



---

## ENVIRONMENTAL ISSUE OF SUSTAINABLE TEXTILE INDUSTRY – EXAMPLES OF GOOD MANUFACTURING PRACTICES

Professional paper  
DOI: 10.5937/CT\_ITI24060Z

Darja Žarković<sup>1,a</sup>, Marija Vučićević<sup>1,b</sup>, Milica Vlahović<sup>2,\*</sup>

<sup>1</sup>Academy of Applied Studies Politehnika, Katarine Ambrozić 3, Belgrade, Serbia

<sup>a</sup>[dzarkovic@atssb.edu.rs](mailto:dzarkovic@atssb.edu.rs), ORCID 0009-0008-9389-9639;

<sup>b</sup>[mvucicevic2021.10226@politehnika.edu.rs](mailto:mvucicevic2021.10226@politehnika.edu.rs)

<sup>2</sup>University of Belgrade, Institute of Chemistry, Technology and Metallurgy -  
National Institute of the Republic of Serbia, Njegoševa 12, Belgrade, Serbia

\*[m.vlahovic@ihtm.bg.ac.rs](mailto:m.vlahovic@ihtm.bg.ac.rs), ORCID 0000-0002-7893-9191

---

**ABSTRACT:** Growing impact on the environment and the rising demand for water, energy and raw materials that has resulted from the worldwide expansion of industry, put the principles of sustainability and cleaner production in a front line, as emergent activity. The textile industry consumes a high amount of energy and generates an enormous quantity of wastewater - worldwide, it generates 20 % of industrial wastewater and 8 % of greenhouse gas (GHG), while cotton production uses large amounts of pesticides, water and fertilizers. Many aspects of sustainable textile industry are not related only to production process itself (product quality and its market price, production process, supply of raw materials and its costs), but also to nus products, energy and water consumption, equipment service time, occupational health, and environmental issue. Thus, successful companies in textile production are driven by the basic principles of sustainable development and implementation of good manufacturing practice and cleaner production principles. This paper presents main principles of environmental protection in textile industry to be adopted toward sustainable production; these principles consider minimization of water, energy, virgin raw materials and chemicals usage, which results in reduction of the CO<sub>2</sub> emissions, toward climate neutral production and business. Described company increases the share of sustainable/renewable materials and recycled materials, by accomplishing its own sustainability goals concerning environmental issue.

**Keywords:** Textile industry, sustainability, CO<sub>2</sub> emission reduction, renewable materials, circularity, waste minimization.

---

## EKOLOŠKI ASPEKT ODRŽIVOSTI U TEKSTILNOJ INDUSTRIJI – PRIMERI DOBRE PROIZVOĐAČKE PRAKSE

---



VII International scientific conference

„Contemporary trends and innovations in the textile industry“

19-20th September, 2024, Belgrade, Serbia

**APSTRAKT:** Sve veći uticaj na životnu sredinu i rastuće potrebe za vodom, energijom i sirovinama, koje su posledica rasta industrijske proizvodnje na globalnom nivou, stavljaju principe održivosti i čistije proizvodnje u prvi plan, kao aktivnosti od izuzetnog značaja. Tekstilna industrija troši veliku količinu energije i stvara ogromnu količinu otpadnih voda – procenjuje se da na globalnom nivou proizvodi 20 % industrijskih otpadnih voda i 8 % gasova staklene bašte (GHG), a proizvodnja pamuka je značajan potrošač pesticide, vode i đubriva. Mnogi aspekti održive tekstilne industrije nisu vezani isključivo za sam proizvodni proces (kvalitet proizvoda i njegova tržišna cena, proizvodni proces, nabavka sirovina i troškovi proizvodnje), već i za nus proizvode, potrošnju energije i vode, servisiranje opreme, zaštitu na radu i pitanje očuvanja životne sredine. Uspešna preduzeća u tekstilnoj industriji su vođena osnovnim principima održivog razvoja i implementacijom dobre proizvođačke prakse i principa čistije proizvodnje. Ovaj rad predstavlja glavne principe zaštite životne sredine u tekstilnoj industriji koje treba usvojiti u pravcu održive proizvodnje; ovi principi razmatraju minimiziranje upotrebe vode, energije, sirovina i hemikalija, što rezultira smanjenjem emisije CO<sub>2</sub>, prema klimatski neutralnoj proizvodnji i poslovanju. Opisana tekstilna kompanija povećava udeo održivih/obnovljivih i recikliranih materijala, ostvarivanjem sopstvenih ciljeva održivosti koji se tiču pitanja životne sredine.

