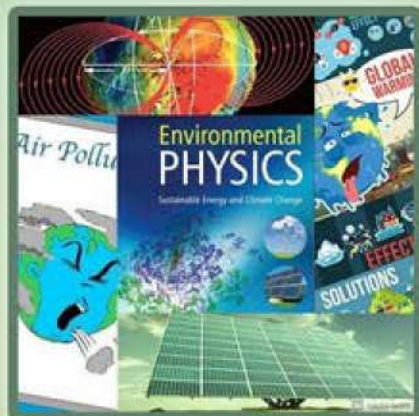




UNIVERSITY OF NOVI SAD
Technical faculty "Mihajlo Pupin"
Zrenjanin, Republic of Serbia



**IV International Conference on
Physical Aspects of Environment
ICPAE 2025**

PROCEEDINGS

Zrenjanin, Serbia, August 29-30, 2025.



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



IV International Conference on Physical Aspects of Environment ICPAE2025

Proceedings

Zrenjanin, 29 – 30th, August 2025.

Proceedings of the IV International Conference on Physical Aspects of Environment ICPAE2025

Conference Organizer:

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

Publisher:

Technical Faculty "Mihajlo Pupin" Zrenjanin, University of Novi Sad, Đure Đakovića bb, Zrenjanin, Serbia

For Publisher:

Milan Nikolić, Ph.D, Professor

Dean of the Technical Faculty "Mihajlo Pupin" Zrenjanin, University of Novi Sad, Serbia

Editor:

Darko Radovančević, Ph.D, Assistant Professor

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

Co-Editor:

Ljubiša Nešić, Ph.D, Professor

Faculty of Sciences and Mathematics, University of Niš, Serbia

Technical preparation:

Luka Đorđević, M.Sc, Assistant

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

CIP Classification:

CIP - Каталогизacija y публикацији
Библиотеке Матице српске, Нови Сад

502(082)(03.034.4)

INTERNATIONAL Conference on Physical Aspects of Environment (4 ; 2025 ; Zrenjanin)

Proceedings [Elektronski izvor] / IV International Conference on Physical Aspects of Environment ICPAE2025, Zrenjanin, 29-30th August 2025 ; [editor Darko Radovančević]. - Zrenjanin : Technical Faculty "Mihajlo Pupin", 2025. - 1 elektronski optički disk (CD-ROM) : tekst, ilustr. ; 12 cm

Sistemske zahteve: Nisu navedeni. - Nasl. sa naslovnog ekrana. - Elektronska publikacija u formatu pdf opsega IX, 247 str. - Str. V: Introduction / Darko Radovančević. - Bibliografija uz svaki rad.

