

CHALLENGES AND OPPORTUNITIES OF TEXTILE WASTE MANAGEMENT IN SERBIA'S CIRCULAR ECONOMY

Višnja MIHAJLOVIĆ

DOI: 10.12700/STAR.2026.018

University of Novi Sad, Technical Faculty Mihajlo Pupin, Zrenjanin, Serbia

Abstract:

The growing volume of textile waste presents a significant environmental and economic challenge worldwide, and Serbia is no exception. This paper explores the current state of textile waste management in Serbia, examining the current legislative framework, collection systems, recycling capacities, and public awareness levels. Serbia's textile waste sector remains underdeveloped, with most post-consumer textiles ending up in landfills or informal channels. The lack of infrastructure, limited investment in recycling technologies, and weak enforcement of environmental policies further hinder progress. This study identifies key trends likely to shape the future of textile waste management in Serbia, including the adoption of EU-aligned regulations, increased participation of the private sector, and rising consumer consciousness about sustainability. By analysing current barriers and highlighting future opportunities, the paper offers recommendations and directions for building a more efficient and sustainable textile waste management system in Serbia.

Keywords:

textile waste, sustainable development, circular economy, recycling

1. INTRODUCTION

The global textile and apparel industry is one of the largest manufacturing sectors worldwide and a major contributor to trade and employment, but it is also highly resource- and pollution-intensive. Recent reviews show that textiles consume large amounts of water, energy and chemicals across the life cycle, while fast fashion has accelerated production volumes and shortened product lifetimes, leading to rapidly growing material throughput and waste generation [1]. Every year, 92 million tonnes of textile waste is produced globally. In 2024 discarded clothing worldwide reached 120 million metric tons. The global production of textiles has almost tripled, 65% made from fossil energy (plastic fibres from oil). Textile consumption will increase 63% up to 2030. However, recent trends in fast fashion and issues connected to greenwashing are also contributing to increase of textile consumption and generation of textile waste. Most of the textile waste becomes part of municipal solid waste and ends up at landfills - only 1% of used clothes are recycled into new clothes. From extracting raw materials to manufacturing—accounts for 92% of the fashion industry's greenhouse gas emissions

In 2022, 11 million tonnes of textile products were imported to the EU and came mainly from China, Bangladesh and Turkey. Since 2000, the export of used textiles has nearly tripled, from a little over 550,000 tonnes in 2000, to 1.4 million tonnes in 2019. Within the broader transition to a circular economy (CE), the textile and apparel sector is frequently cited as a priority industry because of its significant environmental footprint and complex global supply chains [2].

Environmental pressures occur at all stages of the textile value chain. Fiber production (both natural and synthetic) is associated with land use, pesticide and fertilizer application, fossil resource use, and high greenhouse gas emissions, while wet processing, dyeing and finishing generate large volumes of chemically contaminated wastewater [3]. At the end of life, most post-consumer textiles are still landfilled or incinerated, causing further emissions and the loss of potentially valuable fibres. Systematic reviews of textile reuse and recycling highlight that, although reuse and high-quality recycling can deliver substantial climate and resource benefits, their actual contribution remains limited by low collection rates, quality losses and technological barriers [4].

In response, CE strategies such as durability, reuse, repair, fiber-to-fiber recycling and new circular business models are increasingly promoted for the textile sector. However, evidence from recent literature reviews and empirical studies shows that implementation is uneven and faces multiple challenges. On the technological side, current recycling technologies often struggle with mixed fibers, elastane content, dyes and finishes, and may require high energy or chemical inputs, especially for chemical and advanced recycling routes [5].

On the systemic side, key barriers include fragmented supply chains, insufficient separate collection and sorting infrastructure, unclear economic incentives, and limited market demand for recycled fibers [4]. Studies of circular practices in the textile industry further underline the importance of supportive policy frameworks, extended producer responsibility (EPR), and collaboration among brands, recyclers and public authorities to scale circular solutions [6,7]. Despite growing awareness of circular economy principles, Serbia's waste management system still operates largely under a linear "take-make-dispose" model. According to the national Circular Economy Roadmap, textile materials remain a minor component in formal recycling streams, and the country shows limited capacity for textile-specific recovery operations. Meanwhile, consumer and business attitudes toward textile reuse and recycling are hampered by low environmental awareness and limited incentives for sustainable textile design and disposal.

