

## Recycled cotton on the market: A review

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Review\*\*

*The continuous growth of population, consumer standard and fashion trends are causing the increasing need for textiles. Global textile fibres production in 2021 amounted to 113 million tons, by 2030 an increase is assessed to 134 million tons, with natural fibres share of about 22.5% in 2021. Also, expenses of textile raw materials represent a major cost for the textile industry. In recent years, the prices of textile fibres have been increasing rapidly. Cotton is the most important natural fibre, but its production is increasing very slow as it is limited with agricultural areas and yield per hectare. Its global crop in the 2020/2021 season was 24.47 million tons, that is 21.7% of global textile fibres production in 2021. Cotton is an indispensable fibre for clothing (especially underwear) and interior textiles (bed linen, towels). Cotton clothes are breathable, absorb sweat and keep you cool in a hot environment. Cotton fibre biggest advantage over synthetic fibres is its biodegradability. Because of the fast fashion cycles, fashion became a disposable fashion and due to the shorter life cycles of textiles the amount of textile waste is increasing rapidly. Cotton is one of the most common raw materials, as a result of which a significant amount of cotton textile waste is produced. Recycled cotton is mainly produced today by recycling pre-consumer wastes (unsold and damaged products), and very little from production wastes (fibres, yarns, cloth scraps, fabrics cut-offs and roll ends) or post-consumer wastes like used clothes and interior textiles that are discarded because they are worn and damaged. The article provides an overview of modern strategies for recycling cotton waste into products with added value and the current offer of recycled cotton textiles for apparel and interior decoration.*

**Keywords:** sustainability; textile recycling; quality assessment; textile waste; fast fashion.

Pregledni rad\*\*

Kontinuirani rast stanovništva, standard potrošača i modni trendovi uzrokuju sve veću potrebu za tekstilom. Globalna proizvodnja tekstilnih vlakana u 2021. iznosila je 113 milijuna tona, a do 2030. se procjenjuje porast na 134 milijuna tona, s udjelom prirodnih vlakana od oko 22,5% u 2021. Također, troškovi tekstilnih sirovina predstavljaju velik trošak za tekstilnu industriju. Posljednjih godina cijene tekstilnih vlakana brzo rastu. Pamuk je najvažnije prirodno vlakno, ali njegova proizvodnja raste vrlo sporo jer je ograničena poljoprivrednim površinama i prinosom po hektaru. Njegov globalni urod u sezoni 2020./2021. iznosio je 24,47 milijuna tona, što je 21,7% globalne proizvodnje tekstilnih vlakana u 2021. Pamuk je nezamjenjivo vlakno za odjeću (posebno donje rublje) i tekstil za interijere (posteljina, ručnici). Pamučna odjeća je prozračna, upija znoj i hladi u vrućem okruženju. Najveća prednost pamučnih vlakana u odnosu na sintetska je njihova biorazgradivost. Zbog brze mode odjeća je postala jednokratna, pa kraći životni ciklus tekstila doprinosi porastu količine tekstilnog otpada. Budući da je pamuk jedna od najčešćih sirovina, proizvodi se značajna količina otpada od pamučnog tekstila. Reciklirani pamuk danas se uglavnom proizvodi recikliranjem otpada prije potrošnje (neprodani i oštećeni proizvodi), a vrlo malo od proizvodnog otpada (vlakna, pređa, ostaci tkanine, odrezaci tkanine i krajevi rola) ili otpada nakon potrošnje poput rabljene odjeće i tekstila za unutarnje uređenje koji se odbacuje jer je istrošen i oštećen. Rad donosi pregled modernih strategija za recikliranje pamučnog otpada u proizvode s dodanom vrijednošću i trenutnu ponudu recikliranog pamučnog tekstila za odjeću i unutarnje uređenje.