ISBN 978-86-7672-390-4

a) Заштита животне средине -- Зборници

COBISS.SR-ID 174657801

SCIENTIFIC PROGRAM COMMITTEE

- Vasilije Petrović, University of Novi Sad, Technical Faculty “Mihajlo Pupin“, Zrenjanin, Serbia – President of the Scientific Program Committee
- Darko Radovančević, University of Novi Sad, Technical Faculty “Mihajlo Pupin“, Zrenjanin, Serbia – Vice President of the Scientific Program Committee
- Ljubiša Nešić, University of Nis, Faculty of Sciences and Mathematics, Nis, Serbia - Vice President of the Scientific Program Committee
- Đorđe Vučković, University of Novi Sad, Technical Faculty “Mihajlo Pupin“, Zrenjanin, Serbia
- Nadežda Ljubojev, University of Novi Sad, Technical Faculty “Mihajlo Pupin“, Zrenjanin, Serbia
- Snežana Filip, University of Novi Sad, Technical Faculty “Mihajlo Pupin“, Zrenjanin, Serbia
- Bogdana Vujić, University of Novi Sad, Technical Faculty “Mihajlo Pupin“, Zrenjanin, Serbia
- Višnja Mihajlović, University of Novi Sad, Technical Faculty “Mihajlo Pupin“, Zrenjanin, Serbia
- Ljiljana Radovanović, University of Novi Sad, Technical Faculty “Mihajlo Pupin“, Zrenjanin, Serbia
- Jelena Stojanov, University of Novi Sad, Technical Faculty “Mihajlo Pupin“, Zrenjanin, Serbia
- Jasna Tolmač, University of Novi Sad, Technical Faculty “Mihajlo Pupin“, Zrenjanin, Serbia
- Mila Kavalić, University of Novi Sad, Technical Faculty “Mihajlo Pupin“, Zrenjanin, Serbia
- Saša Jovanović, University of Pristina with temporary headquarters in Kosovska Mitrovica, Faculty of Technical Sciences, Kosovska Mitrovica, Serbia
- Jovan Stepanović, Univerzitet u Nišu, Tehnološki fakultet u Leskovcu, Leskovac, Srbija
- Lana Pantić Randelović, Univerzitet u Nišu, Prirodno-matematički fakultet, Niš, Srbija
- Ljubiša Đorđević, University of Nis, Faculty of Sciences and Mathematics, Nis, Serbia
- Vesna Nikolić, Univerzitet u Nišu, Fakultet zaštite na radu, Niš, Srbija
- Tatjana Jovanović, Univerzitet u Nišu, Medicinski fakultet, Niš, Srbija
- Milan Pantić, University of Novi Sad, Faculty of Sciences, Novi Sad, Serbia
- Miodrag Krmar, University of Novi Sad, Faculty of Sciences, Novi Sad, Serbia
- Nataša Todorović, University of Novi Sad, Faculty of Sciences, Novi Sad, Serbia
- Jovana Nikolov, University of Novi Sad, Faculty of Sciences, Novi Sad, Serbia
- Nikola Jovančević, University of Novi Sad, Faculty of Sciences, Novi Sad, Serbia
- Dragan Markušev, Institute of Physics, Belgrade, Serbia
- Zoran Mijić, Institute of Physics, Belgrade, Serbia
- Dragan Đorđić, Institut za opštu i fizičku hemiju, Beograd, Srbija
- Robert Repnik, Univerza v Mariboru, Fakulteta za naravoslovje in matematiko, Maribor, Slovenija
- Vanja Radolić, Josip Juraj Strossmayer University of Osijek, Department of Physics, Osijek, Croatia
- Diana Mance, University of Rijeka, Department of Physics, Rijeka, Croatia

- Slavoljub Mijović, University of Montenegro, Faculty of Science and Mathematics, Podgorica, Montenegro
- Lambe Barandovski, Ss. Cyril and Methodius University, Faculty of Natural Sciences and Mathematics, Skopje, North Macedonia
- Snježana Dupljanin, University of Banja Luka, Faculty of Natural Sciences and Mathematics, Banja Luka, Bosnia and Herzegovina
- Senad Odžak, University of Sarajevo, Faculty of Science, Sarajevo, Bosnia and Herzegovina
- Eugenia Riemschneider, West University of Timisoara, Faculty of Arts and Design, Timisoara, Romania
- Roohollah Bagherzadeh, Amirkabir University of Technology, Institute for Advanced Textile Materials and Technology (ATMT), Tehran, Iran
- Yuqiu Yang, Donghua University, Shanghai, China
- Wang Hua, Donghua University, Shanghai, China
- Guoxiang Yuan, World Textile University Alliance, Donghua University, Shanghai, China
- Xu Ming, Donghua University, Glorious Sun School of Business and Management, Shanghai, China
- Sheng Hongfei, Industrial Design Department, Wuhan Textile University, Wuhan, China
- Zamir Ahmed Awan, Global Silk Route Research Alliance, Pakistan
- Adane Haile Woldemariam, Bahir Dar University, Ethiopia

ORGANIZING COMMITTEE:

- Darko Radovančević, University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia – President of the Organizing Committee
- Ljubiša Nešić, University of Nis, Faculty of Sciences and Mathematics, Nis, Serbia – Vice President of the Organizing Committee
- Luka Đorđević, University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia – Secretary of the Organizing Committee
- Milan Marković, University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia – Secretary of the Organizing Committee
- Danka Đurđić, University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia – Secretary of the Organizing Committee
- Katarina Ivanović, University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
- Anita Milosavljević, University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, Serbia
- Natalija Nikolić, University of Novi Sad, Faculty of Sciences, Novi Sad, Serbia
- Teodora Crvenkov Marković, University Clinical Centre of Serbia, Belgrade, Serbia

INTRODUCTION

IV International Conference on Physical Aspects of Environment (ICPAE2025), held on August 29–30, 2025, was organised by the Technical Faculty “Mihajlo Pupin” Zrenjanin. The Conference co-organiser was the Faculty of Sciences and Mathematics, University of Niš.

