



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In today's world, the environment has been endangered by the use of outdated technology, fossil fuels and environmental law violations.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 I: ENVIRONMENTAL ISSUES

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Abstract

The production of clothes has significant impacts on the environment since the textile industry has high demands regarding the use of land, water, energy, chemicals, etc. The major pollution comes from the production phase of textiles. However, various pollutants could be emitted during the specific processes of clothes manufacturing, such as bleaching, dyeing, printing, etc. The lowest impact on the climate change is associated with clothes made from natural fibers compared to the synthetic ones, of which polyester has the lowest impact. Public awareness of the environmental pollution with microplastics is increasing in recent years, while the textile industry is recognized as one of the major sources of microplastics in the oceans.

Keywords: textile, clothes, environmental pollution, microplastics

INTRODUCTION

Textile industry is very important for nowadays society, providing us with clothing, shoes, various household items, furniture, etc. The textile industry is one of the industries that is highly globalised, including millions of manufactures and billions of consumers worldwide [1]. This makes the textile industry the third largest employer in the world, after food and housing. 50% of workers are employed in the clothing production, but only about ¼ of this employment takes place in Europe, illustrating its highly global nature. Most of the textile production takes place in Asia, due to low production costs [2,3]. In the period between 2000 and 2014, the estimation of the global clothing production almost doubled reaching 14 produced items of clothing per every person in 2014. Within the same period, the number of clothing items, purchased by the average consumer, was gradually increasing, reaching 60% more purchased items by 2014 [4]. In Europe, textiles and clothing represent an important manufacturing sector, making Europe, after China, the second largest exporter of textiles and clothing in the world. During 2017, in the European Union (EU) 7.4 kg of textiles per person was produced and nearly 26 kg was consumed [1]. During 2019, the EU textile and clothing sector had a turnover of 162 billion EUR, employing over 1.5 million people across 160,000 companies [2]. Clothing items are high-value products compared to their low weight. For example, during 2020, 9% of EU production related to textiles was equal to 38% of the value of clothes [3]. From the estimated total textile consumption in Europe in 2020, amounting to 15 kg per person, the average consumption of clothing products was 6 kg or approximately 600 EUR spent by Europeans [2].

However, the profit in the textile industry comes with a high environmental impact. The type and magnitude of impacts predominantly depend on the type of fibre from which the textile i.e. clothes are made, followed by the case-specific parameters, including production process, dyeing technique, fabric construction, etc. [4].

Increased attention for the presence of microplastics in the environment is observed in recent years. Microplastics can be released directly into the environment (primary microplastics) or can result from degradation or breakdown of larger plastic items present in the environment (secondary microplastics) with an average size of 0.001–5 mm or even smaller (<0.001 mm). The long-term environmental and health impacts of pollution with microplastics are still poorly understood. However, due to the microplastics size and shape, it is proven that it can be readily ingested by aquatic species, and by entering the food chain, it could lead to chronic human exposure via food products. Textiles are a major source of microplastic pollution of the environment. Since they typically have a fibre shape, microplastics are often called microfibrils. The wearing and maintaining (washing, drying and ironing) of clothes made from synthetic fibers is recognised as one of the sources of microplastics in the environment [3,5].

The paper aims to present an overview of the environmental impacts that manufacturing of clothes have made in Europe in recent years.

RESULTS AND DISCUSSION

The impact of textile production on the environment

Environmental impact of the textile production (Figure 1) can be divided in a few main categories: the impact related to the cultivation and production of natural (land and water use, fertilizers and pesticides) and manmade fibres (use of energy and various chemicals); the impact made during manufacturing of textile products (energy and water use and uses of a broad variety of chemicals); transport emissions during distribution and retail; packaging waste and unsold textile products which end up as waste as well. However, four categories in which the textile industry is recognized a major source of environmental pollution are: use of resources, water and land use and greenhouse gas (GHG) emissions [3].