**Ključne riječi:** održivost; recikliranje tekstila; procjena kvalitete; tekstilni otpad; brza moda.

## 1. Introduction

The global demand and consumption of textile products are constantly increasing due to population growth, economic development, and ultra-fast fashion. For this reasons, large amounts of textile waste are generated, most of which is disposed of and that is why the textile industry faces enormous environmental and resource challenges [1]. Among all consumption sectors in the European Union (EU), the consumption of clothing, footwear, and household textiles is the fourth largest consumer of primary raw materials and water [2]. The production of textiles requires large amounts of energy, water, and chemicals; in addition, distribution and retailing cause transport emissions and packaging waste [3]. For this reason, the new Circular Economy Action Plan recognizes the textile sector as a priority product value chain due to its high global resource use of materials, water, land and chemicals, greenhouse gas emissions and waste generation. To tackle these challenges, an EU strategy for textiles is being developed with the aim of strengthening the competitiveness of the European textile industry by creating a market for sustainable and circular textile products, services, and business models [4]. Therefore, circular design is an important component of circular business models for textiles that can ensure higher quality, longer life, better use of materials, and better opportunities for reuse and recycling [3].

### 1.1. The biggest global cotton producers

Cotton is one of the most commonly used raw materials in the textile industry and the most produced natural textile fibre [5]. Cotton fibre is the purest source of cellulose and the most important natural

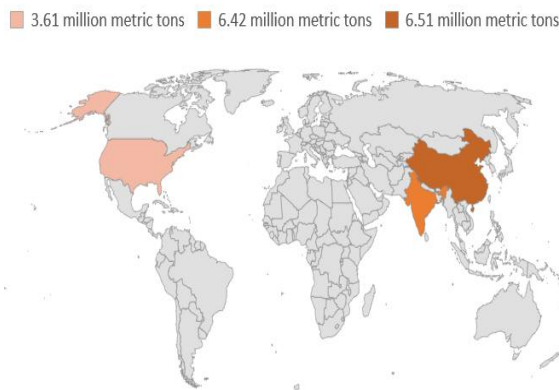


Fig.1 The World's biggest cotton producers

fibre which is wide spread due to its strength, softness, and water absorbency [6]. Due to its good properties, cotton is known as the main component of the clothing industry, with a total supply of about 26.2 million tons around the world and a market share of 24.4% in 2020 [7]. The United States Department of Agriculture (USDA) annual report indicates that China, India, and the United States are the largest producers of cotton fiber in the world [8]. Most cotton-producing country is China, followed by India, while the USA had a top third position for cotton raising country (Fig.1) [8].

### 1.2. Cotton waste

Cotton waste is also one of the most common textile wastes. Every year, 11.6 million tons of cotton waste are generated worldwide. The use of chemicals and water in both crop and textile production is associated with significant environmental impacts and pollution [6]. The textile production process of garments from cotton fibres to fabrics (Fig.2) requires the extensive