The members of Conference committees were distinguished professors and researchers from the University of Novi Sad, the University of Niš, the University of Pristina with temporary headquarters in Kosovska Mitrovica, the Institute of Physics in Zemun, the University of Maribor, the University of Josip Juraj Štrosmajer in Osijek, the University of Rijeka, the University of Montenegro, the “Ss. Cyril and Methodius” University in Skopje, the University of Banja Luka, the University of Sarajevo, the West University of Timișoara, Amirkabir University of Technology (Tehran, Iran), Donghua University (Shanghai, China), and Wuhan Textile University (Wuhan, China).

The paper presentations at the Conference were moderated by Vasilije Petrović, Ph.D, Professor; Ljubiša Nešić, Ph.D, Professor; Jasna Tolmač, Ph.D, Assistant Professor; Darko Radovančević, Ph.D, Assistant Professor.

The Conference included 42 submitted papers, of which 5 were presented as plenary lectures, and the remaining were allocated to brief oral sessions. Among the submissions, 14 papers had first authors from China, Iran, Sweden, Romania, Bulgaria, North Macedonia, Montenegro, Bosnia and Herzegovina, Croatia, Slovenia, and Ethiopia, and 28 papers had first authors from Serbia. One paper had a co-author from the United Kingdom.

The Conference gathered distinguished participants who presented their research, ideas, and accomplishments on a range of pressing topics, including geophysics, environmental modelling, air pollution, the greenhouse effect, global warming and climate change, radiation and the environment, energy efficiency and sustainable development, environmental physics and education, as well as industry and new materials.

President of the Organizing Committee

Darko Radovančević, Ph.D, Assistant Professor

Zrenjanin, 29 - 30th August 2025.

Conference participants are from the following countries:



United Kingdom



Bosnia and Herzegovina



Romania



North Macedonia



Serbia



Croatia



Iran



Bulgaria



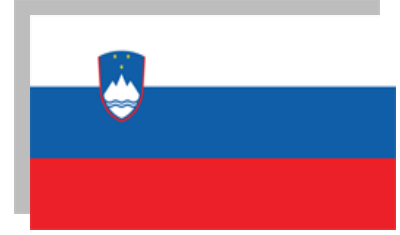
Ethiopia



Montenegro



China



Slovenia



Sweden

CONTENTS

INVITED LECTURES

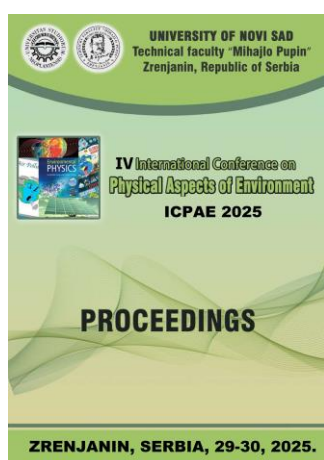
<i>From Planck's Quantum to a Sustainable Future</i> (Milan Pantić)	2
<i>Horizontal Mixing of Air Parcels at High Altitudes</i> (Ljubiša Nešić)	3
<i>Circular Economy in the Textile Industry</i> (Vasilije Petrović)	4
<i>Waste Practices in Vojvodina's Apparel Industry</i> (Nadiia Bukhonka, Marija Pesic, Ineta Nemesa, Darko Radovancevic, Valentina Bozoki)	12
<i>Milankovitch Cycles and Climate Change</i> (Darko Radovančević)	23

LECTURES

<i>Changing the Planet Earth Through Sustainable Materials</i> (Anita Milosavljević, Vasilije Petrović, Dragan Đorđić, Darko Radovančević Marija Petrović, Sonja Jordeva)	30
<i>Assessment of the Impact of Global Warming and Climate Change on the Quality of Durum Wheat</i> (Milana Drašković, Gellért Gligor, Danijela Jašin)	36
<i>The Importance of Biomaterials in Medicine</i> (Slaviša Đurđević, Anita Milosavljević, Vasilije Petrović, Guoxiang Yuan, Predrag Pecev, Dragan Đorđić, Marija Petrović)	41
<i>Biodegradable Textile Materials as a Sustainable Alternative to Synthetic Fibers</i> (Dragan Đorđić, Vasilije Petrović, Anita Milosavljević, Darko Radovančević, Marija Petrović)	49
<i>Bridging Theory and Practice: The Role of Service-Learning in Design Education in Private Universities in Taiwan</i> (Chia-Yi Wu, Guoxiang Yuan, Vasilije Petrović, Qingxin Peng)	57

