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**III INTERNATIONAL SCIENTIFIC CONFERENCE**

# CONTEMPORARY TRENDS AND INNOVATIONS IN THE TEXTILE INDUSTRY

**III MEĐUNARODNA NAUČNA KONFERENCIJA**

# SAVREMENI TRENDOVI I INOVACIJE U TEKSTILNOJ INDUSTRIJI

# PROCEEDINGS

## ZBORNIK RADOVA

**EDITOR: Prof. dr SNEŽANA UROŠEVIĆ**

**Belgrade, 17-18 th September, 2020**
**Union of Engineering and Technicians of Serbia**
**Dom inženjera „Nikola Tesla“**

**Conference is financially supported by The Ministry of Education, Science and Technological Development of the Republic of Serbia**

**UNION OF ENGINEERS AND TEXTILE TECHNICIANS OF SERBIA**

**"CONTEMPORARY TRENDS AND INNOVATIONS IN THE TEXTILE INDUSTRY" CT&ITI 2020**

**PROCEEDINGS**

**Editor: Prof. dr Snežana Urošević,**
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**Publiher: Union of Engineers and Textile Technicians of Serbia, Belgrade, Serbia, September, 2020.**

**For the publisher:** Prof. dr Snežana Urošević

**Printed:** SatCip,Vrnjačka banja, Serbia

**Printing: 100 copies**

**ISBN 978-86-900426-2-3**

**CIP - Каталогизација у публикацији**
**Народна библиотека Србије, Београд**

677(082)
687.1(082)

**МЕЂУНАРОДНА научна конференција Савремени трендови и иновације у текстилној индустрији (3 ; 2020 ; Београд)**
Zbornik radova = Proceedings / III Međunarodna naučna konferencija Savremeni trendovi i inovacije u tekstilnoj industriji = III International Scientific Conference Contemporary Trends and Innovations in the Textile Industry, CT&ITI 2020, Belgrade, 17-18 th September, 2020 ; [organized by] Union of Engineers and Textile Tehnicians of Serbia ... [et al.] ; editor Snežana Urošević. - Belgrade : Union of Engineers and Textile Technicians of Serbia, 2020 (Vrnjačka Banja : SatCip). - [10], 470 str. : ilustr. ; 25 cm

Radovi na srp. i engl. jeziku. - Tiraž 100. - Str. [4]: Preface / Snežana Urošević. – Napomene i bibliografske reference uz radove. – Bibliografija uz svaki rad.

ISBN 978-86-900426-2-3

1. Савез инжењера и текстилних техничара Србије (Београд)
a) Текстилна индустрија - Зборници b) Индустрија одеће - Зборници

COBISS.SR-ID 19917065

**Conference is financially supported by The Ministry of Education, Science and Technological Development of the Republic of Serbia**

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# PREFACE

The 3 rd International conference "Contemporary Trends and Innovations in the Textile Industry" CT&ITI 2020, is co-organized by the Union of Engineers and Textile Technicians of Serbia, the Union of Engineers and Technicians of Serbia, the Faculty of Technology and Metallurgy in Belgrade, the University of Faculty of Technology, Shtip, North of Macedonia, Society for Robotics of Bosnia i Herzegovina and Balkan Society Of Textile Engineering-BASTE of Greece.

The Ministry of Education, Science and Technological Development of the Republic of Serbia recognized the importance of this Conference, and thus, supported it. The aim of this Conference is to consider current technical, technological, economic, ecological, R&D, legal and other issues related to the textile industry, then the application of contemporary achievements and the introduction of technical and technological innovations in the production process of fiber, textile, clothing and technical textile by applying scientific solutions in order to improve the business and increase the competitive advantages of the textile industry on the domestic and global market.

Leading scientists and experts from the Balkans and other countries, working at faculties, textile colleges and institutes, but also individuals who professionally deal with the issues at hand are taking part in this Conference.

