

Recycling Waste Clothes for a Greener Future

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Abstract

The exponential development of fashion and textile industries around the world has largely increased the production of waste cloth, which has grown at a steep rate, presenting serious environmental issues in terms of landfill waste, greenhouse gas emissions, and waste depletion. Millions of tons of textiles are disposed of every year, and the recycling of waste cloth has become one of the critical solutions to a circular economy in the process of eliminating environmental degradation. This paper examines the recycling of waste fabrics as an efficient way of reducing waste textiles while promoting sustainable development. The main aim of the given research is to compare the possibility of recycling different types of textiles using mechanical, chemical depolymerization, and imaginative upcycling techniques, in terms of their feasibility, efficiency, and environmental advantages. The research is a mixed approach where literature review, experimental analysis, and case study of textile recycling industries have been used. The data is processed to determine material recovery, energy use, and carbon footprint impacts of each approach. The most critical results show that mechanical recycling can be used to recycle natural fibers, including cotton and wool, but chemical recycling can be used to recycle synthetic fibers, including polyester, and recover almost virgin-quality fibers. Despite being small-scale, upcycling practices have a great impact on local economies and social sustainability through job creation and promotion of eco-friendly consumer behavior. In general, the study shows that effective waste cloth recycling can significantly decrease landfill waste, save natural resources, and decrease the emission of CO₂. Textile recycling can be a transformative element in attaining a green, more sustainable future through the addition of recycling technologies, public awareness, and policy support. This paper explains why the implementation of circular textile systems should become the foundation of worldwide environmental sustainability and conscious consumption.

Keywords: Cloth waste reduction, green technology, resource conservation, sustainable fashion, upcycling

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INTRODUCTION

Waste and Environmental Impact Background

The global textile and fashion industry has been growing rapidly, which has led to a great surge in the production and consumption of textiles, thus causing a resulting increase in the production of textile waste. Millions of tons of used garments and fabric scraps are discarded every year, and much of this is in landfills or burned. The textile industry is among the most resource-intensive industries as it uses tremendous volumes of water, energy, and raw materials and discharges toxic chemicals and dyes into the environment. Non-biodegradable polyester and nylon synthetic fibers pollute in the long term as they remain in landfills for decades, releasing microplastics into the soil and water bodies. Further,

20% of the industrial water pollution worldwide is attributed to dyeing and finishing of textiles. The fast fashion culture, which encourages short product life cycles and overconsumption, also contributes to the burden on the environment. As a result, textile waste not only drains natural resources but also leads to a great contribution to greenhouse gas emissions and deterioration of the ecosystem (Figure 1). The need to reduce environmental impact and achieve a circular economy in the textile industry has consequently led to the necessity of addressing this specific issue through the implementation of sustainable waste management and recycling practices. Textile waste is any waste cloth, fabric scrap, or fibrous material that is not in use anymore or that has been rejected in the production, use of the product, or disposal of the product. It contains both pre-consumer waste (waste produced in the manufacturing and processing stage) and post-consumer waste (discarded clothes by households and retailers). As the worldwide population increases together with the shift in lifestyle patterns, textile waste has been at an alarming rate. An average of millions of tons of garments is discarded annually, most of which are discarded in landfills or burned. These practices introduce toxic chemicals, dyes, and microfibers to the soil, water, and air, which result in severe pollution and the degradation of the ecological condition in the long run. Artificial fibers like polyester and nylon require hundreds of years to decay, emitting greenhouse gases like methane during decomposition. The total environmental cost of textile waste is thus enormous, as it has a substantial contribution to climate change, water pollution, and loss of biodiversity.

The Contribution of the Fast Fashion Industry to the Generation of Waste

In recent decades, the fast fashion industry has become one of the main causes of textile waste (Figure 2). Fast fashion brands manufacture fashionable, low-priced products at a high rate to suit shifting consumer needs. Although this model makes fashion affordable and accessible to many, it also fosters overconsumption and a disposability culture. Customers are urged to purchase more clothes, use them less frequently, and change them with new designs frequently. Consequently, an enormous quantity of clothes is discarded much earlier than the date of their



Figure 1. Textile waste and its impact on the environment.



Figure 2. The role of the fast fashion industry in the generation of waste

utilization. In addition, the fast fashion industry tends to be based on inexpensive synthetic fabrics and high production speeds that use tremendous amounts of water, power, and chemicals. Low-quality fabrics, short product lifecycles, and low recycling efforts have contributed to the huge piles of waste in landfills. It is one of the greatest environmental challenges of our time, as it not only damages the environment but also abuses labor and wastes natural resources.