<i>The Role of Air Pollution in Shaping Migration Trajectories: A Case Study of Belgrade, Serbia</i> (Milica Langović, Vladimir A. Srećković, Zoran Mijić, Marija Ljakoska)	65
<i>The European Circular Economy in the Textile Sector</i> (Roohollah Bagherzadeh, Vasilije Petrovic, Guoxiang Yuan, Yuqiu Yang, Biljana Klincov - Djurdjevic, Anita Milosavljevic, Dragan Djordjic, Marija Petrovic).....	70
<i>Determination of the Amount of Cutting Waste and Its Characterization</i> (Sonja Jordeva, Silvana Zhezhova, Saska Golomeova Longurova, Sanja Risteski, Anita Milosavljevic).....	76
<i>EnergyPLAN-Based Scenarios for Serbia's 2030 Low-Carbon Power System</i> (Jovana Radnović, Jasmina Pekez, Nadežda Ljubojev).....	83
<i>Industry 4.0 Technologies and Sustainable Development of Domestic Enterprises</i> (Verica Gluvakov, Mila Kavalić, Sanja Stanisavljev, Stefan Ugrinov, Snežana Mirković)	91
<i>Radiotracers in Industrial and Environmental Processes</i> (Srdan Vuković, Danijela Rajić, Aleksandar Vuković, Svetlana Pelemiš).....	97
<i>Overview of Air Pollution Monitoring Software Tools</i> (Tamara Milic, Darko Radovancevic, Nemanja Tasic, Igor Vecstejn).....	103
<i>Adoption of Sustainable Logistics Practices and Their Impact on Environmental Performance in Manufacturing Supply Chains</i> (Stefan Ugrinov, Đorđe Vučković, Sanja Stanisavljev, Verica Gluvakov, Mila Kavalić).....	111
<i>Radon-222 as a Tracer for Managed Aquifer Recharge in Karst Systems: Preliminary Results from Southern Istria, Croatia</i> (Marija Čargonja, Diana Mance).....	116
<i>Analysis of the Energy Efficiency of the Syrup Evaporation Plant</i> (Jasna Tolmac, Slavica Prvulovic, Uros Sarenac, Darko Radovancevic, Milan Markovic).....	121
<i>Modeling Toxic and Flammable Gas Dispersion of Hydrogen Sulfide and Propane at the Oil Refinery</i> (Jovana Čugalj, Branislava Radišić).....	127
<i>Strategies for Increasing Efficiency in the Clothing Production Line - A Theoretical Approach</i> (Jelena Djukic, Vasilije Petrović, Anita Milosavljević, Darko Radovančević)	133
<i>Conceptual Challenges in Teaching Environmental Physics</i> (Ivana Krulj, Ljubiša Nešić, Darko Radovančević)	137
<i>Measuring the Speed of Sound with Smartphones: Bridging Physics and Environmental Science</i> (Lazar Radenković, Ljubiša Nešić, Darko Radovančević)	142
<i>Movement of Quantity and Morphological Composition of Municipal Waste in the Subotica Agglomeration</i> (Gellért Gligor, Milana Drašković, Danijela Jašin).....	147
<i>Neoliberal Globalization and the National Environmental Protection System</i> (Edi Daruši).....	152
<i>Neoliberal Capitalism and Global Climate Change</i> (Edi Daruši).....	157