The Conference program involves papers dedicated to the scientific and practical aspects of the following topics: Textile and Textile Technology, Textile Design, Management and Marketing in the Textile Industry and Ecology and Sustainable Development in the Textile Industry. The Conference program includes 47 papers, and a total of 103 participants from 12 countries: Bosnia and Herzegovina, Bulgaria, Finland, Latvia, North of Macedonia, Montenegro, Romania, Russia, Serbia, Slovenia, Turkey and Ukraine.

Therefore, this Conference is an opportunity for establishing scientific, educational and economic cooperation of our country with other countries. Certain number of papers by domestic authors present the project results dealing with fundamental research and technological development, financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

I would like to thank all those who have made it possible to organize the conference Contemporary Trends and Innovations in the Textile Industry and make it a success. First, I would like to thank the Scientific and Organizing Committee for working hard, spending countless hours and finding the best solutions for numerous organizational aspects of our Conference. Also, I would like to express my gratitude to all sponsors who believed in the importance of this Conference and co-financed it. I also thank all the other institutions that supported the Conference in various ways, because without their support, the Conference could not have been organized. Last but not least, I would like to thank plenary lecturers, all authors and co-authors and guests for their participation in the Conference.

On behalf of the Organizing Committee
***Prof. dr Snežana Urošević, president***

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# TEXTILE WASTE MANAGEMENT PRACTICES

**Sonja Jordeva[1*], Elena Tomovska[2], Silvana Zhehzova[1], Sashka Golomeova Longurova[1], Vangja Dimitrijeva-Kuzmanoska[3]**

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***ABSTRACT:*** *Textile waste originates from the community via a number of streams including the textile and apparel industry, consumers, the commercial and service industries. There are two main categories: post-consumer and pre-consumer textile waste. Pre-consumer apparel cutting waste requires a different approach to waste management. In the case of apparel cuttings, reuse is not a viable option; therefore, the apparel cutting waste stream can be best managed by recycling. In order for apparel cutting waste to become a valuable resource, certain amount of processing is necessary to deliver goods that are sorted by fibre content or colour, packed in a suitable manner. A significant amount of pre-consumer textile waste is generated in N. Macedonia, a material with retained physical and mechanical characteristics. This waste is not sorted (mainly due to lack of workers), which is the main precondition and obstacle for its further processing.*

***Keywords:*** *textile waste, management, sorting, apparel production.*

# PRAKSE U UPRAVLJANJU TEKSTILNIM OTPADOM

***APSTRAKT:*** *Tekstilni otpad potiče iz zajednice kroz brojne tokove, uključujući tekstilnu industriju i industriju odeće, potrošače, komercijalnu i uslužnu industriju. Postoje dve glavne kategorije tekstilnog otpada: post-potrošački i pre-potrošački. Pre-potrošački tekstilni otpad zahteva drugačiji pristup u njegovom upravljanju. U slučaju otpada od krojenja ponovna upotreba nije održiva opcija; prema tome bolja opcija bi bila njegovo recikliranje. Otpad od krojenja postaje dragoceni resurs samo posle njegovog procesiranja, odnosno sortiranja prema sirovinskom sastavu i boji, upakovan na pogodan način. U R. S. Makedoniji stvara se značajna količina pre-potrošačkog tekstilnog otpada, materijal zadržanih fizičkih i mehaničkih karakteristika. Ovaj otpad se ne sortira (uglavnom zbog nedostatka radnika), što je glavni preduslov i prepreka za njegovu dalju preradu.*

***Ključne reči:*** *tekstilni otpad, upravljanje, sortiranje, proizvodnja odeće.*

## 1. INTRODUCTION

Waste is generally defined as a product or substance that has no further use or value for the person or organization that owns it, and which is, or will be, discarded. However, what may be discarded by one party may have value to another side [1,2,3]. Waste is a clear material impression of every aspect of the life and work of the people. It is impossible to imagine a process that does not produce waste. In general, the waste ranges from waste products from households to many toxic industrial waste specialty products [4]. The waste can not be avoided, so the question is: how to deal with it, or how to manage the waste?