Significance of Textile Waste Recycling to be Sustainable

Recycling textile waste is crucial for creating a sustainable and environmentally friendly future. It decreases the amount of pressure on landfills, saves resources, and decreases the contamination of textile production. Reprocessing previously discarded clothes and fabrics into new materials or products will significantly reduce the demand for virgin resources such as cotton, water, and oil, which are used to produce synthetic fibers. Recycling further reduces carbon emissions and energy use compared to the production of new textiles. In addition, it helps the idea of a circular economy, wherein products undergo reuse, repair, and reuse instead of disposal. Sustainable textile recycling is beneficial to the environment and creates job opportunities in the collection, sorting, and processing industry. Prompting consumers to recycle, donate, or upcycle old clothes helps create a more responsible and conscious attitude toward fashion. Therefore, textile recycling is critical to the realization of a balance between economic development, environmental conservation, and social well-being.

The Purpose and Intention of the Study to Promote a Greener Future by Recycling Clothes

It is hoped that the proposed research will help find new and viable ways of recycling waste clothes to establish a greener and more sustainable future. The paper examines different methods of recycling, using mechanical and chemical methods and creative upcycling, and compares them based on environmental and economic advantages. It also seeks to understand the prevailing issue in the waste management of textiles and come up with effective measures to improve it. The breadth of this study will extend beyond the identification of sources of textile waste to the possible recycling of fabrics in the fashion and industrial industries. It focuses on awareness of the masses, policy formulation, and the use of technology in converting garbage into useful products. Finally, the study envisions making an impact on the issue of efficient recycling through adopting sustainable approaches to recycling to decrease pollution, save natural resources, and create a new fashion system that is eco-conscious and based on circularity to meet the global environmental objectives.

Problem Statement

The amount of discarded clothing has become a significant issue in the global environment, with millions of tons of discarded textile waste being deposited in landfills annually. With the increase in the production and use of clothes, the number of non-biodegradable synthetic fabrics that take hundreds of years to decompose is filling up these landfills. This continuous accumulation of waste in the textile industry not only occupies productive land space but also introduces dangerous chemicals, dyes, and microfibers into the soil, air, and water channels. Synthetic materials also release greenhouse gases, such as methane, when they decompose, harming groundwater and causing an imbalance in the ecosystem due to the release of toxic substances. Moreover, the manufacturing of new fabrics also uses enormous portions of natural resources, especially water, energy, and raw materials such as cotton and petroleum-based fibers, thus exacerbating the issue of resource depletion and environmental deterioration. Despite the urgency of the problem, the level of awareness towards textile recycling among the population is very low, as well as the absence of proper waste management systems in most areas. The lack of good collection, sorting, and recycling facilities results in an endless process of waste production and disposal. Consequently, the world is becoming increasingly ecologically stressed, which is why it is necessary to start working on the sustainable recycling of textile products and encourage people to be more concerned about the future and their role in promoting a more sustainable environment.

Objectives of the Study

- To study various methods of recycling waste clothes.
- To analyze the environmental and economic benefits of recycling.
- To promote sustainable fashion practices.
- To explore innovative technologies for textile reuse.

LITERATURE REVIEW

The rapid increase in the consumption of textiles and the control of fast fashion have greatly contributed to the rise in the production of waste in the textile sector, necessitating the recycling and reuse of textile waste to attain the objectives of sustainability and the circular economy. Recycling textile waste helps decrease the landfill load, as well as save resources, energy, and raw materials, and encourages green industry. The literature review presented below is a compilation of key works in reverse chronological order to reflect the current developments and directions that can be taken in researching how waste cloth can be recycled for a greener future. Biyada and Urbonavičius (2025) [1] examined the issues of circularity in managing textile waste and identified obstacles of complex materials, inefficiencies in collection processes, and recycling. Their analysis suggested technological innovation, alignment of policy, and better value-chain cooperation to be avenues of sustainable textile circularity. In a similar manner, Shamsuzzaman et al. (2025) [2] have given a systematic review of textile waste management in the context of the circular economy. The paper highlighted recovery methods like reuse, recycling, remanufacturing, and eco-design and highlighted policy, stakeholder cooperation, and consumer involvement as major implementation methods on a large scale. Tripathi et al. [3] reviewed the latest technologies that transform textile waste into value-added products, including composite materials, insulation, and bio-based chemicals. Their efforts prove that instead of being taken as waste, the textile material may be utilized to produce more sophisticated materials. Dissanayake and Weerasinghe (2021) [4] carried out a systematic review devoted to organizational issues, techniques, and problems of fabric waste recycling. They discovered mechanical, chemical, and thermal recycling methodologies, although they highlighted the sorting and fiber blending problems as significant constraints. Bengtsson et al. (2022) [5] investigated the chemical recycling of polyester-viscose mixtures using alkaline hydrolysis and elucidated the reaction mechanisms for recovering polyester to increase the effectiveness of blended textile recovery. Yesodharan et al. (2021) [6] investigated neutral hydrolysis to depolymerize polyester and nylon 6 in the co-processing systems, and the study showed that mixed synthetic fabrics could be recycled. According to Wang (2010) [7], previous studies have examined fiber and textile waste in terms of usage paths, including recycling, reuse, and energy