**Cljučne reči:** Tekstilna industrija, održivost, smanjenje emisije CO<sub>2</sub>, obnovljivi materijali, cirkularnost, minimizacija otpada.

## 1. INTRODUCTION

One of the most used definitions of sustainable production is the one that defines it as a production of goods and services in a manner that is socially beneficial, economically viable and environmentally benign over whole life cycle [1]. In entrepreneurial points of view, environmental sustainability is a business strategy for using processes without generating harmful effects to the environment and natural resources throughout the life cycle (e.g., consisting of collection, processing, application, replenishment, consumption, and disposal) of natural resources [2-4]. Besides the high quality of final product and its competitiveness at market, the aim of sustainable textile production is also to ensure conservation of resources and preserve the regenerative capacity of the environment, as well as to obtain social benefits for employees and associated companies [5]. In practice, sustainable production is based on optimized balance between inputs (raw materials, water, energy, human resources etc.) and production outputs (main products, nus-products, and effluents) [5]. Sustainable production integrates ecological, social, and economic aspects, leading management to invest in cleaner production, human well-being, and effective resource usage. This approach presents a long-term profitable strategy that saves resources, reduces production costs, and lowers the final product's price, all without compromising quality.

This paper presents one successful international fashion/textile company, as an example of good manufacturing practice, especially concerning environmental issue of sustainable textile production – minimization of emissions to water, air and soil, economic usage of



resources, waste management (3R principle), energy efficiency, and all of them in accordance with local legal regulations. The special part in sustainable production of textile garments presents the evaluation of positive impact of sustainability goals and the circular economy principles – recycling textile material and waste reuse, as well as minimizing generation of solid waste and its characterization if needed. This company promotes new and efficient technologies for waste recycling and decarbonization - reduction of greenhouse gasses (GHGs) emissions.

## **2. ENVIRONMENTAL ISSUE OF SUSTAINABILITY IN THE TEXTILE INDUSTRY**

The textile industry uses a large amount of energy and generates a huge quantity of waste water. Worldwide, it is estimated to produce 8% of GHG emissions and 20% of industrial wastewater. Additionally, cotton production demands great amounts of pesticides, water and fertilizers. Microfibers released from synthetic textiles during production, use, and disposal enter surface water, further polluting already heavily stressed ecosystems. The textile industry is also intensive user of chemicals (it is estimated that 1 kg of textiles requires almost half a kilogram of chemicals on average), which presents another environmental time bomb, because a large part of these chemicals ends up in the effluent of the processing plants. The impact of textile industry on the environment can be eliminated or strongly reduced by [6]:

- decreasing the amount of chemicals used (e.g. by getting a higher percentage of a dye to stay on the fabric);
- substituting hazardous chemicals by less harmful and
- using better abatement techniques (e.g. water treatment facilities).

The environmental impact of the textile industry extends beyond hazardous chemicals to include chemicals widely used in the industry that are not classified as hazardous to humans. For example, starch, one of the highest volume chemicals used in the textile industry, is not hazardous but can cause environmental harm if released untreated into surface water bodies (rivers, lakes, etc.). In such cases, algae thrive while most other aquatic life suffers from oxygen depletion. Emissions to air and energy consumption are also significant concerns. The textile industry uses stenters – long ovens where surface treatments are cured and solvents are driven out – primarily powered by natural gas. These stenters emit common air pollutants from combustion, such as NO<sub>x</sub>, along with other chemicals used in the process [6].

### **2.1. Best available techniques (BAT) in textile industry**

In the global manufacturing industry, the textile production is one of the longest and most complex industrial production/supply chains; it is a fragmented and heterogeneous sector dominated by a majority of small and medium-sized enterprises, as well as multinational companies, which demand is mostly driven by three main end uses: clothing, home furnishing and industrial use. The entire manufacturing cycle in textile and clothing production chain consists of a wide range of subsectors: from the production of raw