<i>Climate Change, Green Technologies, and State Interventionism</i> (Edi Daruši).....	162
<i>New Materials in Packaging Industry</i> (Danijela M. Jašin, Milana Drašković, Gellért Gligor).....	168
<i>GIS Analysis of Agriculture–Ecotourism Land Use Conflict in Kladovo Municipality, Serbia</i> (Natalija Nikolić, Ivan Novković).....	173
<i>PET Recycling in Textiles: Multiple Cycles, Quality and Circular Design</i> (Eugenia Elena Riemschneider).....	178
<i>Summer Measurements of Indoor Air Quality at TCAS</i> (Iris Borjanović Trusina, Jelena Kiurski Milošević, Željko Ereimić).....	187
<i>Modernising Physics and Mathematics Teacher Education: Integrating Digital Competencies and Sustainability for Primary Schools</i> (Robert Repnik, Arbresha Hölbl, Petra Cajnko, Damjan Osrajnik, Robert Sterkuš, Eva Klemenčič).....	193
<i>Reusing Post-Consumer Textiles for Decorative and Insulating Panels: A Sustainable Design Approach</i> (Valentina Ștefănescu).....	201
<i>Sustainable Fashion and Educational Design as a Tool for Environmental and Social Change</i> (Mihajlo Manigodić, Miljana Ivković, Edi Daruši).....	207
<i>Increasing Oil Production by Polymer Injection – Repair and Isolation Operations (RIO)</i> (Radovan Jagodin, Slavica Prvulović, Branislava Radišić, Martina Paunjorić).....	213
<i>Radiative-Cooling Textiles for Passive Body Cooling – A Teaching Concept</i> (Gebregziabher Kidus Tesfamariam, Vasilije Petrović, Ljubiša Nešić, Darko Radovančević, Anita Milosavljević).....	218
<i>Ultraviolet Radiation and Human Health – A Model of an Interdisciplinary Lesson in Natural Sciences</i> (Ranko Radovančević).....	223
<i>Monitoring Microclimate Parameters in a Schoolyard Using Basic Physical Concepts</i> (Vera Zoroska, Ljubcho Jovanov, Katerina Drogreshka).....	228
<i>Connection Between Bio-Economy and Climate Change</i> (Vladimir Petrovic).....	233
<i>Modeling Global Warming with En-Roads Simulator</i> (Vladimir Petrovic).....	238
<i>Artificial Intelligence (AI) in Physics Concept Visualization: Advancing Understanding of Abstract Phenomena</i> (Nemanja Tasić, Miodrag Kovačević, Igor Vecštejn, Tamara Milić, Marjana Pardanjac).....	243



**IV International Conference on Physical
Aspects of Environment ICPAE2025
August 29-30th, 2025, Zrenjanin, Serbia**

INVITED LECTURES

Determination of the Amount of Cutting Waste and Its Characterization

Sonja Jordeva¹, Silvana Zhezhova¹, Saska Golomeova Longurova¹,
Sanja Risteski¹, Anita Milosavljevic²

¹ *University Goce Delcev Stip, Faculty of Technology, Republic of North Macedonia*
sonja.jordeva@ugd.edu.mk

² *University of Novi Sad, Technical faculty “Mihajlo Pupin” Zrenjanin*
Dure Đakovića BB, Zrenjanin, Serbia
anita.milosavljevic@uns.ac.rs

Abstract. The generation of cutting waste is an inevitable outcome of production processes in the clothing industry. Efficient management of cutting waste can lead to significant cost savings, resource optimization, and environmental sustainability. Although this waste can be a valuable resource, it is currently only one of the environmental pollutants. In order to implement a more efficient way of managing apparel cutting waste, a comprehensive analysis of its quality and quantity needs to be done. This paper presents an applied methodology to determine both the quantity and quality of cutting waste at the place of creation in the clothing manufacturing company. The application of this methodology will be the basis for further research to develop a more efficient way of managing cutting waste than the current one - disposal in landfills.

Keywords: textile waste, cutting waste, methodology

INTRODUCTION

The textile industry in the Republic of North Macedonia represents one of the leading manufacturing industries, with significant contributions to GDP formation, high labor absorption, and exports. This industry employs around 35,000 workers, which accounts for approximately 27% of all employees in the manufacturing sector or about 6.7% of the total number of employees in the country. The industry is export-oriented and contributes about 13% to the total Gross Domestic Product (GDP) and 27% to Macedonian exports. In terms of regional distribution, the textile industry is spread across the entire territory of the Republic of North Macedonia, with a significant concentration in the eastern part of the country. The volume of textile waste depends on production capacity. Textile waste is a significant problem, as 2 to 15 kilograms of waste per person are generated annually in Europe [1,2].

THEORETICAL PART

Most of the companies in North Macedonia are focused on garment production, consequently, the majority of textile waste is apparel cutting waste. This type of waste is a valuable resource because of its preserved physical and mechanical qualities. Despite this potential, it is largely disposed of in landfills. The amount of cutting waste depends on the cutting layout, garment type, and frequency of material defects. The most of the textile companies are small to medium-sized, limiting their ability to invest in recycling equipment. Studies indicate that 94.19% of clothing producers discard waste in landfills, while only 3.49% sell it to licensed recyclers. Disposal and customs clearance costs for textile waste reach €1.5 million annually [2-4].