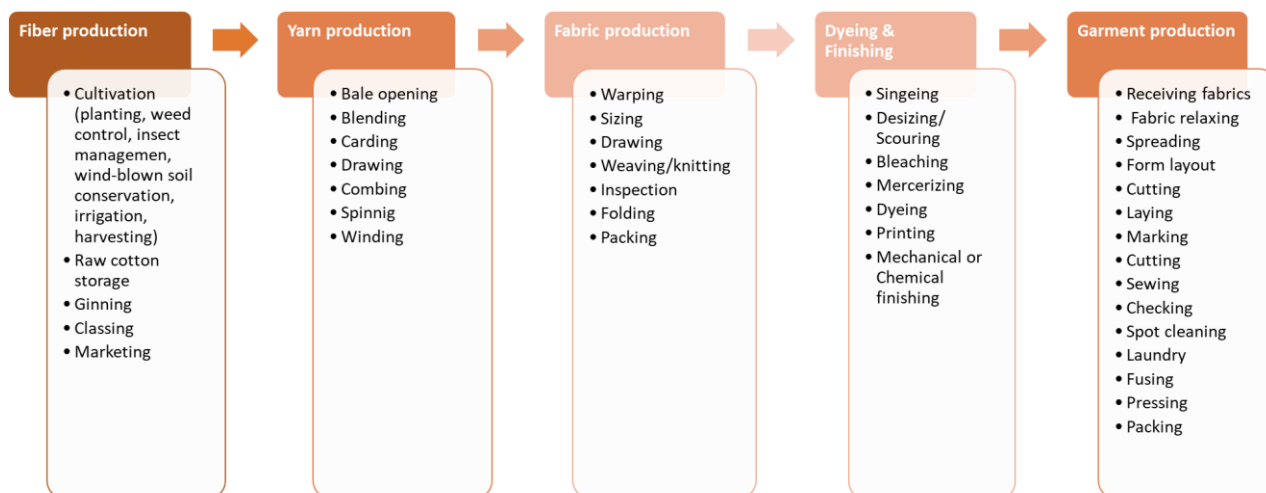


Fig.2 The basic steps of cotton production [6,9,10]

use of chemicals and energy to reduce the level of natural impurities found in the fibre, to improve dye and finishing chemical uptake, and impart new functional properties to the final fabric with hydrophobic, anti-microbial, easy ironing, stain resistance, fire resistance, soft touch and other properties [6].

The U.S. Environmental Protection Agency (US EPA) estimates that 9.5 million metric tons of clothing and textiles end up in landfills each year in the United States. Yet, it has been estimated that more than 80% of cotton waste is suitable for mechanical recycling into new textiles and less than 1% of the clothing produced is recycled back into new clothing. The use of recycled cotton has the potential to reduce the use of water, energy, pesticides, and dyeing chemicals, and to reduce the amount of waste sent to landfills [2].

### 1.3. Circular Economy of Cotton Textile Recycling

Circular business models (Fig.3) which are based on recycling and reuse turn products that can no longer be used for their original purpose into raw materials for (re)manufacturing [2]. It is vital to have a circular business model because it emphasizes seeking scientific solutions to complete the loop. Waste is reduced at the source and is recycled back into the economy for reuse rather than production and consumption being stopped due to garbage disposal [9]. These models involve reusing parts and cuts and producing recycled fibres for re-spinning and use in other products. It contributes to potential reduce of water, energy, pesticides, and dyeing chemicals consumption, and reduce landfill waste.

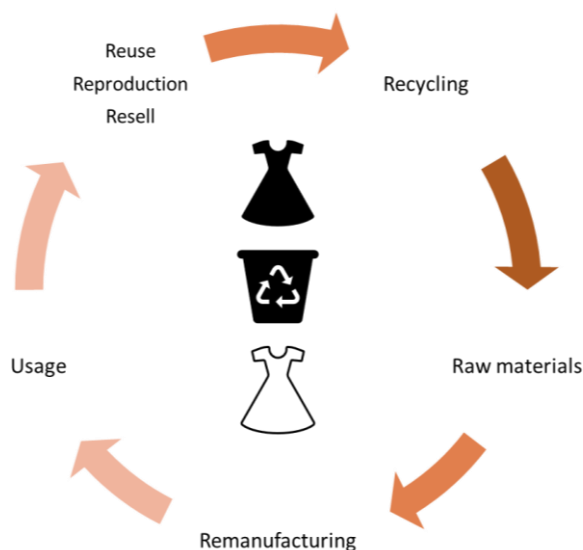


Fig.3 Circular business model [9]

In addition, increasing reuse and repurposing will also reduce the amount of textile materials that are needed for production [2,9].