recovery, as the main sustainable ways to valorize textile waste. The chemical recycling of cotton fibers was studied by Schuch (2016) [8], and the results demonstrated that it was possible to produce regenerated cellulose of acceptable quality, which proved the prospects of cotton recycling. Lyocell-type recycling processes have become economically and environmentally efficient because Elsayed et al. (2020) [9] proved that ionic liquid solvents recycled in the process of regenerated cellulose production are economically viable and do not harm the environment. The study by Moriam et al. (2021) [10] took a repair step in developing regenerated cellulose fiber with better toughness, which improves textile performance on recycled cellulose. Ma et al. (2020) [11] exhibited wet-spinning regenerated fibers through different waste cellulose sources, demonstrating that textile waste cellulose can generate new fibers with competitive properties. Michud et al. (2016) [12] proposed a technology called Ioncell-F, which produces fibers based on ionic liquids as an alternative to viscose processes in a sustainable manner. A literature review of the thermochemical recycling of post-consumer textiles into fuels and biocarbon [13] by Athanasopoulos and Zabaniotou offers the opportunity to use pyrolysis and gasification in energy recovery systems. Miranda et al. (2007) [14] conducted research on textile waste pyrolysis and established that it can be used to produce oils, gases, and chars that can be used as fuels. Ruiz et al. (2023) [15] compared conventional and flash pyrolysis methods for textile biomass waste and found that the product yield was higher, and the energy prospects were promising. Ozsin and Putun (2022) [16] investigated the kinetics of pyrolysis and gas evolution during the decomposition of textile waste, which was used to optimize the design of a reactor. The study by Rittfors (2020) [17] employed pyrolysis and gasification of cotton and polyester wastes to substantiate that thermochemical recycling is a real option of waste management. Balcik-Canbolat et al. (2016) [18] investigated mixed-textile fibers pyrolysis, examining both gaseous and solid products as a source of energy. Yosef et al. (2021) [19] suggested functionalization of pyrolysis-derived char to be used as cement composite fillers, not only as fuels. As evidence of the enhanced environmental performance of synthetic textile waste conversion, Kwon et al. (2021) [20] demonstrated catalytic pyrolysis based on the use of CO₂ as a raw material. The study conducted by Yosef et al. (2021) [21] on the nature of pyrolysis lint microfibers in dryers found new uses of secondary textile wastes in recycling. Enzyme-based treatments were reviewed by Piribauer et al. (2021) [22] as promising solutions to fiber separation using enzymes as an environmentally friendly method. In a study by Ribul et al. (2021) [23], the researchers suggested the use of mechanical, chemical, and biological recycling paths to reach closed-loop bio-based textile recycling systems. Muratov and Kim (2002) [24] also investigated enzymatic hydrolysis in the supercritical CO₂ environment, revealing enhanced performance of fibers in terms of hydrolysis. Gritsch et al. (2023) [25] showed the enzymatic recovery of high-purity glucose and polyester on blended textiles and, therefore, opened a pair of closed-loop fabric recycling pathway. These socioeconomic benefits of textile recycling were reviewed by Leal Filho et al. (2019) [26], where employment, environmental benefits, and resource savings were identified. During the textile industry process, industrial membrane filtration technologies [27] have become increasingly popular in wastewater treatment and recycling processes, enhancing the efficiency of water reuse. In a study by Aluigi et al. (2009) [28], the authors used wool waste as the basis of their keratin-based nanofibers and utilized the nanofibers in the filtration process, which adds value to textile by-products. A review of nanofiltration membranes in dye wastewater treatment by Lau and Ismail (2009) [29] endorses sustainable textile recycling by purifying water used to recycle the textiles. Nguyen et al. (2021) [30] indicated the use of textile waste in the production of ropes that can be used in soil erosion control, which provides civil engineering reuse possibilities. In pursuing the possibility of environmental application of recycled textile materials, Hyvonen (2022) [31] examined cotton-polyester waste as a soil application, which offered potential prospects for the application of the material in various environmental settings. Broda et al. (2016) [32] created geotextiles using recycled fibers to be used in the reinforcement of highways. Zornberg (2017) [33] summarized the use of geosynthetics in the construction of roadways, where recycled textiles can be used in reinforcement and drainage systems. Lastly, Ghosh et al. (2014) [34] showed that woven jute can be used as a geotextile in geotechnical applications, indicating that natural fibers can be recycled in the construction sector. It is evident in the literature that textile waste recycling technologies have now been extended to mechanical recycling, chemical depolymerization, enzymatic treatment, thermochemical conversion, fiber regeneration,

filtration material, and civil engineering. Nevertheless, fiber separation, blended material recycling, process economics, and scalable infrastructure are still considered to be major challenges. To achieve a green textile future, future studies should incorporate the model of the circular economy, new separation technologies, and development of value-added products.