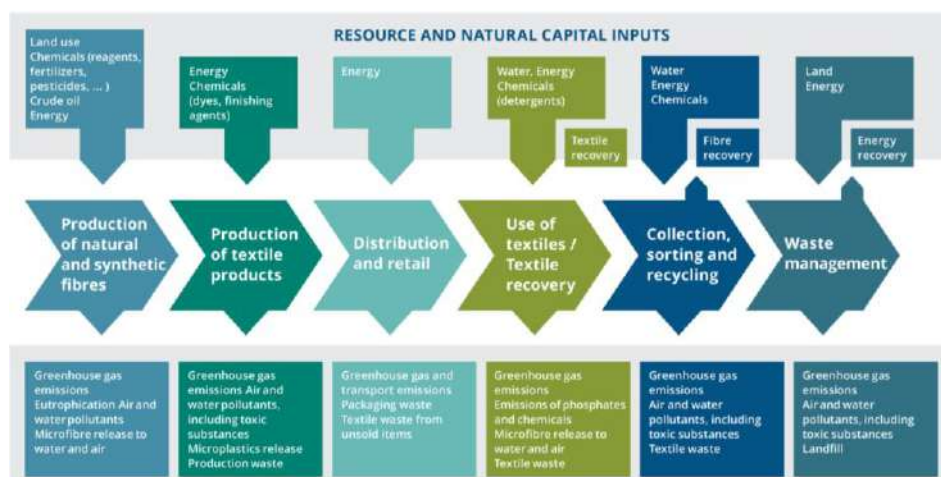


Figure 1 Environmental impacts across the life-cycle of textiles [3]

During 2020, of estimated 175 million tonnes of raw materials used in the EU (391 kg per person) roughly 40% was attributed to the clothes production. In terms of primary raw material use, this ranks textile industry as the fifth highest, which is at about the same level as health, furnishings and household goods, recreation and culture sectors [3]. The use of raw materials includes all types of materials needed for producing natural and synthetic fibres (fossil fuels, chemicals, fertilisers, etc.), all building materials, minerals and metals used in the construction of production facilities, as well as transport and retail of the textile products. Only 20% of primary raw materials are produced or extracted in Europe, which implies that 80% of environmental impacts generated by textile consumption in Europe take place outside Europe [2].

Water and land consumption for textiles bought in Europe takes place outside Europe, mostly in China and India where the major production of cotton fibres is done. It is estimated that the production of 1 kg of cotton requires about 10 m³ of water, which is the most water-consuming phase of textile production. Also, animal-based fibres (e.g. wool), have a significant impact on land use. All this makes textile industry the third most important impact on land use (after food and housing) of which 43% is attributed to the production of clothes [3].

About 80% of the total impact of textile production on the climate change occurs in the production phase, 17% in the use phase, and 3% during the end of life phase. The production of textile products, bought in the EU during 2020, generated 121 million tonnes of CO₂ equivalent (CO₂-eq) or 270 kg of CO₂-eq per person. This makes textiles the sector with the fifth largest impact on climate change (after housing, food, transport and recreation and culture), from which 50% of the GHG emissions are attributed to the production of clothes. About 75% of GHG emissions are released mostly in textile-producing regions, such as Asia. The GHG emissions could appear during fibre (0.5–9.5 kg CO₂-eq/kg fibre), yarn and fabric production, dyeing, finishing steps and confectioning [3].

Clothes made from cotton fibres generally have the lowest climate change impact (Figure 2), while those made of synthetic fibres, such as nylon and acryl, have a much higher climate impact mostly due to their fossil origin, as well as the large energy consumption during production [3]. Since 1975, the global production of textile fibres has almost tripled. Today, 60% of produced textile fibres are synthetic [1]. Since the late 1990s, polyester has surpassed cotton as the most commonly used fibre in textiles [6]. Synthetic textile fibres are produced from non-renewable resources, such as oil and natural gas. GHG emissions are generated mostly during production, consumption and waste handling of synthetic textile fibres. The production itself requires large amounts of energy. On the other hand, the production of synthetic fibres does not use agricultural resources, toxic pesticides or fertilisers, synthetic fibres are cheap and versatile, enabling the production of cheap and high-performance textiles for durable clothing. Polyester is the most commonly used synthetic fibre in the clothes industry. Although it is produced from carbon-intensive processes, requiring approximately 1% of crude oil production at a global level [1,6] compared to the other synthetic fibers, polyester has generally lower impact regarding all seven factors given in the Figure 2. More than 50% of the global synthetic fibre production accounts for polyester production with 55 million tonnes in 2018, while the production of nylon is at the second

place with 5 million tonnes in 2018. Production and use of bio-based synthetic fibres is currently negligible [6]. Production of natural fibers besides cotton, which is dominant, includes hemp and linen [2].

