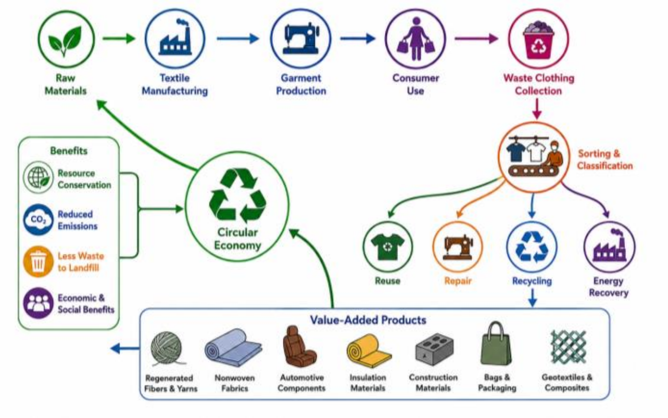

Figure 2. Global Waste Clothing Recycling Framework

The whole life cycle of textiles, from the extraction of raw materials and the production of clothing to consumer use, collection, sorting, recycling, and the creation of value-added goods, is depicted in the Global Waste Clothing Recycling Framework. It highlights the shift from a linear "take–make–dispose" approach to a circular economy, in which used clothing is recycled, recovered, and reused. Through effective material recovery and ongoing product life-cycle extension, this framework encourages resource conservation, decreases landfill waste, lessens environmental effects, and supports sustainable textile production.

IV. VALUE CREATION OPPORTUNITIES

Waste clothes recycling promotes resource conservation, environmental sustainability, and economic growth while providing substantial opportunity to turn waste textiles into high-value products. Recovered textile fibers can be used to make a variety of consumer, commercial, and industrial goods rather than disposing of discarded clothing as waste. This strategy promotes the concepts of the circular economy by extending material life cycles, reducing dependence on virgin resources, and limiting landfill dumping. Advances in recycling technologies have further increased the applications of recycled textiles across numerous industrial sectors.

1. Regenerated Textile Fibers
The creation of regenerated fibers for the production of new textiles is one of the most beneficial uses of recycled waste clothing. Recycled yarns and fabrics can be made from cotton, polyester, wool, and nylon recovered from used clothing while using less energy, water, and raw materials. In addition to promoting sustainable clothing manufacturing and lowering reliance on virgin fiber production, textile-to-textile recycling dramatically reduces environmental impacts.

2. Nonwoven Fabrics
Nonwoven fabrics are frequently made from recycled textile fibers using needle punching, thermal bonding, and chemical bonding techniques. These nonwoven materials are used in industrial wipes, agricultural covers, packaging materials, medical textiles, hygiene products, and filtering systems. They are appealing substitutes for traditional materials due to their low production cost, lightweight design, and recyclable nature.

3. Building and Construction Materials
In the building sector, waste textile fibers have drawn a lot of interest as sustainable reinforcing materials. Cement composites, concrete blocks, roofing materials, wall panels, insulation boards, and fiber-reinforced composites all contain recycled textiles. These solutions encourage the use of waste materials in green building applications while demonstrating enhanced thermal insulation, sound absorption, crack resistance, and less environmental effect.

4. Thermal and Acoustic Insulation
Both natural and synthetic textile fibers are good at absorbing sound and resisting heat, which makes them useful for insulation. The usage of recycled textile insulation materials in commercial buildings, industrial equipment, cold storage facilities, and residential buildings is growing. Textile-based insulation products are more environmentally friendly, lightweight, recyclable, and energy-efficient than traditional insulation materials.

5. Automotive Components
Recycled textile fibers are widely used in the automotive industry to make door panels, floor carpets, seat cushions, trunk liners, roof liners, dashboard insulation, and noise-cancelling parts. These uses lessen vehicle weight, enhance acoustic performance, and support environmentally friendly car manufacturing. As part of their environmental sustainability programs, a number of automakers have integrated recycled textile materials into the interiors of their vehicles.