## 2. Mechanical recycling

Textile recycling is the reprocessing method, which includes mechanical, chemical, and thermal routes, of textile waste for use in new textile or non-textile products. Recycling can be divided into downcycling, where the recycled material has a lower value or quality than the original product, and upcycling, where the product made from the recycled material has a higher value or quality than the original product [7]. Although recycled cotton fibres can be used to make carpets, geotextiles, composites, and nanoparticles, existing textile recycling routes generally recycle textile waste into a lower quality material such as blankets, insulation, and so on. On the other hand, the use of recycled cotton for clothing production is problematic because the quality of cotton fibres decreases at recycling [10].

Recycling cotton waste is challenging because cotton textiles are often mixed with other natural fibres (e.g., wool, soybean, and bast), chemical fibres (e.g., polyester, polyurethane, and polyamide), and textile dyes [5]. Current methods of recycling cotton waste consist mainly of mechanical, chemical, and biological recycling, but the majority of recycled cotton is obtained through mechanical recycling [11].

Mechanical recycling is a cost-effective process that involves short technological processes and re-spinning of end-of-life fibres, is well established, and is used for both pre- and post-consumer waste [5,6]. The mechanical recycling of cotton fibres requires shredding of the waste materials / garments, which shortens the staple length of the fibres [10]. As the mechanical process breaks the fibres, quality and strength are reduced, so the recovered staple fibres must be blended either with virgin cotton fibres or with other fibres to improve strength and achieve color matching so that re-dyeing is not required [6,9]. The process flow diagram in Fig.4 shows the potential of mechanical recycling of cotton to produce recycled fibres for apparel and blended materials for various applications [6]. Recent research has shown that systematic sorting of textile waste (by structure and previous finishing treatments) and optimization of shredding parameters are very important, as this leads to the production of higher quality yarns than the recycled fibres from mixed waste [10], which is a good starting point for the production of further upcycled cotton products.

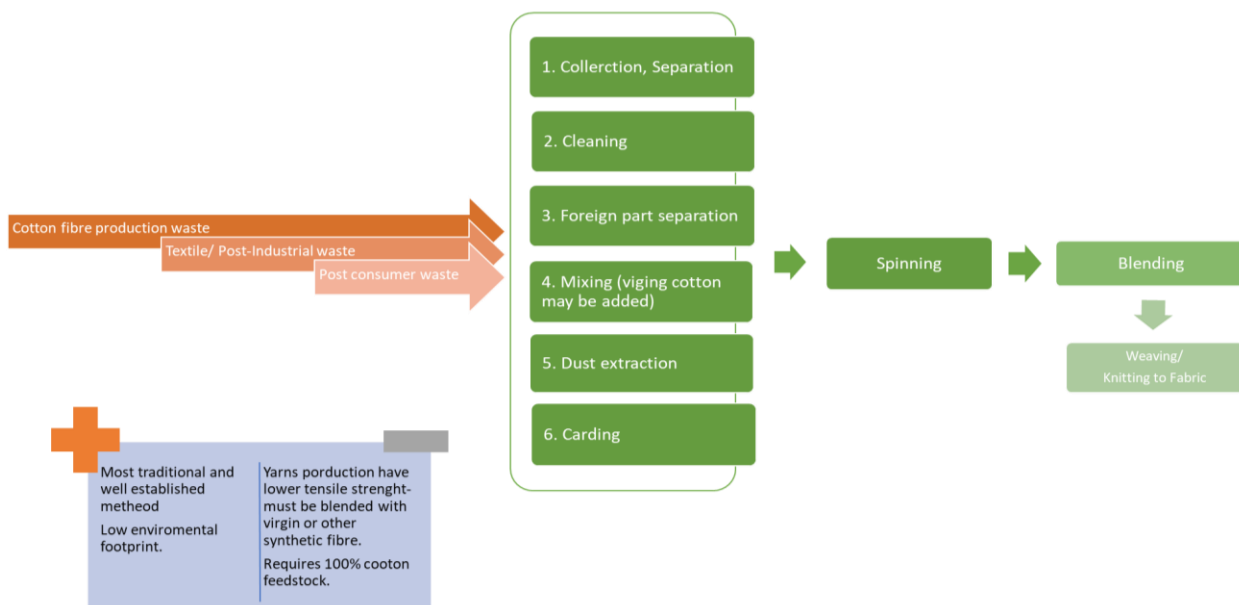


Fig.4 Overview of mechanical recycling process of cotton [6]