METHODOLOGY

By recycling textiles, the initial action is to ensure that waste cloths of all kinds are collected systematically, including those from households, garment factories, tailoring units, retail stores, and textile industries. Old curtains, beddings, and garments that are not currently used constitute post-consumer waste found in household collections. Industrial sources, in their turn, produce pre-consumer waste in terms of fabric trimmings, rejected materials, and unsold products. Waste samples were collected from urban and semi-urban locations, where the consumption of textiles is very high, to enable representativeness. The experience can include local recycling agencies, collections, and partnerships with municipalities and clothing stores. Good records are kept of the quantity, type, and condition of the fabrics collected to facilitate their analysis. This step is crucial because it forms the foundation on which recycling methods can be considered, and it is also possible to estimate the scale of the textile waste produced within a given area (Figure 3). Timely collection is not only a measure to guarantee a constant stream of recyclable waste but also to promote the involvement of the community or raise awareness about the necessity of separating textile waste.

Subsequently, the waste textiles are sorted by fabric type and quality and the possibilities of reuse. Recycling is important because various fibers (natural and synthetic) have different recycling methods. Examples of materials that can be biodegraded and recycled using mechanical or chemical methods to produce cellulose fibers include cotton, whereas polyester and nylon can be more effectively reused through depolymerization or thermochemical processes. Protein-based fibers, such as wool and silk, require special treatment to preserve their structure. Sorting can also be done manually by trained personnel who visually determine fabrics by feel, color, and weave. However, sophisticated facilities can employ automated methods, including near-infrared (NIR) scanning.



Figure 3. Working methodology.

spectral analysis to perform sorting more rapidly and with increased accuracy. Sorting is also a process of purification of materials by eliminating contaminants such as zippers, buttons, elastics, and labels. This action is critical in defining whether the recycling process is effective and good, as mixed or low-quality sorting of fabrics may result in the loss of fiber quality, high processing expenses, and poor value of the final product.

The sorted fabrics are then recycled using different methods, which vary according to their composition and final application. Shredding is the mechanical recycling of textiles, in which textiles are cut and torn into smaller strands that can be recycled into new yarn, used as stuffing, insulation, or as an industrial cleaning agent. It is best suited for natural fibers such as cotton and wool. Chemical recycling, however, is used to recycle synthetic materials such as polyester and nylon by hydrolyzing, glycolyzing, or depolymerizing them into their monomeric components. The recovered monomers can then be purified and re-polymerized into new fibers, thus saving virgin raw materials. Upcycling is a creative and sustainable method in which formerly worn clothes or fabric scraps are recycled into a more valuable product, in the form of fashion accessories, home decor, or artwork, instead of being torn down into bare fibers. These techniques have their own environmental and economic benefits that can be used to maximize waste recovery and reduce the ecological footprint of textile production. The method used is determined by the type of fabric, availability of technology, and quality of the product required.

The last part of the methodology is the analysis of data that has been gathered on the recycling operations to evaluate their effect on the environment and economy. The key performance indicators like energy saved, reduction of greenhouse gas emissions, and cost efficiency are measured and compared with the traditional methods of production of textiles. To give an example, recycling cotton or polyester uses a lot less energy and water compared to the process of producing new fibers from raw materials. The analysis of emissions can be used to define the amount of carbon dioxide or methane prevented from entering the atmosphere because of less landfill disposal and less dependence on the necessity of extracting virgin material. Cost evaluation involves such factors as collection, processing, labor, and transportation, against possible profits in the recycled products. Qualitative observations usually support quantitative data, including community involvement, consumer behavior, and technological efficiency. The analysis presents scientific information on the viability and sustainability of textile recycling projects. It also shows loopholes and further improvements, and finally, paves the way to the notion that waste cloth recycling is not only clean but also profitable in the future of a greener and more circular world.

TYPES OF CLOTH RECYCLING

Recycling: Recycling of Old Cloths to Make New Yarns

The most predominant and simplest recycling technique in textile waste management is mechanical recycling, which uses the physical processing of discarded fabric to extract fibers for reuse. Under this process, used clothes and scraps of cloth are sorted by first determining the type of fiber and color of the garments. The chosen fabrics are subsequently shredded, carded, and re-spun into new yarns without the use of complex chemicals. It is particularly appropriate for natural fibers such as cotton, wool, and denim, and even some blends, which can undergo mechanical processing (Figure 4). A significant benefit of mechanical recycling is that it lowers virgin fiber production, which conserves water, energy, and agricultural resources. Nevertheless, there are also disadvantages, such as recycled fibers tend to be shorter and weaker than original ones, and this may influence the quality and durability of the end product textile. To overcome this, recycled fibers are sometimes mixed with virgin fibers to enhance their strength and texture. Nevertheless, mechanical recycling is a significant element of the circular textile economy that allows the efficient use of waste fabrics and contributes to a significant decrease in the negative environmental impact of textile manufacturing.

Recycling Chemicals: Recycling Synthetic Fibers into Usable Raw Material

Chemical recycling employs high-technology chemical reactions to decompose synthetic fibers, such as polyester, nylon, and acrylic, into their starting monomers or other reusable raw materials (Figure 5).

