University of Belgrade, Technical Faculty in Bor

29th International Conference Ecological Truth & Environmental Research

EcoTER'22

Proceedings

Editor
Prof. Dr Snežana Šerbula

21-24 June 2022, Hotel Sunce, Sokobanja, Serbia

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PREFACE

In today's world, the environment has been endangered by the use of outdated technology, fossil fuels and environmental law violations. Therefore, environmental and many other scientists all over the world have been concerned about finding sustainable technology in resolving these issues. That is why environmental research and ecological truth are at the focus of the 29th International Conference Ecological Truth & Environmental Research 2022 (EcoTER'22), which will be held in Sokobanja, Serbia, 21–24 June 2022. On behalf of the Organizing Committee, it is a great honor and pleasure to wish all the participants a warm welcome to the Conference.

We hope to convey the message of the conference, which is that a transformation of attitudes and behavior would bring the necessary changes. This is also an opportunity for the participants who are experts in this field to exchange their experiences, expertise and ideas, and also to consider the possibilities for their collaborative research.

The 29th International Conference Ecological Truth & Environmental Research 2022 is organized by the University of Belgrade, Technical Faculty in Bor, and co-organized by the University of Banja Luka, Faculty of Technology, the University of Montenegro, Faculty of Metallurgy and Technology – Podgorica, the University of Zagreb, Faculty of Metallurgy – Sisak, the University of Pristina, Faculty of Technical Sciences – Kosovska Mitrovica and the Association of Young Researchers, Bor.

These proceedings include 85 papers from the authors coming from the universities, research institutes and industries in 6 countries: Bulgaria, Italia, Albania, Bosnia and Herzegovina, Montenegro and Serbia.

As a part of this year's conference, the 4th Student section – EcoTERS'22 is being held. We appreciate the contribution of the students and their mentors who have also participated in the Conference.

Financial assistance provided by the Ministry of Education, Science and Technological Development of the Republic of Serbia is gratefully acknowledged by the Organizing Committee of the EcoTER'22 conference.

The support of the Platinum donor and their willingness and ability to cooperate have been of great importance for the success of EcoTER'22. The Organizing Committee would like to extend their appreciation and gratitude to the Platinum donor of the Conference for their donation and support.

We appreciate the effort of all the authors who have contributed to these Proceedings. We would also like to express our gratitude to the members of the scientific and organizing committees, reviewers, speakers, chairpersons and all the Conference participants for their support to EcoTER'22. Sincere thanks go to all the people who have contributed to the successful organization of EcoTER'22.

Prof. Snežana Šerbula,

President of the Organizing Committee

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THE IMPACT OF TEXTILE AND CLOTHES PRODUCTION ON THE ENVIRONMENT – PART II: WHAT CAN WE DO?

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Abstract

In recent years, a reduced product lifetime due to a low quality and increased affordability of clothes, led to generation of huge volume of textile waste. Fast fashion trends are based on the unsustainable consumption patterns and encourage disposability of clothes. In order to reduce the environmental and climate change impacts of textile production, circular business model should be implemented for sustainable consumption and usage of raw materials, energy, water and land, as well as for decreasing emission of polluting substances during production phase. One of the main aims of circularity is to reduce volume of waste to a minimum and keep the materials within the production loop as long as possible. Other than textile production improvements, consumption patterns and social habits should undergo changes in order to make clothing production more environmentally sustainable and responsible.

Keywords: textiles, clothes, waste, R strategy, circular economy

INTRODUCTION

Textile industry is one of the industries with the highest environmental impact. During 2017, only in the European Union (EU), the consumption of various textiles was responsible for the emission of 335 million tonnes of CO_2 equivalent and the use of 360 000 km^2 of land, 53 000 million m^3 of water and 676 million tonnes of primary raw materials, including natural fibres, numerous chemicals, fossil fuels for the production of synthetic fibres, transport and processing, etc. [1]. According to some estimation, fashion industry is responsible for 10% of global carbon emissions, which is more than international flights and maritime shipping combined [2]. If the current production/consumption model in the textile industry sustains, it is projected that pollution of the environment would increase by at least 50% by 2030. However, if the number of times a garment is worn is doubled on average, the greenhouse gas (GHG) emissions would be 44% lower [3].