Textile manufacturing also involves significant use of heat consumption, particularly during drying and curing operations and wet treatments [7].

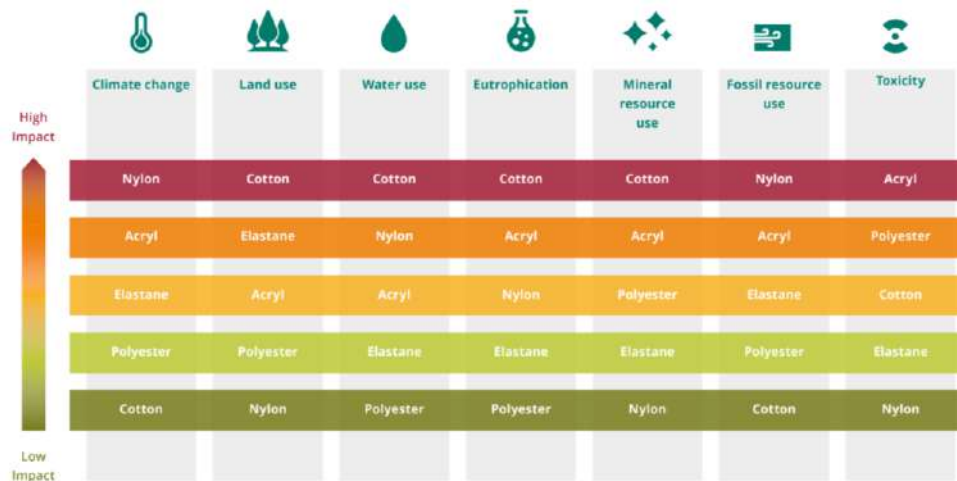


Figure 2 Comparison of the environmental impacts for the manufacturing of 1 kg of dyed woven fabric to 1 kg of synthetic (nylon, acryl, elastane, polyester) and natural (cotton) fibres [6]

Types of pollutants emitted during textile production

From approximately 3 500 substances used in the textile industry 750 of them have been classified as hazardous for human health and 440 substances are classified as hazardous for the environment [1]. The hazardous chemicals are often used in other specific processes in order to provide the final product with desired visual and functional properties. Many chemicals used in textiles pose a significant risk to water and human health, including certain phthalates, azo colours and dyes, perfluoroalkyl and polyfluoroalkyl substances, Cr(VI), dimethylfumarate, etc. For example, the production of 1 kg of cotton t-shirts requires about 3 kg of chemicals, such as dyes and finishing agents. Some chemicals which should be avoided include: heavy benzene compounds, dichromates as oxidizing agents, chlorinated and fluoro-chlorinated solvents in open systems, etc. [7].

It is estimated that about 20% of global water pollution is caused by dyeing and finishing textile products, affecting the health of workers and local communities as well [1]. Dyeing can require up to 150 L of water per kilogram of fabric [8]. Wet processing or finishing processes include: desizing, bleaching, mercerizing, dyeing, printing, and other specific treatments. In this phase fabrics are treated with chemicals and liquor baths with several steps of washing, rinsing, and drying. Wastewater effluents consist of suspended solids, mineral oils (antifoaming agents, grease, spinning lubricants, none or low biodegradable surfactants) and other organic compounds: including phenols, colour pigments, halogens, amines from dyeing; halogenated organics, hydrogen peroxide, sodium hypochlorite and sodium chlorite used in bleaching; caustic soda used in mercerizing. Effluents from dyeing process are typically hot and colored and may contain significant concentrations of heavy metals, such as

Cr, Cu, Zn, Pb or Ni. Effluents from natural fibre processing (e.g. cotton) may contain pesticides used in pre-finishing processes, potential microbiological pollutants (bacteria, fungi, and other pathogens), as well as other contaminants (sheep marking dye, tar). Process wastewater originating from the textile manufacturing is typically alkaline and needs to be neutralized [7].