Using this technique, it is possible to recover the pure components of chemicals that may be re-polymerized to form new high-quality fibers without reducing the quality of their performance. Hydrolysis, glycolysis, methanolysis, and depolymerization are processes that are usually involved in separating polymer chains and dissolving dyes and impurities. Researchers have found that polyester blends are reusable, as demonstrated by Bengtsson et al. (2022) and Yesodharan et al. (2021), who demonstrated the ability of chemical recycling to convert blends into reusable materials and provide a sustainable alternative to petroleum-based virgin fibers. This process is especially helpful because it can deal with complicated blended textiles that are difficult to work with using mechanical processing. Even though chemical recycling requires high attention to solvents, energy, and emissions, modern inventions such as enzyme-assisted depolymerization and closed-loop solvent systems are turning it into a friendlier process for the environment and business. This will not only reduce textile waste but also lead to the goal of achieving zero-waste production and the vision of the fashion industry being circular.



Figure 4. Mechanical recycling process of old clothes to make new yarns.

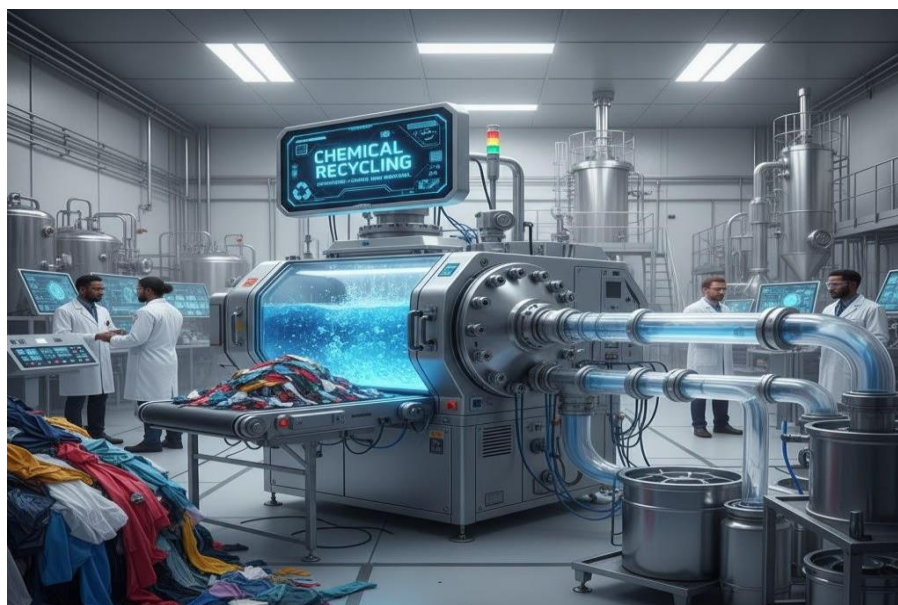


Figure 5. Recycling process of synthetic fibers into usable raw material.

Creative Upcycling: New Clothes and Household Goods Made of Old Ones

Creative upcycling is a sustainable and artistic method of recycling textiles, where used clothing and fabric scraps are reused and remade into new and more valuable products without dismantling them into raw materials. In contrast to conventional recycling, upcycling is more about design and making, as waste cloths are turned into stylish garments, handbags, ornaments, interior decorations, or even art pieces (Figure 6). This is done through cutting, sewing, drying, and merging various types of fabrics to produce distinctive and beautiful products that possess environmental and cultural value. The upcycling of creative items contributes not only to a decrease in the number of garments sent to landfills but also to recyclable fashion, as product life is prolonged. It allows designers and local craftsmen to work beyond ordinary production and provoke consumer consciousness regarding slow fashion and conscious consumption. In addition, upcycling has economic and social advantages, such as local businesses, entrepreneurs, and community-based recycling programs. Located on the border between environmental responsibility and artistic expression, creative upcycling helps fill the gap between the needs of the environment and the needs of artists; thus, it can be viewed as one of the most effective instruments in the process of achieving a greener and more ethical fashion ecosystem.

Industrial Application: Transforming Waste Textiles into Insulators, Carpets, or Cleaning Rags

Another important use of recycled textiles is industrial recycling, where waste fabrics are refurbished to form useful products such as thermal and acoustic insulation, geotextiles, rugs, wipers, and pad materials. This form of recycling aims to reuse textile waste that cannot be directly converted into the production of garments because it is mixed, contaminated, or its fibers have been destroyed. Recycling in industries is usually performed using mechanical means, such as shredding, compressing, and felting, to transform waste into dense and durable resources. For example, recycled cotton or polyester fibers are utilized as insulation for buildings and cars, and the waste of wool and jute is used as carpet underlays and soundproofing materials. Such a strategy not only eliminates huge amounts of waste in landfills but also lowers the use of synthetic insulation among other non-renewable resources. Moreover, industrial reuse would help develop a low-cost, energy-efficient substitute to produce secondary products, which would be in line with sustainability objectives. By using textile waste as part of the industrial process, the recycling industry establishes a connection between the fashion, construction, and manufacturing sectors to create a more circular and highly resource-efficient economy.



Figure 6. Creative upcycling of new clothes and household goods made of old ones.