In the resent years, existing trend of lowering quality of clothing led to a decrease of prices, which made both consumers and the textile industry treat garments as "easily disposable products". This global phenomenon is called "fast fashion" which led to acceleration of the clothing consumption and generation of large amounts of waste, since mass-produced clothes are widely accessible and affordable [1,4]. In the period 1996–2018, the clothing prices in the EU dropped by more than 30% [5], resulting in enlargement of the amount of bought clothes per person in the EU by 40% between 1996 and 2012 [3].

Compared to the average clothing brands, which usually release around five collections per year, some fast fashion brands provide more than 20 new clothing collections (Zara for example 24, and H&M between 12 and 16 collections per year). The number of collections increased from two during 2000 to five collections during 2011 [1,3]. Also, a wide range of clothing has become more accessible by online purchases, especially in the past few years during the COVID-19 pandemic [1].

In the EU, consumers annually discard about 5.8 million tonnes of textiles, approximately 11 kg per person, of which about ⅔ of textile are made from synthetic fibres [6]. However, textile waste is not yet in the main focus in most of the countries. Under the 2020 Circular Economy Action Plan – CEAP, the EU is expected to make textile more prominently a part of the next waste prevention programmes, by identifying textile as a "key product value". At the "end of life" various textiles are collected, sorted and reused, recycled or incinerated for energy recovery. Still, a significant amount of textiles end up in the mixed waste, resulting in incineration or landfill [4]. Methane, one of the GHG, is released by the decomposition of textiles in landfills [3]. Textile waste is usually a part of the residential solid waste, categorized as the "other waste". The share of textile waste approximates around 2.5% of a bulk residential waste [7]. In Europe, about ⅓ of textile waste is collected separately, and a large part is exported for reuse or recycling outside Europe. The percentage of the textile waste collection vary significantly in the EU countries, from 4.5% in Latvia to 45% in the Netherlands [6,8], with unclear portion of reusable clothes [3]. In the EU, out of all collected textiles about 60–70% is reused locally or abroad, 10–30% is recycled and 10–20% is incinerated or landfilled. Globally, it is estimated that only 0.06% of all textile waste (typically cotton-rich products) is recycled into fibres for new textile products [6]. The revised Waste Framework Directive 2018/851 obliges separate collection of textile waste in the EU by 2025. It is expected that the amount of textile waste in residential waste will reduce and, at the same time, the amount of waste which is available for reuse or recycling will increase [1].

In the Republic of Serbia, during 2020, the textile was collected with residential waste in the share of 4%, from which 1024 tonnes was reused as secondary material. Also, during the same year, 266 tonnes of textile waste was imported to Serbia [9]. During 2019, the share of textile in residential waste was 3%, while more than 340 tonnes of textile waste was imported [10]. For 2018, the only available data on textile waste in Serbia was the export of 529 tonnes and import of 479 tonnes of textile waste [11].

The aim of the paper is to present the changes in the clothing sector of the textile industry, which needs to be implemented in order to make clothing production more environmentally sustainable and responsible.

RESULTS AND DISCUSSION

Sustainability in the textile industry

In recent years, the well-known "3R strategy – Reduce, Reuse, Recycle" is replaced by the upgraded "R strategy" or "R list", which could be explained through two main guidelines: steps regarding product consumption (Refuse, Rethink, Reduce, etc.) and steps regarding extended life spans and functionality of clothes (Reuse, Repair, Refurbish, Remanufacture,

Repurpose, Recover, etc.) [1,4]. The "R list" relies on the long-established waste prevention and management hierarchy (Figure 1) as the optimal option for dealing with waste generation.