Waste management is a set of activities, decisions and measures for: waste prevention, reduction of the volume and its harmful impact on the environment, collection, transport, processing and supervision of processing operations and care for the places where the waste is disposed. This is a very complex process influenced by political, economic and social factors [4,5]. The amount of waste generated, and its actual and potential negative effects on the environment and human health, are matters of concern to the Governments, industry and the civil society. The quantity of waste that is increasing every day and the irreversible loss of valuable resources and energy upon its disposal impose the need to introduce sustainable ways of managing it [1]. The basic principles of modern waste management are based on the concept of sustainable development. The United Nations World Commission on Environment and Development defines sustainable development as a development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Resources Institute, 1992) [2].

According to European legislation, the modern waste management principle is based on: a) the principle of sustainable development, b) the polluter pays principle, c) the proximity principle, d) the "producer's responsibility" principle, e) precautionary principle, f) the principle of hierarchy. The waste management hierarchy classifies the various options from the "worst" to the "best" from the environmental perspective in the following order: disposal or combustion without energy utilization contained in waste, recycling or composting, reuse and prevention [ 2,4,5]. The amount of waste is a direct consequence, but also an indicator of the degree of economic development of a country. The ratio of gross domestic product (GDP) as the basic economic indicator and the amount of waste is almost linear [4]. Not only the amount of waste but also the manner of its management depends on the degree of economic development of the country. Table 1 shows a comparison of the basic elements of the waste management system depending on the level of economic development of the country, [6]. Like all wastes, textile waste originates from the community via a number of streams including the fibre, textile and apparel industry,consumers, the commercial and service industries [7]. According to the European Commission, the textile and apparel industry are industries that cover a wide range of fiber production activities and their transformation into yarns, fabrics and non-woven textiles used in the manufacture of various products, not only in

the apparel industry but also in the automotive and the construction industry, medicine, sports, etc. [7,8].

**Table 1:** Comparison of the basic elements of the waste management system depending on the level of economic development of the country [6]

| Activity | Degree of development of the country | | |
|---|---|---|---|
| | **Poorly developed** | **Medium developed** | **Highly developed** |
| **Waste collection** | Not enough, only in urban areas. Insufficient number and quality of mechanization for collection. The share of the population covered by collecting is below 50%. | Relatively developed collection system with high percentage of involved urban population. The waste from the rural areas is collected very little. Collection rate varies between 50 to 80%. | High percentage of waste collection, over 90%. Organized gathering in rural areas as well. Modern mechanization is used for collection. |
| **Primary and secondary separation (separation or sorting)** | There is no primary separation, while the secondary is very poorly developed. The market for secondary raw materials is poorly developed. | The primary selection is very poorly developed, at the household level there is no primary separation. Secondary separation is partially present. | Highly developed primary separation, primary separation at household level. Developed plant system for secondary separation. |
| **Disposal** | The only way for waste treatment. Landfills do not meet the minimum of technical and technological requirements. | The most dominant method of waste treatment. Existence of sanitary landfills, but also a certain number of landfills that do not meet the minimum technical and technological requirements. | The emphasis is on reducing landfills. Existing landfills meet the minimum of technical and technological requirements regarding environmental protection. |
| **Recycling** | The only form of recycling is based on the informal sector. The market is undeveloped, there is no legal regulation. There is a big difference in the prices of recycling materials. | The informal sector is still present. There is a certain number of plants for waste sorting. Due to insufficient capacity of the plants waste (recyclables) is mainly exported. The prices of recycling materials are | Organized collection of recycling materials availability of adequate sorting and processing facilities. The market and legislation are clearly defined and regulated. Introducing the |

| | | | |
|---|---|---|---|
| | | generally uniform. | principle of producer responsibility. |
| **Composting** | Very little represented. The only form is informal composting in the household. | There is a certain number of composting plants, but the compost is mainly contaminated and with poor quality due to insufficient primary separation. | Presented at the household level as well as at the central level in large plants. The compost is with good quality due to the developed primary separation. |
| **Combustion** | Practically does not exist due to the high costs and lack of professional staff. | There are a number of combustion plants with major financial and operational difficulties in operating. Poor monitoring of the emissions of gases. | High power consumption and sophisticated technologies to reduce gas pollution. Developed monitoring system for gas emissions. |