6. Polymer and Fiber-Reinforced Composites
To create lightweight composite materials, recycled textile fibers are increasingly mixed with thermoplastic and thermosetting polymers. These composites have low production costs and exceptional mechanical strength, durability, and resistance to corrosion. They provide an eco-friendly substitute for traditional reinforcement materials and are extensively utilized in consumer goods, automotive, aerospace, marine, sports equipment, and packaging.

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7. Geotextiles and Agricultural Applications
Geotextiles for landscaping, road construction, drainage systems, soil stabilization, and erosion control are made from recycled textile materials. Biodegradable textile materials are used in agriculture as erosion-control blankets, mulch mats, crop protection covers, and fabrics that retain moisture. These treatments encourage sustainable farming methods, lessen environmental deterioration, and enhance soil quality.

8. Furniture and Home Furnishing Products
Upholstery textiles, beds, carpets, rugs, cushions, curtains, and decorative items are all made from leftover garment fibers. In addition to lowering waste production and encouraging sustainable interior products, recycled textile materials offer affordable substitutes for traditional filling materials.

9. Packaging and Industrial Products
Eco-friendly packaging materials, protective cushioning, filtering media, cleaning cloths, industrial wipes, and absorbent goods are increasingly using recycled textiles. They contribute to environmental sustainability by being appropriate substitutes for single-use plastic packaging and disposable industrial products because to their durability, flexibility, and recyclable nature.

10. Economic and Environmental Benefits
There are significant social, economic, and environmental advantages to turning used clothing into items with added value. Recycling lowers greenhouse gas emissions, conserves natural resources, minimizes landfill waste, and uses less water and energy than the manufacturing of virgin textiles. Along with encouraging sustainable entrepreneurship and industrial growth, it also generates job possibilities in the fields of gathering, sorting, processing, manufacturing, and product creation. Additionally, by increasing resource efficiency and prolonging product life cycles, value-added recycling advances the goals of the circular economy.

All things considered, the creation of creative value-added items from used clothing shows that discarded textiles are useful secondary resources rather than just waste. The significance of textile recycling in attaining sustainable manufacturing and resource conservation will be strengthened and economic prospects will be further expanded by ongoing developments in recycling technologies, material engineering, and circular business models.

V. COMPARATIVE ANALYSIS

In terms of processing techniques, product quality, environmental impact, economic viability, and industrial usefulness, waste clothes recycling systems vary greatly. Selecting a suitable recycling procedure depends on the type of textile waste, fiber composition, contamination level, processing cost, and the intended end product. Chemical recycling has drawn more attention for manufacturing high-quality regenerated fibers, but mechanical recycling is now the most popular method because of its ease of use and low operating costs. Biological recycling is an emerging sustainable alternative for biodegradable textiles, whereas thermal recycling is mostly used for energy recovery from non-recyclable textile waste.

The benefits of mechanical recycling include minimum chemical use, low energy consumption, and comparatively easy processing. Repeated mechanical treatment, however, shortens the fiber's length, reducing its mechanical qualities and making it less suitable for the creation of high-quality textiles. On the other hand, chemical recycling facilitates closed-loop textile-to-textile recycling and allows for the recovery of fibers with characteristics similar to virgin materials. However, this method necessitates advanced machinery, greater financial outlay, and cautious handling of chemical reactions.

For polluted or mixed textile waste that cannot be profitably recycled using other techniques, thermal recycling is especially appropriate. In addition to recovering valuable energy in the form of heat, electricity, or fuels, it successfully lowers landfill dumping. However, if appropriate emission-control measures are not put in place, it may produce greenhouse gas emissions and contribute very little to material recovery. Although it is still in its infancy, biological recycling offers environmentally friendly processing using enzymes and microorganisms with little use of chemicals. Its use is presently restricted to biodegradable natural fibers, and large-scale commercialization will require additional technological development.

Regenerated textile fibers, nonwoven fabrics, polymer composites, automotive components, thermal and acoustic insulation materials, geotextiles, packaging materials, construction products, furniture padding, and filtration media are just a few of the value-added products that can be produced from waste clothing beyond recycling technologies. These uses cut greenhouse gas emissions, encourage resource conservation, lessen reliance on virgin raw materials, and open up new business prospects. Artificial intelligence, robotics, the Internet of Things (IoT), and automated sorting systems are examples of Industry 4.0 technologies that are integrated to improve supply chain sustainability, material recovery, and recycling efficiency.