materials (man-made fibers) to semi-processed materials (yarns, woven and knitted fabrics with their finishing process) and final/consumer products (carpets, home textiles, clothing and industrial textiles). Best available techniques (BAT) are advanced, state-of-the-art processes, *techniques*, facilities or methods of operation that are developed at a scale that enables implementation of a particular measure for limiting discharges to the environment, under economically and technically viable conditions. BAT are proven techniques for preventing and controlling industrial emissions and the wider environmental impact caused by industrial installations. The BAT concept has evolved as a key element for setting emission limit values and other permit conditions in environmental permits for these installations. The range of emission levels obtained under normal operating conditions using BAT (or a combination of BAT), as described in BAT conclusions [7] and expressed as an average over a given period of time under specified reference conditions, presents Associated Emission Level (BAT-AELs). In the textile industry, BAT-AELs are defined for emissions to air and water. Other environmental performance levels (so-called indicative levels) include specific energy consumption, specific water consumption, specific wool grease recovery level, and caustic soda recovery level. BAT Reference Document (BREF) for the Textiles Industry is part of a series of documents presenting the results of an exchange of information between EU Member States, the industries concerned, non-governmental organizations promoting environmental protection, and the Commission. This exchange aims to draw up, review, and update BREF as required by Directive 2010/75/EU on Industrial Emissions [8].

## 2.2. Life cycle assessment (LCA)

Life cycle assessment (LCA) is a scientific method or technique to identify, quantify and evaluate the environmental impacts (inputs and outputs) of a product, service or activity, from cradle to grave stages [9]. It can be used to quantify the environmental impact of processes and has many variants. It is highly useful for assessing the environmental impacts of a product from the beginning (raw material extraction stage or cradle) to the end (disposal or end of life, also called the grave stage) [2]. The life cycle of a typical textile product comprises the five stages as depicted in Fig. 1.

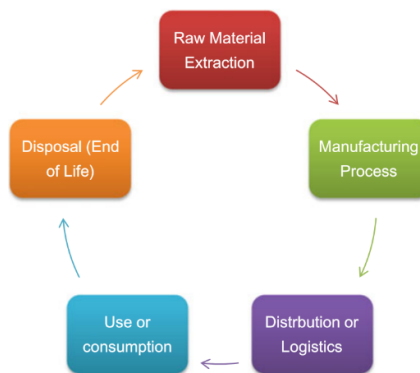


Figure 1: Life cycle stages of a typical textile product [2]



### 3. GOOD MANUFACTURING PRAXIS IN TEXTILE INDUSTRY

In textile production, the usage of energy, chemicals, and water are major environmental impact generators throughout the life cycle of products [2]. To ensure environmental sustainability, apparel designers should create products based on environmentally and socially responsible design approaches and trends; the supply chain must consider its impacts on society, economy, and environment for their business practices [2,3,10]. The example of good manufacturing praxis concerning environmental issue of sustainability is one successful international fashion/textile company, founded in 1954. in Alingsås, with Head office in Gothenburg, Sweden (part of the Stockmann Group) [11]. The Company employs about 4,300 people and operates around 440 stores in 18 markets, nine of which are franchises. Online shopping is available in 34 markets. Their main advertisement is pointed at the Company's web site saying that 42 % of their assortment has at least 15 % recycled content and 78 % of their assortment is made from more sustainable materials. The Company does not own any factories; instead, it works with selected independent suppliers in close, long-term collaborations, enabling mutual commitment to support, investment, and improvement projects. They have five production offices in Bangladesh, China, Hong Kong, India and Turkey. Their production offices work in close collaboration with their design and buying department in the development and production of the collections. They also work closely together with suppliers to make sure that the styles that end up in store and online meet the standards when it comes to quality, fit and sustainability [11]. As the fashion industry heavily depends on and consumes natural resources, this Company believes the only sustainable path forward is through a circular transformation of its business. This transformation aims to decrease its climate impact, minimize natural resource use, and influence consumer behavior to reduce overconsumption.

#### 3.1. Achieving sustainability goals

Described Company has a responsibility to contribute to the UN Sustainable Development Goals, for their customers, for society and for their business today and tomorrow. Main goals concern climate, circularity and natural resources. To reduce climate impact in line with scientific recommendations throughout their entire value chain, the company defined two main goals [12]:

- By 2023, they plan to become climate neutral in their own operations;
- By 2030, they aim to reduce CO<sub>2</sub> emissions in their entire value chain by 50% compared to the 2017 baseline.

In the field of minimizing natural resource use and impacting consumer behavior to reduce overconsumption, the company defined several goals, including two main ones:

- By 2025, 100% of their materials will be recycled or sustainably sourced;
- By 2025, their entire assortment will be designed for longevity and/or circularity [13].