The exact impact of textiles on the environment varies greatly depending on the type of fiber and the products from them. A larger amount of textile production and the consumption of textile products means a greater quantity of textile waste. Increasing of the textile production is the result of a rise in living standards, that is a function of consumer demands influenced by the state of the economy [9]. According to the results of the survey issued by the United Nations (2011), world fibre consumption, and therefore the consumption of final product made of fibers, has grown nearly 30 times since the 1950s [10]. Global textile consumption is estimated at more than 30 million tons a year, [11]. Textile and apparel industries are enormously growing, but at the same time, the environmental issues associated with them are multiplied. For this, the trend of the frequent and early replacement of textile products with new ones is greatly contributed. [12]. The future of textiles and clothing faces with many problems such as: limited natural resources, global warming, the issue of sustainability and other social and political trends [13]. How in the context of sustainable development textile is positioned and what is perception of the textile industry enough speaks the fact that it is still considered as one of the most polluting industries and textile as an environmental threat. Until recently, development in the textile industry has focused on the development of technologies and the creation of products that will be competitive on the market with an emphasis on the low price of the final product. Designers, manufacturers and retailers paid less attention to other aspects, for example the impact on the environment [13,14]. Table 2 shows the unsustainable impact of the textile industry on the environment and society [14].

**Table 2**: Unsustainable influence of the textile industry [14]

| Influence of the textile industry on the environment | Influence of the textile industry on the society |
|---|---|
| ***Contribution to climate change***<br>-combustion of fossil fuels to obtain electricity | ***Low salary***<br>-minimal salary sometimes lower than minimal salary needed for life<br>-poverty |
| ***Toxic chemicals***<br>-fertilizers and pesticides in agriculture<br>-in the stages of production process, such as fiber extraction, dyeing, printing and other stages of ennoblement | ***Low working standard***<br>-bad working conditions<br>-utilization of kids labor |
| ***Textile waste increasing***<br>-biologically non-degradable<br>-large quantities due to premature replacement | ***Low level of collective negotiation***<br>-some countries do not allow the establishing of trade unions |
| ***Water consumption***<br>-usage large quantities of water during cotton cultivation, the process of ennoblement and textile care | ***Lack of fair trade***<br>-in some countries grant and regulations prevent fair trade |
| ***Unsustainable raw materials***<br>-fossil fuels (oil, coal, gas) used in production of synthetic fiber | |
| ***Occupation of space (area)***<br>-large space (area) for cotton cultivation or pastures (instead of being used for food production) | |

In the textile and apparel production solid waste is produced at all points in the manufacturing process. The discarded materials are predominantly paper/cardboard, metals, glass, plastic, and textile products such as fibers, yarn, and cutting waste.Textile waste can be divided in two main categories (by its origin): post-consumer or household waste, and pre-consumer waste generated during the manufacturing process. Pre-consumer textile waste is actually a material that is discarded or sent for recycling before being ready for final use [7,11]. From clothing manufacturers, 450-600 million tonnes of waste are generated annually from the process of cutting. The volume of textile waste in production depends on the complexity and number of production processes in the enterprise. Generally, the total amount of waste from the whole cycle of industrial production, from fibers to sewing, may be between 40 - 50% of the raw material. Each year, 750000 tonnes of pre-consumer textile waste is recycled into new products for the automotive industry, the furniture industry etc. [15]. The World Resources Institute reported that the share of post-consumer textile waste in the total amount of municipal solid waste was 4% [16]. According to the US Recycling Council (2006), 4.5 kg post-consumer waste per capita per year is generated. This category of waste is considered to be a waste of quality that allows the reuse of recyclable goods by other users or is sold as second hand in the third world countries. 48% of this waste is recycled as second-hand clothing, and the rest ends at landfills [11,16]. In EU countries, consumers throw approximately 5.8 million tons of textiles every year. Only 1.5 million tonnes (25%) of

this textile is recycled in industrial enterprises or used as a donation. The remaining 4.3 million tonnes are land-filled or burnt, [17].