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Table 1. Comparative Analysis of Waste Clothing Recycling Technologies

Parameter	Mechanical Recycling	Chemical Recycling	Thermal Recycling	Biological Recycling
Principle	Physical shredding and fiber recovery	Depolymerization and regeneration of fibers	Energy recovery through combustion, pyrolysis, or gasification	Degradation using microorganisms and enzymes
Suitable Materials	Cotton, wool, polyester	Polyester, nylon, blended textiles	Mixed and contaminated textile waste	Natural fibers such as cotton, wool, and silk
Product Quality	Moderate	High (near-virgin quality)	Energy products	Bio-based products and compost
Material Recovery	Moderate	Very High	Low	Moderate
Energy Requirement	Low	High	High	Low
Chemical Requirement	Very Low	High	Low	Very Low
Capital Investment	Low	High	Moderate to High	Moderate
Environmental Impact	Low	Moderate	Higher due to emissions	Very Low
Commercial Maturity	Commercially established	Rapidly developing	Commercial	Emerging technology
Major Applications	Nonwovens, insulation, composites	Regenerated fibers and textiles	Electricity, heat, fuels	Biofuels, compost, bio-based chemicals

Table 2. Comparative Evaluation of Value Creation Opportunities

Value-Added Product	Resource Conservation	Economic Value	Commercial Potential	Sustainability
Regenerated Fibers	Very High	Very High	Excellent	Excellent
Nonwoven Fabrics	High	High	Excellent	High
Polymer Composites	High	High	High	High
Automotive Components	High	Very High	Excellent	High
Thermal Insulation	High	Moderate	High	Very High
Acoustic Insulation	High	Moderate	High	Very High
Construction Materials	High	High	High	High
Geotextiles	Moderate	Moderate	High	High
Packaging Materials	Moderate	Moderate	Moderate	High
Furniture and Upholstery	Moderate	High	High	Moderate

No single recycling process is appropriate for all types of textile waste, according to the comparison analysis. Chemical recycling provides better material recovery and product quality, but mechanical recycling is still the most cost-effective option for large-scale processing. While biological recycling offers a sustainable alternative for biodegradable materials, thermal recycling is suitable for non-recyclable textile waste. To optimize resource conservation, increase recycling efficiency, and boost value creation throughout the textile supply chain, future waste clothing management should incorporate a variety of recycling technologies with cutting-edge digital tools and circular economy concepts.

Challenges and Future Scope

Challenges

The establishment of a sustainable textile recycling ecosystem is still hampered by a number of technical, financial, and policy-related issues despite notable advances in waste clothing recycling technologies. The growing usage of mixed-fiber fabrics, including cotton-polyester blends, which are challenging to separate using traditional recycling techniques, is one of the main obstacles. The recycling process is made more difficult and the quality of recovered fibers is decreased by the presence of dyes, chemical finishes, coatings, zippers, buttons, and other accessories.

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The inadequate infrastructure for collection and sorting presents another significant obstacle. Textile waste is often combined with municipal solid waste in developing nations, leading to contamination and reduced recycling effectiveness. Automated sorting systems demand a significant capital investment, whereas manual sorting is labor-intensive, time-consuming, and frequently wrong. Additionally, there are less high-quality recyclable textile materials available due to the absence of regular waste segregation procedures.

The widespread use of recycling technologies is also hampered by economic considerations. Advanced recycling techniques, especially chemical recycling, are less economically feasible for small and medium-sized businesses due to their high energy consumption, costly equipment, and trained labor requirements. Additionally, the market competitiveness of recycled materials is frequently diminished by changes in the price of virgin textile fibers.

Another major obstacle is the constraints imposed by policy and regulations. Comprehensive laws supporting extended producer responsibility (EPR), circular economy principles, and textile waste management are lacking in many nations. The implementation of sustainable recycling methods is further slowed by inadequate financial incentives, insufficient public awareness, and poor cooperation between producers, recyclers, legislators, and consumers.