The Company's main goals for minimizing their impact on ecosystems and biodiversity with a responsible and regenerative approach to natural resources are:



- By 2025, all their business partners with water-intensive operations will be required to measure their water use, set reduction goals, and incorporate reduction, reuse, and recycling of wastewater into their environmental management systems;
- By 2025, the company will eliminate the release of all hazardous and toxic substances from their supply chain and promote transparency and more sustainable chemistry.

The Company continuously develops its sustainability goals, ambitions and strategies within its own promise to the customers and business partners; update on their progress is described in their annual sustainability report [12]. The last sustainability report (for 2023) shows significant improvements in several fields concerning „respect the planet”, as shown in Table 1.

**Table 1:** The Company's progress of environmental goals in 2023 (2017 baseline year) [12]

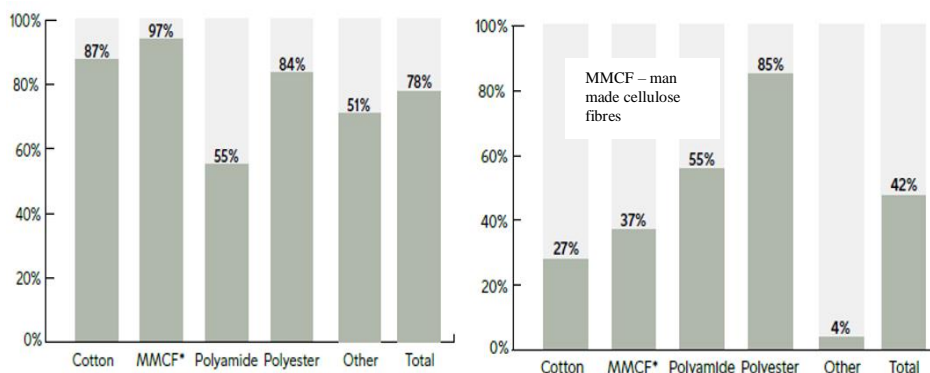
TOPIC	GOAL	PROGRESS in 2023	NOTES
Climate	By 2023, operations are climate neutral	Emissions decreased by 50%	Initially included offsetting that is no longer in the strategy.
	By 2030, the Company achieves 50% reduction of CO <sub>2</sub> emissions	Emissions decreased by 42%	Excludes customer use phase, including laundry, care, and transportation to and from stores.
Circularity	By 2026, all Company's materials are recycled or sustainably sourced	78%	A garment counts towards their 100% goal if it contains at least 50% "more sustainable materials," meaning renewable or recyclable raw materials produced with less environmental impact.
	By 2026, 70% of products include a minimum of 15% recycled content	42%	They now have a goal specific to recycled fibers uptake compared to previous in 2025.
	By 2025, the entire assortment is designed for longevity and/or circularity		Going forward, this goal aligns with the emerging EU regulations on eco-design.
	By 2025, all Company's stores have functioning collection and recycling systems for paper and plastic	96%	-
	By 2025, paper and plastic packaging follows the Company's circular materials strategy	98% of all plastic packaging has 100% recycled content	This includes their transport business packaging, e-com consumer packaging, plastic bags and sales packaging

Natural resources	By 2025, its business partners measure their water use, set reduction goals and RRR of wastewater in the EMSs	72%	Progress in 2022 was 79 % for both goals (more than in 2023), but scoring methodology is changing. Currently this score is a higher-level environmental score encompassing all areas.
	By 2025, no hazardous substances will be released from its supply chain, promoting transparency and sustainable chemistry.	72%	

RRR- reduction, reuse and recycling; EMS- environmental management system

### 3.1.1. Sustainable/renewable materials and recycled materials

All raw materials used by the Company require natural resources, but it is possible to choose materials with minimal impact on people and the environment. The Company designates these materials as "more sustainable", meaning the raw material comes from a renewable or recyclable source and the fiber is cultivated or produced using methods that have less negative impact on people, animals, and the planet compared to conventional alternatives. Using recycled materials is part of the Company's 2030 circularity strategy, which aims to eliminate all waste. Utilizing recycled synthetic materials wherever possible significantly reduces the footprint of their produced synthetic fibers, such as polyester and polyamide, thereby reducing pressure on natural resources and climate impact. With new partnerships and a focus on mechanically recycled content, they have made great progress in recycling viscose and cotton materials. Figure 2 shows the Company's trends in switching to more sustainable raw materials and the share of products with more than 15% recyclable content.