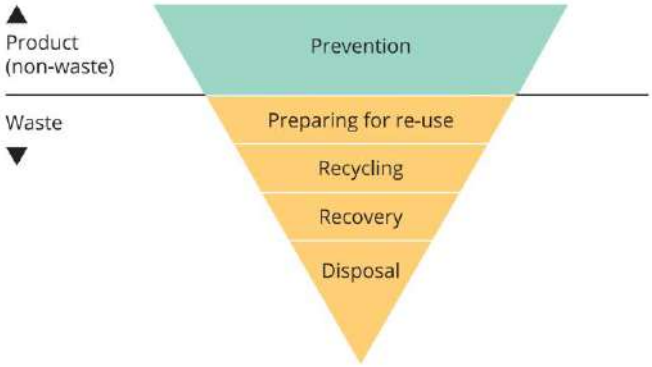

Figure 1 *Waste prevention and management hierarchy [1]*

The selection of materials and design as well as available "end of life" options, reflects the textile industry impact on the environment. The main aim is to enable sustainable production of both synthetic and natural fibres, including recycled and reused materials [5,6].

Among the natural fibres with the highest environmental impact, silk has an especially damaging effect regarding depletion of natural resources and climate change impact, compared to cotton, which is contributing excessively to water scarcity, or wool, contributing to the GHG emissions. Therefore, less frequently used natural fibres, such as hemp, flax, linen and nettle, which require less water, fertilisers and pesticides during production, are tested. The textile industry is also experimenting with bio-based polyester (bio-synthetics), which is at least partly made from renewable resources, such as starches and lipids from corn, sugar cane, beet or plant oils. The main challenge is to find feedstock that is not competitive with food production and that do not require usage of large amounts of water and pesticides. Man-made cellulosics (MMC) is biodegradable and make about 9% of fibres used in clothes in the EU and it is derived from renewable feedstock (wood pulp of trees). The most commonly used MMC is viscose. The main challenge during production is also sustainable sourcing, since the global production of MMC doubled in the period 1990–2017. In the recent years, the textile industry is trying to introduce other sustainable and innovative materials, such as: lyocell (made of cellulose from eucalyptus, which grows quickly and requires no irrigation or pesticides), bemberg (made of cotton linter that cannot be used to spin yarn), and Piñatex (made of pineapple leaves) [3]. It is important to note that not all fibres made from natural resources are biodegradable. For example, bio-based polyester is chemically equivalent to fossil-based polyester and does not biodegrade, and therefore affects the bulk microfiber loads in the environment [12].

During the textile production and finishing steps of clothes manufacture, if avoidance of hazardous chemicals is not possible, it is recommended to minimize the use of hazardous chemicals or replace them with biodegradable, bio-eliminable chemicals that do not generate potentially toxic metabolites [7] or enzymes [3]. The Dutch company DyeCoo is experimenting with novel dyeing processes, such as using CO_2 as the dyeing medium instead

of water, while other companies are experimenting with different cuts, computer controlled tools for pattern making in order to minimize cut-offs, garments with no or fewer seams, bonding or gluing instead of sewing, etc. [3].

A circular system of textile production and consumption

One of the future tasks in the textile production is a progress to a circular textile production and consumption system. Along with reductions, the system relies on longer use, more reuse and recycling of garments in order to decrease the impacts of overall clothing consumption. Important measures of circular design of textiles (Figure 2) are aimed to improve the product durability, reparability and recyclability as well to ensure the use of secondary raw materials in the composition of new textile products [8].