Attention must also be paid to environmental issues related to certain recycling systems. Thermal recycling can increase greenhouse gas emissions in the absence of efficient emission-control systems, while chemical recycling may entail dangerous solvents and produce secondary pollutants if improperly managed. Consequently, recycling methods that are ecologically friendly continue to be a top research goal.

VI. CONCLUSIONS

Rapid urbanization, population increase, and the expansion of the worldwide textile industry have made the growing generation of waste clothing a significant environmental and resource management concern. In addition to causing the loss of priceless textile resources, conventional disposal methods like landfilling and incineration also increase greenhouse gas emissions and environmental contamination. As a result, effective waste clothes recycling has become a viable strategy for supporting a circular economy, reducing waste production, and conserving natural resources.

This analysis looked at the main recycling technologies—mechanical, chemical, thermal, and biological—that are used to manage textile waste. While chemical recycling produces high-quality regenerated fibers appropriate for closed-loop textile manufacture, mechanical recycling continues to be the most economical and commercially viable method for handling substantial amounts of textile waste. While biological recycling is an eco-friendly option for biodegradable textiles, thermal recycling provides an efficient way to recover energy from non-recyclable textile waste. Each process has unique benefits and drawbacks, and the choice of technology is influenced by factors such as fiber composition, product quality standards, economic viability, and environmental concerns.

The study also identified a number of potential for value generation that arise from recycling waste apparel. Regenerated fibers, nonwoven fabrics, polymer composites, automotive parts, thermal and acoustic insulation, geotextiles, building materials, packaging, and furniture applications are all viable uses for recovered textile materials. In addition to lowering reliance on virgin raw materials, these value-added goods foster employment, new company prospects, and sustainable industrial growth.

Despite these developments, a number of obstacles still stand in the way of the widespread adoption of textile recycling, including mixed-fiber separation, contamination, poor infrastructure for collecting, high processing costs, low public awareness, and a lack of regulatory backing. Technological innovation, investments in cutting-edge recycling systems, standardized waste management procedures, and more cooperation between governments, businesses, researchers, and consumers are all necessary to address these issues.

The integration of Industry 4.0 technologies, including robotics, blockchain, Internet of Things (IoT), artificial intelligence, and automated sorting systems, will be crucial to future advancements in waste clothing recycling. These technologies assist intelligent circular supply chains and can greatly enhance material identification, resource recovery, traceability, and collection efficiency. Additionally, the shift to environmentally responsible textile production and waste management will be accelerated by the use of circular economy ideas, extended producer responsibility, eco-design techniques, and sustainable consumer behaviors.

In conclusion, discarded clothing should be viewed as a valuable secondary resource with substantial economic and environmental potential rather than as an environmental burden. Waste clothes recycling may play a critical role in attaining resource conservation, lowering environmental impacts, and promoting sustainable development by using cutting-edge recycling technology, creating creative value-added goods, and bolstering policy and industry support. The development of a robust and sustainable circular textile economy will be facilitated by ongoing research and industry cooperation, which will further improve recycling efficiency.

Future Scope

The creation of comprehensive, intelligent, and circular textile management systems is the key to the recycling of discarded clothes in the future. Textile collection, sorting, traceability, and recycling efficiency are predicted to be revolutionized by emerging technologies like artificial intelligence (AI), machine learning, robotics, hyperspectral imaging, blockchain, the Internet of Things (IoT), and digital product passports. Robotic sorting systems and automated fiber identification can greatly increase material recovery while cutting labor expenses and processing time.

In order to recover fibers from blended and contaminated textiles without sacrificing material quality, future research should concentrate on creating high-efficiency recycling systems. Environmental sustainability and commercial viability can be enhanced by advancements in green solvents, enzyme-assisted recycling, biodegradable compounds, and low-energy processing methods. To accomplish complete closed-loop material cycle, textile-to-textile recycling should also receive more attention.

All things considered, recycling used clothing has a bright future. Discarded textiles will become significant secondary resources thanks to ongoing technical progress, encouraging government policies, industrial cooperation, and improved consumer awareness. The realization of a worldwide circular textile economy, sustainable manufacturing, resource conservation, and environmental preservation will all be greatly aided by these developments.

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