**Figure 3:** The Company's achievements in switching to more sustainable materials in production (left: sustainable share per fiber type; right: share of products with at least 15 % recycled content) [12]



### 3. CONCLUSION

The environmental challenges of sustainable textile production have prompted management to invest in cleaner production and efficient resource usage. This approach presents a long-term profitable strategy, saving resources, reducing production costs, and lowering the price of the final product without compromising quality. Given the fashion industry's heavy reliance on natural resources, textile companies are increasingly embracing circular business models to reduce their climate impact, minimize resource use, and influence consumer behavior to curb overconsumption. As an exemplary case of manufacturing best practices, the described textile company has made significant strategic decisions and investments towards environmental sustainability in recent years. For instance, 42% of their product assortment contains at least 15% recycled content, and 78% is made from more sustainable materials. By 2023, they achieved a 42% reduction in CO<sub>2</sub> emissions across their entire value chain compared to a 2017 baseline. Additionally, 96% of their own stores have operational collection and recycling systems for paper and plastic waste streams. Despite these achievements, the Company maintains ambitious sustainability goals, particularly in climate action, circularity, and natural resource management. Over the next few years, they plan to achieve climate neutrality in their operations and reduce CO<sub>2</sub> emissions across their value chain by 50% from 2017 levels. They also aim for all materials to be recycled or sustainably sourced, with the entire product range designed for longevity and circularity. Moreover, they require all business partners with water-intensive operations to measure, set goals for, and manage water use, including reduction, reuse, and recycling of wastewater in environmental management systems. Furthermore, the Company is committed to eliminating the release of hazardous and toxic substances from their supply chain while promoting transparency and adopting more sustainable chemistry practices.

### ACKNOWLEDGMENTS

This research has been financially supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Contract No: 451-03-66/2024-03/200026).

### REFERENCES

- [1] Rosen, M.A., Kishawy, H.A. (2012). Sustainable Manufacturing and Design: Concepts, Practices and Needs, *Sustainability*, Vol. 4, 154-174.
- [2] Muthu, S.S. (2017). Evaluation of Sustainability in Textile industry. In: Muthu, S. (eds) Sustainability in the Textile Industry. *Textile Science and Clothing Technology*, Springer Nature Singapore Pte. Ltd., 9-15.
- [3] Choudhury, A.K.R. (2015). Development of eco-labels for sustainable textiles, Roadmap to Sustainable Textiles and Clothing. In: Muthu S. (Ed.) Roadmap to Sustainable Textiles and Clothing, *Textile Science and Clothing Technology*, Springer, Singapore, 137-173.



- 
- [4] Khan, M.R, Islam, M. (2015). Materials and manufacturing environmental sustainability evaluation of apparel product: knitted T-shirt case study, *Textiles and Clothing Sustainability*, 1(1), 1-12.
- [5] Žarković, D., Marković, S. (2023). Sustainable production in cardboard industry, *International scientific and professional conference POLITEHNIKA 2023*, Belgrade 15 December 2023, pp. 177-181.
- [6] <https://eipie.eu/the-sevilla-process/brefs/textile-industry-txt-bref/> (Accessed 18 May 2024).
- [7] Commission Implementing Decision (EU) 2022/2508 of 9 December 2022 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for the textiles industry (notified under document C(2022) 8984), *Official Journal of the European Union*, 325, 20.12.2022.
- [8] Roth, J., Zenger, B., De Geeter, D., Gómez Benavides, J., Roudier, S. (2023). Best available techniques (BAT) reference document for the Textiles Industry, European Commission, *Publications Office of the European Union*, Luxembourg, JRC 131874.
- [9] Life Cycle Analysis, obtained from: <http://www.gdrc.org/sustdev/concepts/17-lca.html> (Accessed 18 May 2024).
- [10] Adams C.A., Frost G.R. (2008). Integrating sustainability reporting into management practices, *Accounting Forum*, 32(4), 288-302.
- [11] <https://about.lindex.com/sustainability/> (Accessed 20 May 2024).
- [12] Sustainability report 2023 LINDEKX.
- [13] Lindex reuse, recycling and donation policy, November 2017.