Given this context, Serbia faces a crucial juncture: the challenges of scaling textile waste management are significant, but so are the opportunities. By integrating circular economy strategies — such as enhanced collection systems, investment in recycling technology, and producer responsibility frameworks. This study identifies key trends likely to shape the future of textile waste management in Serbia, including the adoption of EU-aligned regulations, increased participation of the private sector, and rising consumer consciousness about sustainability. By analysing current barriers and highlighting future opportunities, the paper offers recommendations and directions for building a more efficient and sustainable textile waste management system in Serbia.

2. RESULTS AND DISCUSSION

Dominant waste management method in Serbia is landfilling [8]. Serbia follows global patterns, with approximately 12 kg per capita, much of which is discarded soon after purchase. In average morphological composition of mixed municipal waste in Serbia 2,8% is textile [8]. In 2020 in Serbia 81.405 tons of textile waste generated, 61 tons separated whereas 60 tons recycled. There is no infrastructure for textile waste (separate collection, treatment). According to Waste Management Strategy by the end of 2029 a separate collection of textiles should be established [8].

Based on the research conducted in 120 companies in Vojvodina, micro-enterprises dominate the regional business structure, making up 81 firms (67.5%), with the largest concentration in Southern Bačka (43), followed by Northern Bačka (12), Srem (7), and Southern Banat (6). This pattern reflects a regional economy driven primarily by small entrepreneurial activity, typical of transitional economies. Small enterprises account for 20 firms (16.7%), mostly in Southern Bačka (8), indicating gradual business growth in parts of Bačka. Medium-sized enterprises are limited (11 firms, 9.2%), with Southern Bačka hosting nearly half, highlighting challenges in sustaining mid-scale development. Large enterprises are the least common (8 firms, 6.7%), concentrated in Bačka (5) and Banat (3), underscoring the region's weak industrial base and limited capacity to attract major investment [9]. The main challenge in the adoption of CE practices is financial incentives, particularly for micro and small enterprises, and investment support for medium enterprises. Dominance of micro and small enterprises is a barrier for technological advancement, sustainable practices, and implementation of circular economy practices.

However, largest share of companies operates in the manufacture of other wearing apparel, accounting for 50 firms or 41.7%, followed by smaller groups in finished textile products, workwear and other textile items. The industry is dominated by micro-enterprises, which limits the sector's capacity to scale, invest in new technologies, and adopt sustainable practices. The strong concentration in general apparel suggests market saturation, while specialized segments such as workwear and technical textiles present

opportunities for growth. Overall, the sector remains focused on low value-added production, highlighting the need for modernization, innovation, and diversification into higher-value textile segments [9]. To comply with EU regulation, companies will need to pay for the management of textile waste, proposed by Extended Producer Responsibility schemes [10]. This means producer producers will finance, collection and sorting of post-consumer textiles, recycling system development. and awareness campaigns and eco-design improvements. This will be one of the biggest challenges in long term, and probably impact the micro and small companies, more than medium size.

Sustainable waste management practices in the companies remains very low. Only eight companies (6.7%), mostly large enterprises, send their textile waste to authorized operators, indicating very limited but positive uptake of sustainable waste management practices. Contract manufacturing is used by nine companies (7.5%), mainly micro and small firms, with waste returned to foreign clients. Majority of the companies send their waste to the municipal landfill, more than 50%. Therefore, direct municipal disposal remains the most common method, only 10.8% reuse some textile waste before disposing of it as municipal waste, demonstrating a modest level of circularity [9]. European legal framework will vision for 2030 is that all textile products on the EU market are durable, repairable, and recyclable made primarily from recycled fibres, free of hazardous substances based on Ecodesign for Sustainable Products Regulation [11]. Therefore, challenge for the companies will be, integrating sustainable waste management practices order to meet those criteria. In addition, mandatory digital ID for each product which will means containing sustainability and origin data of the product, become a mandatory for every company export to EU, whereas Serbia exports more than 75% of its textile production.

Use of digital technologies is also at very low level, only 18% of medium and large apparel companies use digital technologies, primarily in design, product development, and material procurement. These tools streamline workflows and significantly reduce material waste, lowering losses from the typical 30–35% to just 8–10%. [9]. This demonstrates the strong potential of digitalization to enhance both operational efficiency and sustainability in the apparel sector. Ecodesign for Sustainable Products Regulation sets buy the EU, among other issued set minimum requirements design for disassembly and repair, thus the increased use of digital technologies over traditional patternmaking and cutting [11].