OBSERVATION AND DISCUSSION

Benefits of Cloth Recycling

- *Less garbage and pollution in landfills:* Saving waste clothes would reduce the increasing volume of textile waste in landfills, which usually causes the emission of harmful chemicals and greenhouse gases during decomposition. Through recycling and reusing fabrics and converting worn-out clothes, we minimize a significant amount of pollution of soil, air, and water, thereby establishing a cleaner and healthier environment.
- *Water and energy conservation:* The textile sector uses enormous quantities of water and energy during the process of producing fibers and dyeing them. The recycling of fabrics will decrease the production of virgin material, save natural resources, and minimize industrial energy consumption and water wastage.
- *Recycling and sustainable fashion development:* The process of cloth recycling provides new workplaces in fields such as waste collection, sorting, processing, and upcycling design. The emergence of sustainable fashion companies and recycling centers helps in the local development of the economy and the creation of green jobs.
- *Marketing of environmentally conscious consumerism:* Recycling textiles promotes responsible consumption by encouraging people to donate, repair, or recycle their old clothes. It creates awareness of sustainable fashion options and suggests long-term, eco-friendly lifestyles.

Challenges and Limitations

- *Inadequacy of recycling facilities:* Most areas have poor collection systems, recycling facilities, and advanced machines to process textiles, which hinders large-scale recycling.
- *Hardly separable mixed types of fabrics:* Mixed fabrics of natural and synthetic fibers are difficult to recycle because they require sophisticated technology to segregate and work effectively.
- *Inadequate citizen interest and knowledge:* A large part of the population does not know what recycling textiles can bring them, or they do not have the means of proper disposal, which results in the further development of waste.
- *There are high processing costs of some materials:* the use of synthetic fibers and chemically treated textiles may not be economical in terms of energy, and the treatment procedures involved could be costly to recycle.

Solutions and Recommendations

- *Innovation of new recycling technologies:* Recycling can be made more effective and less expensive with investments in new techniques, such as chemical depolymerization and automated fiber sorting.
- *Incentives provided by the government to recycle textiles:* Industries could be encouraged to use recycling and the circular economy by providing subsidies, tax advantages, and policy aid.
- *Sensitization on the use of sustainable clothes:* Through educational campaigns, social media campaigns, and neighborhood efforts, consumers can be persuaded to wear green and minimize wastage.
- *Partnerships between brands, non-governmental organizations, and consumers:* Collaborations among fashion companies, environmental agencies, and customers can create an effective network to promote the reuse of textiles and sustainable manufacturing.

Table 1 shows an integrated framework that highlights how traditional recycling techniques (e.g., reuse, upcycling, and mechanical recycling) lay the foundation for sustainability, while emerging technologies (AI, biotechnology, blockchain, and circular processes) drive the next generation of smart, efficient, and traceable textile recycling systems. The convergence of digital innovation and green material science marks the path toward a fully circular textile economy, reducing global textile waste and carbon footprints.

Table 1. Comparative overview of traditional and emerging cloth recycling methods.

Type/method	Description/process	Significance/advantages	Limitations/challenges	Applications/future prospects
Reusing/donation	Direct reuse or redistribution of wearable garments through charities, thrift stores, and second-hand markets.	Extends garment lifespan; reduces waste; supports low-income communities.	Dependent on garment condition and fashion relevance; hygiene and sorting concerns.	Second-hand retail, relief programs, social welfare initiatives.
Upcycling / creative reuse	Converting old fabrics into higher-value items like bags, quilts, or accessories.	Promotes creativity, sustainability, and small-scale entrepreneurship.	Labor-intensive; not suitable for large-scale processing.	Eco-fashion products, household décor, artisan crafts.
Downcycling	Converting textiles into lower-grade materials such as rags or insulation.	Reduces landfill waste; simple and cost-effective.	Loss of fiber quality; limited lifecycle.	Cleaning rags, carpets, soundproofing, padding.
Mechanical recycling	Shredding fabrics to produce new fibers or nonwoven materials.	Saves energy and resources compared to virgin fiber production.	Degraded fiber quality; sorting and contamination issues.	Automotive interiors, industrial felt, nonwoven textiles.
Chemical recycling	Breaking down polymers into monomers for	Enables high-quality recovery and recycling of blended fabrics.	High setup cost; complex process	Production of regenerated polyester,

CONCLUSION AND FUTURE SCOPE

In summary, recycling waste clothes is crucial for mitigating environmental pollution, resource conservation, and sustainable development. The results highlight that the application of circular fashion, where materials are reused and regenerated into circular forms, could help significantly decrease the ecological footprint of the textile sector. Through recycling technologies, government assistance, and consumer education, individuals and industries can help create a greener and more sustainable future.

The recycling of waste clothing is a crucial step in realizing a sustainable and greener future. By diverting textiles from landfills, conserving natural resources, and reducing greenhouse gas emissions, clothing recycling not only minimizes environmental harm but also encourages a circular economy. Reusing, processing, and redirecting post-usage textiles from homes into new attire, industrial products, and domestic products exemplifies the beneficial aspects of current waste innovation. Moreover, innovative community engagement, corporate responsibility, and governmental influence all play key roles in developing a strong textile recycling mechanism. Consequently, recycling waste clothes for alternative purposes encourages environmental stewardship, economic efficiency, and social responsiveness, which are critical elements of contemporary sustainability efforts.