### 3. Recycled cotton on the market

#### 3.1. Sustainable cotton initiatives

In the textile industry, several companies are developing industrial scale technologies to upcycle waste cotton using mechanical and chemical recycling methods [12], and various nonprofit groups, academic institutions, and companies have collaborated to create systems, standards, transparency, and traceability toward more sustainable cotton. Through these initiatives, the Textile Exchange partnership aims to support continuous improvement toward a more sustainable cotton future [13]. Since 2017, more than 50 of the most well-known and leading apparel brands have committed to exclusively use sustainable cotton by 2025 through the Sustainable Cotton Challenge. One of the Sustainable Cotton Challenge initiatives is also the Recycled Cotton sustainability program [13]. Recycled Cotton is certified to an independently verifiable standard such as the Global Recycled Standard (GRS) or the Recycled Claim Standard (RCS) [14]. Also, one of the initiatives for more sustainable cotton is Incorporated's CottonWorks™ program, supported by Cotton Incorporated and the Cotton Board's Importer Support Program, which aims to increase demand for and profitability of cotton through research and promotion.

Cotton Incorporated [11] has launched a denim recycling program called Blue Jeans Go Green™. The Blue Jeans Go Green™ initiative recycles old denim jeans to be preprocessed and converted into insulation material. The program, created in 2006, has collected

more than three million pieces of denim and kept more than 1,700 tons of textile waste out of landfills. There are many recycling efforts by well-known brands that have started initiatives in their stores. Companies such as Columbia, The North Face, Patagonia, H&M, Peak Performance, Levi's, and many others have launched recycling programs that reward their customers for returning old clothing. Most of the companies that encourage their customers to recycle their clothing allow garments of all brands to be dropped off. Some of these initiatives offer consumer benefits such as coupons or points toward future purchases. Patagonia also focuses on repairing old clothing to extend the life of the product.

The use of recycled materials, including recycled cotton, is a topic of growing interest related to sustainability. In the textile and apparel market, manufacturers, brands, and retailers continue to review their supply chain footprint and therefore the interest in recycled cotton has increased.

#### 3.2. Recycled cotton suppliers

A good example of a global producer of environmentally friendly, high-quality recycled cotton fibres and fibre blends is Recover, a Spanish company that shreds pre-consumer waste while maintaining the staple length of the cotton fibres so they can be re-used. The company's strategy is to offer a range of fibres that enable the industry to achieve circular fashion for all [15]. Due to sustainability awareness, the demand for recycled cotton is increasing year by year, and so is the number of companies involved in

cotton recycling. An overview of the leading companies around the world producing recycled cotton fibres, yarns and fabrics are given in Tables 1–3.

New companies have also entered the market that specialize exclusively in eco-friendly clothing made from recycled cotton. The New Denim Project produces a range of fabrics using a fully circular model developed by a third-generation family-run Iris Textile mill in Guatemala. They produce fabrics by collecting and sorting post-industrial cotton waste from local garment factories and reprocessing this waste into fibres and then into a fabric (Upcycled Denim), garments, and accessories [16]. The R Collective is another social enterprise based in London and Hong Kong that aims to end fashion waste by rescuing, reusing and recycling fashion

waste and creating responsible products and clothing with a clear conscience [17].

#### 4. Conclusion

As global demand and consumption of textile products continue to grow, large amounts of textile waste are generated. And since cotton is one of the most common raw materials in the textile industry and the most produced natural textile fibres, it is crucial that the development in the field of cotton recycling accelerates. The fact is that the amount of recycled cotton is currently lower than we would like to see, but it is gratifying that there are more and more companies and other textile initiatives working towards a more sustainable textile industry.