## 2. EXAMPLES OF TEXTILE WASTE MANAGEMENT IN SOME COUNTRIES

In economically developed countries, most of the textile waste is post-consumer waste, while the amount of pre-consumer waste is marginal. Because of this, the most attention is paid to the collection and sorting of post-consumer waste. The highest percentage of collected waste is recycled by selling it to poor countries as second-hand clothing. In the UK [1], there is a constant increase in the volume of collected textiles for reuse and recycling. The amount of recycled textile in the United Kingdom in 2008 was 28.000 tonnes. Most of this material is recycled in a material for filling mattresses, for upholstery, for the automotive industry and for thermal insulation in construction. In Japan [1], about 1 million tons of old, worn out garments are collected each year, of which only 12% regenerate in some way. Japanese company Teijin Fibers Ltd. developed a recycling system of polyester materials, so-called ECOCIRCLE TM. In the United States [18] there are 500 recycling companies for textile waste. The recycling industry employs 10000 semi-skilled workers at the primary level and another 17000 in the final stages of the process. In 2007, 11.9 million tons of textile waste was registered in the United States. For the United States and Great Britain, recycling of carpets is typical, resulting from large quantities of this waste.

In general, the main method for the elimination of textile waste in Europe is combustion, because the European Parliament forbids the burial of waste that can be recycled with a resolution [19]. Landfills are officially closed in France, and the same trend exists in Germany. An exception is the United Kingdom where still 70% of the waste is dumped at landfills. The cost of incineration of textile waste in European countries is increasing. For example, in the Netherlands the costs grew by 40% over a period of 5 years. Belgium is the country with the highest costs of incineration of textile waste, roughly around 150 euros per tonne. Unlike other European countries (France, Germany, Spain, Belgium) in Poland, there is an increase in recycling rates of 10-20% annually. In France there is a legal obligation for manufacturers to provide recycling themselves or through the French Environmental Protection Agency and energy management. The Federation of Recycling Industries in France has about a thousand members and is set up to help treat textile waste. It cooperates with all entities, primarily with textile manufacturers and competent authorities (governments and ministries). In 2006, 700.000 tonnes of various textile products were placed on the French market (11 kg / per capita). The same year, 106.000 tons of textiles were collected (1.7 kg / per capita). It should be emphasized that nearly half of this amount of 52,000 tonnes was sorted waste, [20].

The majority of textile production is located in developing countries. As an example, we will consider the practice of treating textile waste in Turkey, Lithuania and South Africa. The selection of these countries was made on the basis of two criteria: they are large textile producers in their regions and have a similar value of GDP with R. N. Macedonia, [21]. In Turkey [22] 62% of textile waste was sold to recycling companies, while only

16% ended in landfills. According to the raw content material cotton (29%) and polyester (24%) prevail. Textile waste that ends at Turkish landfills is 2.62% of the total amount of solid waste. There is no data that this waste is burnt or composted.
The analysis of the textile waste in Lithuania, [23] shows a domination of materials of natural fibers (cotton, flax and wool-47%) as well as mixtures of cotton/polyester, cotton/ polyacrylonitrile and wool/polyacrylonitrile-41%). 13% of the textile waste is from artificial and synthetic fibers. Only 12.1% of the total amount of textile waste is recycled. 14.4% of textile waste is sold to textile waste collection companies, 24.7%, to recycling companies and 0.8% to individuals. Only 0.1% of the waste is donated. 47.6% of the textile waste is dumped in landfills
Waste management studies in South Africa [24] showed that 62.1% of the apparel manufacturers disposed the waste in landfills, while only 7.6% sell it. The lack of equipment and technologies has been identified as a key barrier for recycling.