The prospects are encouraging, with high potential for waste cloth recycling. This is made possible by material evolution, artificial intelligence, and circular business models. Next-generation technologies, including automated sorting using AI and microbiome sorting, can improve efficiency and scalability. The development of environmentally friendly fibers and chemical recycling enables large-scale recovery from fabric mixtures. Creating on-site depots, spurring designer-led recycling, or implementing the use of blockchain can further revolutionize the field. Increased awareness and favorable policies could motivate industries and consumers towards environmentally friendly production and end-user practices, presenting a vast prospect for textile recycling research and development to move society closer to meeting its environmental aspirations and achieving a wholly sustainable green economy.

REFERENCES

1. Biyada S, Urbonavičius J. Circularity in textile waste: Challenges and pathways to sustainability. *Clean Eng Technol.* 2025;24:100905. doi:10.1016/j.clet.2025.100905.

2. Shamsuzzaman M, Islam M, Mamun MAA, Rayyaan R, Sowrov K, Islam S, et al. Fashion and textile waste management in the circular economy: A systematic review. *Clean Waste Syst.* 2025;11:100268. doi:10.1016/j.clwas.2025.100268.
3. Tripathi M, Sharma M, Bala S, Thakur VK, Singh A, Dashora K, et al. Recent technologies for transforming textile waste into value-added products: A review. *Curr Res Biotechnol.* 2024;7:100225. doi:10.1016/j.crbiot.2024.100225.
4. Dissanayake DGK, Weerasinghe D. Fabric waste recycling: a systematic review of methods, applications, and challenges. *Mater Circ Econ.* 2021;3(1):24. doi:10.1007/s42824-021-00042-2.
5. Bengtsson J, Peterson A, Idström A, de la Motte H, Jedvert K. Chemical recycling of a textile blend from polyester and viscose. Part II: Mechanism and reactivity during alkaline hydrolysis of textile polyester. *Sustainability (Basel).* 2022;14:6911. doi:10.3390/su14116911.
6. Yesodharan AT, Braun FIA. Depolymerization of polyester and nylon 6 in a co-process using neutral hydrolysis [thesis]. Aalborg: Aalborg University; 2021.
7. Wang Y. Fiber and textile waste utilization. *Waste Biomass Valor.* 2010;1:135-143. doi:10.1007/s12649-009-9005-y.
8. Schuch AB. The chemical recycle of cotton. *Rev Prod Desenvolv.* 2016;2:64-76. doi:10.32358/rpd.2016.v2.155.
9. Elsayed S, Hellsten S, Guizani C, Witos J, Rissanen M, Rantamäki AH, Varis P, Wiedmer SK, Sixta H. Recycling of superbase-based ionic liquid solvents for the production of textile-grade regenerated cellulose fibers in the Lyocell process. *ACS Sustainable Chem Eng.* 2020;8(37):14217-14227. doi:10.1021/acssuschemeng.0c05330.
10. Moriam K, Sawada D, Nieminen K, Hummel M, Ma Y, Rissanen M, et al. Towards regenerated cellulose fibers with high toughness. *Cellulose.* 2021;28:9547-9566. doi:10.1007/s10570-021-04134-9.
11. Ma Y, Nasri-Nasrabadi B, You X, Wang X, Rainey TJ, Byrne N. Regenerated cellulose fibers wet-spun from different waste cellulose types. *J Nat Fibers.* 2021;18(12):2338-2350. doi:10.1080/15440478.2020.1726244.
12. Michud A, Tanttu M, Asaadi S, Ma Y, Netti E, Kääriäinen P, et al. Ioncell-F: Ionic liquid-based cellulosic textile fibers as an alternative to viscose and Lyocell. *Text Res J.* 2016;86:543-552. doi:10.1177/0040517515591774.
13. Athanasopoulos P, Zabaniotou A. Post-consumer textile thermochemical recycling to fuels and biocarbon: A critical review. *Sci Total Environ.* 2022;834:155387. doi:10.1016/j.scitotenv.2022.155387. PMID:35461931.
14. Miranda R, Sosa-Blanco C, Bustos-Martínez D, Vasile C. Pyrolysis of textile wastes. *J Anal Appl Pyrolysis.* 2007;80:489-495. doi:10.1016/j.jaap.2007.03.008.
15. Ruiz B, Fuente E, Pérez A, Taboada-Ruiz L, Sanz JM, Calvo LF, et al. Employment of conventional and flash pyrolysis for biomass wastes from the textile industry with sustainable prospects. *J Anal Appl Pyrolysis.* 2023;169:105864. doi:10.1016/j.jaap.2023.105864.
16. Özsın G, Pütün AE. An investigation on pyrolysis of textile wastes: kinetics, thermodynamics, in-situ monitoring of evolved gasses and analysis of the char residue. *J Environ Chem Eng.* 2022;10(3):107748. doi:10.1016/j.jece.2022.107748.
17. Rittfors J. Thermochemical textile recycling: investigation of pyrolysis and gasification of cotton and polyester [master's thesis]. Gothenburg (Sweden): Chalmers University of Technology; 2020.
18. Balcik-Canbolat C, Ozbey B, Dizge N, Keskinler B. Pyrolysis of commingled waste textile fibers in a batch reactor: analysis of the pyrolysis gases and solid product. *Int J Green Energy.* 2017;14(3):289-294. doi:10.1080/15435075.2016.1255634.
19. Yousef S, Kalpokaitė-Dičkuvienė R, Baltušnikas A, Pitak I, Lukošiušė SI. A new strategy for functionalization of char derived from pyrolysis of textile waste and its application as hybrid fillers (CNTs/char and graphene/char) in cement industry. *J Clean Prod.* 2021;314:128058. doi:10.1016/j.jclepro.2021.128058.
20. Kwon D, Yi S, Jung S, Kwon EE. Valorization of synthetic textile waste using CO₂ as a raw material in the catalytic pyrolysis process. *Environ Pollut.* 2021;268:115916. doi:10.1016/j.envpol.2020.115916. PMID:33126030.