**Tab.1** Recycled cotton suppliers - Fibres

Country	Company	Website
Europe		
Spain	Recover	<a href="https://recoverfiber.com/">https://recoverfiber.com/</a>
Germany	Gebrüder Otto GmbH & Co.- Recot	<a href="https://www.otto-garne.com/home-de/einzigartigkeit/eigenmarken/">https://www.otto-garne.com/home-de/einzigartigkeit/eigenmarken/</a>
Asia		
India	Kay Gee Enterprises	<a href="https://www.kaygeeindia.com/cotton-fibre-1">https://www.kaygeeindia.com/cotton-fibre-1</a>

**Tab.2** Recycled cotton suppliers - Yarns

Country	Company	Website
America		
USA	Gap Yarns, reCapture	<a href="https://www.recaptureyarns.com/">https://www.recaptureyarns.com/</a>
USA	Giotex Ltd.	<a href="https://giotex.com.mx/en/products-detail">https://giotex.com.mx/en/products-detail</a>
Guatemala	Faxel Textiles	<a href="https://www.ecoyarn.co/">https://www.ecoyarn.co/</a>
Europe		
Netherlands	Ecolological Textiles	<a href="https://www.ecologicaltextiles.com/contents/en-uk/d77_-_-Yarns.html">https://www.ecologicaltextiles.com/contents/en-uk/d77_-_-Yarns.html</a>
Spain	Hilaturas Ferre yarns	<a href="https://ferreyarns.com/products/">https://ferreyarns.com/products/</a>
Italy	Marchi & Fildi S.p.a	<a href="https://www.marchifildi.com/products/#ecotec-en">https://www.marchifildi.com/products/#ecotec-en</a>
UK	Hampton Yarns	<a href="https://hampton yarns.co.uk/about/#">https://hampton yarns.co.uk/about/#</a>
Turkey	Kipaş Mensucat İşletmeleri a.ş.	<a href="https://kipastextiles.com/segments/yarns/#sustainable--recycled-yarns">https://kipastextiles.com/segments/yarns/#sustainable--recycled-yarns</a>
Asia		
Bangladesh	CYCLO Recycled Fibers	<a href="https://www.cyclofibers.com/">https://www.cyclofibers.com/</a>
Bangladesh	Martin Spining	<a href="https://matinspinning.com/products/">https://matinspinning.com/products/</a>
India	Kay Gee Enterprises	<a href="https://www.kaygeeindia.com/cotton-yarn-1">https://www.kaygeeindia.com/cotton-yarn-1</a>

**Tab.3** Recycled cotton suppliers - Fabrics

Country	Company	Website
America		
Guatemala	Iris Textiles- The new denim project	<a href="https://www.thenewdenimproject.com/">https://www.thenewdenimproject.com/</a>
Europe		
Turkey	Kipaş Mensucat İşletmeleri a.ş.	<a href="https://kipastextiles.com/segments/yarns/#sustainable--recycled-yarns">https://kipastextiles.com/segments/yarns/#sustainable--recycled-yarns</a>
Asia		
China	Prosperity Textile (HK) Ltd.	<a href="https://www.prosperity-textile.com/sustainable-denim-mill-prosperity/">https://www.prosperity-textile.com/sustainable-denim-mill-prosperity/</a>

To achieve the Circular Economy Action Plan established by the European Union, end-of-life textiles must be recycled to produce new recycled fibres with similar properties than from virgin fibres, which will be achieved through continuous research and development in the field of cotton recycling. The aim of researchers and textile industry is to develop new, modern strategies for recycling cotton waste into high value-added products, create systems, standards, transparency, and traceability to achieve sustainable cotton production. In addition, consumer awareness and knowledge must be increased, and the fact that leading textile companies are already launching initiatives in their stores is extremely positive.

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