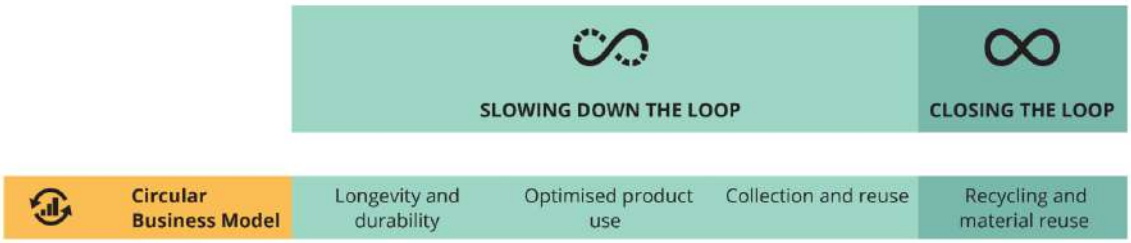

Figure 2 *Circular model of textile production and consumption system [8]*

The first step in the circularity is to ensure the longevity and durability of textile products, which allows longer use and reuse of clothes. This includes: 1) technical requirements for colour fastness and fabric resistance, 2) practical requirements making clothes multifunctional and providing repair kits and/or spare parts, 3) eco-design requirements, etc. The second step is optimising resource use to reduce the environmental impact. The main focus is on reducing and optimising water and energy use, air and water pollution by using safe chemicals and biodegradable materials. At the production stage, eco-design principles have been identified to optimise resource use. These include reducing emissions, waste and inputs such as water, chemicals and energy, and producing fibres from renewable and/or recycled sources [8]. According to some reports, the share of sustainable cotton (eco-cotton or bio-cotton) production increased from 6% during the period 2012–2013 to 19% during 2016–2017 [3]. Design requirements with defined minimum content of recycled material could also optimise resource use. The third step includes collection and reuse of textiles. Currently, only about 20% of consumers regularly buy pre-owned clothes. While the previous steps are focused on "slowing down the loop", the last step, regarding recycling and material reuse – "closes the loop". By reducing resource use and prolonging the useful life of textiles, this model enables the loop to be closed by turning waste textiles into raw material for new textiles or other production chains. The recyclability of textiles is rarely considered in the design step because of specific functional needs (stretchiness), visual (prints) or economic reasons (mixing natural fibres with less expensive synthetic fibres) of the new garments. This results in almost ⅓ of all textile waste being unsuitable for fibre-to-fibre recycling [8].

Globally, recycling of clothes faces a number of issues, such as: a lack of technologies for sorting the collected clothing, separating blended fibres, separating fibres from chemicals

including colour during recycling, establishing which chemicals were used during the production, etc. In addition, technologies that would enable clothes to be recycled into original fibres are still inadequate. This is the reason why most clothes are recycled mechanically – they are cut up and shredded whereby these fibres are shorter, have lower quality and have lost 75% of their value. The mechanically obtained fibres in this way are rather down-cycled into insulation material, wiping cloths or mattress stuffing than used for the production of new clothes. New technologies enable mechanically recycled cotton to be mixed with polyester or MMC. Technologies for chemical recycling that produce original fibres of a high quality are becoming available for polyester and nylon, but are not yet fully economically viable for cotton and fibre blends [3].

CONCLUSION

In Serbia, the collection of textile waste is at a very low level and clothes end up mixed with the residential waste. Unlike fashion brands H&M and Levi Strauss (which conduct voluntary collection of used clothes and jeans, respectively, regardless of whether they are still usable or not, in return for a small reward), in Serbia recycling of clothes is not widely supported. While technological changes, including the development of sustainable textile fibres, resource-efficient industrial production systems and improved sorting and recycling technologies for high-quality textile recycling are needed in the future, it is clear that consumption patterns and social norms should also undergo fundamental changes and transformations. However, in recent years, some examples of good practice are noticeable, such as garments and shoes made from recycled plastics (especially jackets and sneakers) or cotton products made from cotton-sustainable sources. An important measure for enabling the shift to a sustainable textiles system is the development of eco-design guidelines and requirements to ensure that textile products are fit for circularity. Preventing textile waste has great potential, mainly through reducing consumption, eco-design and reuse – the emphasis should be put on product design to promote durable and long-lasting materials, while support should be given to repair and reuse. Also, raising consumer's awareness that textiles should be separately collected from residential waste, combined with an adequate collection infrastructure are pathways for incensement of collection rate, and recycling and material reuse. However, all the needed improvements are difficult to introduce because efforts to reduce environmental impacts may result in higher prices for consumers and convincing consumers to buy fewer clothes ("slow fashion") could reduce the overall fashion industry profit.

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