21. Yousef S, Eimontas J, Striūgas N, Mohamed A, Abdelnaby MA. Morphology, compositions, thermal behavior and kinetics of pyrolysis of lint-microfibers generated from clothes dryer. *J Anal Appl Pyrolysis*. 2021;155:105037. doi:10.1016/j.jaap.2021.105037.
22. Piribauer B, Bartl A, Ipsmiller W. Enzymatic textile recycling - best practices and outlook. *Waste Manag Res*. 2021 Oct;39(10):1277-1290. doi: 10.1177/0734242X211029167. Epub 2021 Jul 9. PMID: 34238113.
23. Ribul M, Lanot A, Tommencioni Pisapia C, Purnell P, McQueen-Mason SJ, Baurley S. Mechanical, chemical, biological: Moving towards closed-loop bio-based recycling in a circular economy of sustainable textiles. *J Clean Prod*. 2021;326:129325. doi:10.1016/j.jclepro.2021.129325.
24. Muratov G, Kim C. Enzymatic hydrolysis of cotton fibers in supercritical CO₂. *Biotechnol Bioprocess Eng*. 2002;7:85-88. doi:10.1007/BF02935884.
25. Gritsch SM, Mihalyi S, Bartl A, Ipsmiller W, Jenull-Halver U, Putz RF, et al. Closing the cycle: Enzymatic recovery of high purity glucose and polyester from textile blends. *Resour Conserv Recycl*. 2023;188:106701. doi:10.1016/j.resconrec.2022.106701.
26. Leal Filho W, Ellams D, Han S, Tyler D, Boiten VJ, Paço A, et al. A review of the socio-economic advantages of textile recycling. *J Clean Prod*. 2019;218:10-20. doi:10.1016/j.jclepro.2019.01.210.
27. Lau WJ, Ismail AF. Polymeric nanofiltration membranes for textile dye wastewater treatment: preparation, performance evaluation, transport modelling, and fouling control—a review. *Desalination*. 2009;245(1-3):321-348. doi:10.1016/j.desal.2007.12.058.
28. Aluigi A, Vineis C, Tonin C, Tonetti C, Varesano A, Mazzuchetti G. Wool keratin-based nanofibres for active filtration of air and water. *J Biobased Mater Bioenergy*. 2009;3:311-319. doi:10.1166/jbmb.2009.1039.
29. Juanga-Labayen JP, Labayen IV, Yuan Q. A review on textile recycling practices and challenges. *Textiles*. 2022;2(1):174-188. doi:10.3390/textiles2010010.
30. Nguyen G, Grzybowska-Pietras J, Broda J. Application of innovative ropes from textile waste as an anti-erosion measure. *Materials (Basel)*. 2021;14:1179. doi:10.3390/ma14051179. PMID:33802306.
31. Mann GS, Singh LP, Kumar P, Singh S. Green composites: A review of processing technologies and recent applications. *J Thermoplast Compos Mater*. 2020;33(8):1145-1171. doi:10.1177/0892705718816354
32. Broda J, Gawłowski A, Rom M, Laszczak R, Mitka A. Innovative geotextiles for reinforcement of roadside ditch. *Tekstilec*. 2016;59:115-120. doi:10.14502/Tekstilec2016.59.115-120.
33. Zornberg JG. Functions and applications of geosynthetics in roadways. *Procedia Eng*. 2017;189:298-306. doi:10.1016/j.proeng.2017.05.048.
34. Ghosh SK, Bhattacharyya R, Mondal MM, Choudhury PK, Sanyal T. Design and development of woven jute geotextiles for potential applications in the field of geotechnical constructions. *J Text Inst*. 2015;106:550-563. doi:10.1080/00405000.2014.929272.