## 3. TEXTILE WASTE MANAGEMENT PRACTICES IN R. N. MACEDONIA

The consumption of textiles and clothing on a global level is different depending on the degree of economic development of the country and the environmental awareness of the citizens. The largest consumer is the United States with 35 kg/capita per year, followed by European countries with 20 kg/capita per year, while the countries with low income consume around 3-9 kg/capita per year [25]. Data on the consumption of textile and clothing per capita in Macedonia is not available, according to the author's assessment, this value is from 10-12 kg/capita per year.
R. N. Macedonia belongs to the countries with developed textile industry (more precisely apparel industry) as a result of what a large amount of pre-consumer textile waste is generated. There are more than 300 apparel companies that export around 1.400.000 pieces of clothing monthly. In the total GDP, the textile industry participates with 15.2% and in the industrial sector with 21.8%. In the total exports, the textile industry participates with 26% and employs 28% of the total number of workers in the industry, [26].
In previous investigations, [27-29, 31-34] Jordeva, S., Tomovska,. E., Trajković, D., and Zafirova, K worked on the characterization of textile waste, the current state of textile waste management and the attitudes of the managers of the apparel companies in the R. N. Macedonia towards the recycling of the textile waste. According to the research [27] 1.7 kg/capita pre-consumer textile waste remains annually, which is new, clean, with retained physical and chemical characteristics. Regarding the raw material content, pure cotton fabrics and their mixtures, 51.16% dominate. Materials from wool and wool blends are only 1.16%. In 60% of companies, about 30% of their materials contain lycra, while in others this percentage is even greater, [28,29].
Any processing of apparel cutting waste is predetermined by the methods of sorting, packaging and transportation. The biggest contribution of the manufacturers to recycling is the willingness to sort waste, because only sorted waste can be recycled.
Grasso [30] emphasizes the importance of sorting and packaging the waste from cutting, as well as the fact that it must be clean, without other objects in order to be seen as a

valuable resource. According to him, baling the waste in bales instead of collecting it in boxes makes an important difference for buyers, it increases its value.

The most common way of packaging textile waste in the R. N. Macedonia is in plastic bags (55.81% of companies use it), in cardboard boxes 17.44%, while 16.28% throws waste directly into containers. 5.81% of companies collect the waste in cotton bags and only 4.65% use baling. 1.16% of companies apply a combination of several methods, for example, baling and packaging in cardboard boxes. Disposal in landfills is the dominant waste management practice. Almost all waste is collected by governmental waste service companies, 94.19% of cases, [31,32]. The key factors or obstacles for introducing the sorting are: insufficient number of workers, difficulties in sorting by color and raw composition and introduction of baling as a method of packing the sorted waste. N. Macedonian's apparel companies produce mostly cutting waste from cotton fabrics with the presence of lycra, which makes them not suitable for mechanical recycling. An alternative way to prevent the loss of this resource is to apply it in a new product such as composite materials, thermal insulation of buildings, concrete reinforcement or other segments mostly in construction.

The main conditions that companies would accept to change the current way of waste treatment and would introduce waste sorting and sale are: profit for 47.06% of companies, and long-term contract with recycling companies by 18.82%. 21.2% of company managers do not want to introduce the sorting and sale of waste under any circumstances, [33,34].

## 4. CONCLUSION

A significant amount of pre-consumer textile waste is generated in R. N. Macedonia, a new material with retained physical and mechanical characteristics. Waste is not sorted (mainly due to lack of workers), which is the main precondition and obstacle for its further processing. The barrier to introducing sorting has a subjective aspect - the negative attitude of the N. Macedonian top managers towards the introduction of sorting as a prerequisite for recycling. As factors contributing to the current situation with the management of pre-consumer textile waste are the lack of a market for recycled products and legislation. As a combination of all objective and subjective factors, almost all of the apparel cutting waste is collected by governmental waste service companies and ends up at local landfills. The government and the textile cluster should make serious efforts to help the apparel companies to change the current way of managing pre-consumer textile waste, especially in the direction of creating a market for recycled products and taking action to raise awareness of the producers about the importance of modern waste management systems.

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