Various air pollutants may be generated during processes of coating, dyeing, printing, fabric preparation, etc. [7]. Textile production includes emissions of formaldehyde, acetic acid, and other volatile compounds (VOCs) such as acetaldehyde, chlorofluorocarbons, dichlorobenzene, ethyl acetate, methylnaphthalene, chlorotoluene, etc. Also, cotton dust is easily combustible and presents a potential explosion hazard [7].

Wastes specific to the textile industry include trials, selvedge, trimmings, cuttings of fabrics, yarns, spent dyes, pigments, printing pastes, and sludge from process wastewater treatment containing mainly fibers and grease [7].

Microplastics

The global consumption of synthetic fibres increased from a few thousand tonnes in 1940 to more than 60 million tonnes in 2018, and it continues to rise. Only during 2017, in European households, roughly 13 million tonnes of textile products were consumed, of which 60% of clothing textiles were made of polyester and nylon [6]. Estimations of the amounts of microplastics released and/or formed in the environment are highly uncertain because of very large number of primary and secondary sources of microplastics and the absence of standardised sampling and measurement methods [5]. They can be dispersed in water, air and soil. The annual estimations are in the range of 16–35% of globally released microplastics to oceans originating from washing plastic based textiles or in the range of 0.2–0.5 million tonnes of emitted microplastics [1,5]. Microplastic is also emitted during textile manufacturing, during clothes wearing and "end of life" disposal, which makes the estimations even more uncertain. For Europe, it is estimated that 13 000 tonnes of textile microfibres (equivalent to 25 grams per person) are yearly released to surface water, accounting for 8% of total primary microplastic emission into water. During wastewater treatment, microplastics are filtered out (Figure 3), but still its significant share eventually ends up in water bodies [5].

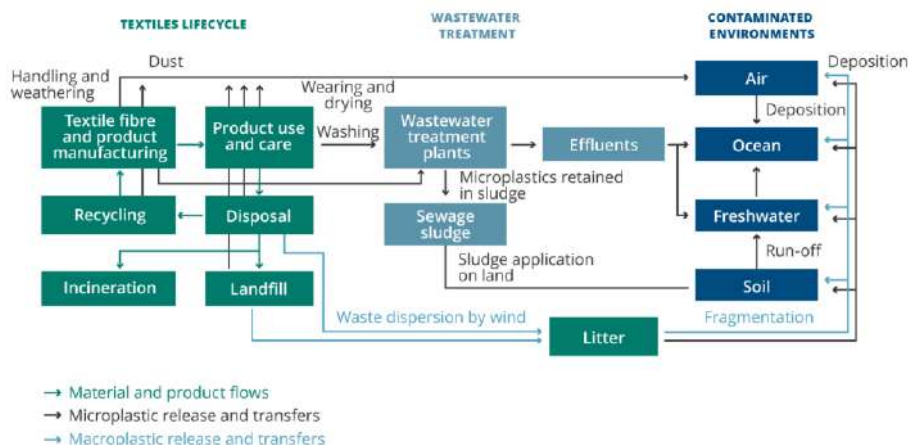


Figure 3 Release and fates of microplastic fibres from textiles [5]

CONCLUSION

In the recent years, the rapid development of technologies and material science have led to improvements in the textile industry, enabling faster production of goods, such as clothes. With mass production of clothes, along with the profit, the number and volume of hazardous substances has increased as well. The fibre production, both natural and synthetic, has great impact on the environment, since the process is related to high consumption of energy and water, high usage of land and other resources, as well as emission of wide range of hazardous substances and greenhouse gases. One of the specific-related pollutants from the textile industry is microplastics, which is generated during the production and usage of clothes made from synthetic fibres. The quantity of microplastics in the environment is uncertain, since the standard sampling procedure does not exist yet, but based on the current estimations, microplastic tends to be one of the most hazardous pollutants in the environment.

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