3. CONCLUSIONS

The transition toward sustainability in the textile industry is no longer optional—it has become an essential requirement for long-term competitiveness and regulatory compliance. To accelerate this shift, financial incentives and targeted investment support are crucial for enabling companies, especially small and medium-sized enterprises, to adopt cleaner technologies, improve resource efficiency, and modernize production processes. Emerging regulatory frameworks—including ESPR, EPR, and DPP will model the market, making circularity a core business model rather than a voluntary practice. In this evolving landscape, textile companies that proactively integrate sustainable design, transparent material flows, and responsible waste management will be best positioned to thrive. In this rapidly transforming regulatory and market environment, textile companies that systematically integrate sustainability principles—from eco-design and material transparency to circular waste management—will be the most resilient and best positioned for long-term growth.

Serbian companies will need to adapt their business to the requirement of EU legal framework in textile industry. Serbian companies are exporting their products to the EU market, 75%. Companies will need to implement best practices and invest in technologies will make their business resilient and best positioned for long-term sustainable growth.

4. REFERENCES

- [1] Rahaman, M. T., Pranta, A. D., Repon, M. R., Ahmed, M. S., & Islam, T. (2024). Green production and consumption of textiles and apparel: Importance, fabrication, challenges and future prospects. *Journal of Open Innovation: Technology, Market, and Complexity*, 10, 100280. <https://doi.org/10.1016/j.joitmc.2024.100280>

- [2] Jia, F., Yin, S., Chen, L., & Chen, X. (2020). The circular economy in the textile and apparel industry: A systematic literature review. *Journal of Cleaner Production*, 259, 120728. <https://doi.org/10.1016/j.jclepro.2020.120728>
- [3] Luo, Y., Song, K., Ding, X., & Wu, X. (2021). Environmental sustainability of textiles and apparel: A review of evaluation methods. *Environmental Impact Assessment Review*, 86, 106497. <https://doi.org/10.1016/j.eiar.2020.106497>
- [4] Tang, K. H. D. (2023). State of the art in textile waste management: A review. *Textiles*, 3(4), 454–467. <https://doi.org/10.3390/textiles3040027>
- [5] Seifali Abbas-Abadi, M., Tomme, B., Goshayeshi, B., Mynko, O., Wang, Y., Roy, S., Kumar, R., Baruah, B., De Clerck, K., De Meester, S., & others. (2025). Advancing textile waste recycling: Challenges and opportunities across polymer and non-polymer fiber types. *Polymers*, 17(5), 628. <https://doi.org/10.3390/polym17050628>
- [6] Thomas, K., & Clarke-Sather, A. (2024). Fundamental challenges and opportunities for textile circularity. *Sustainability*, 16(24), 11117. <https://doi.org/10.3390/su162411117>
- [7] Rahaman, M. T., Pranta, A. D., Repon, M. R., Ahmed, M. S., & Islam, T. (2024). Green production and consumption of textiles and apparel: Importance, fabrication, challenges and future prospects. *Journal of Open Innovation: Technology, Market, and Complexity*, 10, 100280. <https://doi.org/10.1016/j.joitmc.2024.100280>
- [8] Waste management program of the Republic of Serbia for the period 2022-2031, Official Gazette of the Republic of Serbia 353-/588/2022-1
- [9] Nadiia Bukhonka, Marija Pesic, Ineta Nemesa, Darko Radovancevic, Valentina Bozoki, Waste Practices in Vojvodina's Apparel Industry. Conference Proceedings ICPAE 2025, August 29–30, Zrenjanin, Serbia, ISBN 978-86-7672-390-4
- [10] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives
- [11] Regulation EU 2024/1781 of the European Parliament and of the Council of 13 June 2024 establishing a framework for the setting of ecodesign requirements for sustainable products,

Corresponding author:

Visnja MIHAJLOVIC

Department of Environmental Engineering, Technical Faculty Mihajlo Pupin, University of Novi Sad
Djure Djakovic bb

23000, Zrenjanin, SERBIA

E-mail: visnjamihajlovic@uns.ac.rs