Textile waste poses multiple challenges: it harms the environment, increases the demand for landfill space, and generates additional management costs. European waste policy focuses on preventing waste generation to minimize its impact. In line with this, the European Parliament adopted a resolution (2006/2175 INI) to promote waste recycling and reduce landfill volumes [5,6].

The most effective approach to textile waste management is an integrated treatment model guided by sustainable development principles, particularly the 7Rs: reduce, reuse, recycle, regulations, recovering, rethinking, and renovation. Recycling plays a central role, as up to 99% of textile waste can be reused. From the perspective of conserving energy and raw materials, recycling is the preferred treatment method, reducing pollution, lowering waste volumes, and saving resources [7,8].

Garment manufacturers can significantly support recycling efforts by implementing waste sorting processes, as only sorted waste can be reused. However, recent studies in North Macedonia reveal that many managers have a negative outlook on textile waste recycling. Most of the top executives show little interest in sorting waste, despite its importance for recycling.

In the past decade, several studies have been conducted on the quantity and quality of textile waste, specifically cutting waste, in the Republic of North Macedonia as a prerequisite for introducing a more efficient way of managing it [9,10]. At present, there is no standardized methodology for accurately calculating apparel cutting waste produced during the cutting process at its point of origin—within the companies themselves. This paper seeks to develop a straightforward method for determining the quantity of textile waste generated during tailoring at the production site in garment manufacturing.

EXPERIMENTAL PART

Using the knowledge from industrial practice regarding the course of cutting processes, a methodology was developed for determining the quantities of generated textile waste through several stages, directly at the place of its occurrence, as follows:

1. Determination of the total length L (m) and weight T (kg) of the imported textile material. This data is planned to be collected through the analysis of import documentation;
2. Determination of the actual cut length per bale Rlb (m), the sum of:

$$Rlb = [(Lks + Oks) \cdot N] + Ld + Ob \quad (\text{m}) \quad (1)$$

Determination of the Amount of Cutting Waste and Its Characterization

where:

Lks – length of cutting marker (m);

Oks – remnants (leftovers) of cut layers (m);

N – number of cut layers in the cut lay;

Ld – length of material due to removed errors (defects) (m);

Ob – remnants of the ends of the bale (m).

3. Determination of the actual cut total length RL (m), as a sum of:

$$RL = \sum_{i=1}^n Rlb \text{ (m)} \quad (2)$$

In this phase, a cutting form (Material Cut Report) was designed, a form that serves to keep precise records of the use of the textile material, used by operators when forming cut layers. The form is shown in Table 1.

Table 1. Material cut report

Marker number	Marker name	Length of the coil Lb (m)	Marker length Lks (m)	CAD efficiency (%)	Number of layers in the cut lay N	Left-overs of cut layers Oks (m)	Defect Ld (m)	Coil left-overs Ob (m)

4. The next stage is the determination of:

(%) of cut length PLk :

$$PLk = (RL/L) \cdot 100 \text{ (%) } \quad (3)$$

(%) of removed defects PLd :

$$PLd = (Ld/L) \cdot 100 \text{ (%) } \quad (4)$$

(%) of the coil leftovers POb (%):

$$POb = (Ob/L) \cdot 100 \text{ (%) } \quad (5)$$

5. Then follows the determination of:

the gross cut quantity BT (kg):

$$BT = (T/100) \cdot PRL \text{ (kg)} \quad (6)$$

quantity of removed defects KLd (kg):

$$KLd = (T/100) \cdot PLd \text{ (kg)} \quad (7)$$

coil remnants (leftovers) quantity: KOb (kg):

$$KOb = (T/100) \cdot POB \text{ (kg)} \quad (8)$$

6. The next step is the determination of the net cut quantity NT (kg):

$$NT = (BT / 100) \cdot ACADef \quad (9)$$

where:

$ACADef$ – average utilization of the total number of cutting markers

$$BT = (T / 100) \cdot PLk \quad (10)$$

$$ACADef = \sum_{i=1}^n PCADiKSl \quad (11)$$

where:

$PCADiKSl$ – the percentage of utilization of the used cutting markers individually (this data is taken from Table 1, Material Cut Report form).

7. The determination of the inter-cutting loss KMg (kg) was calculated according to the formula 12:

$$KMg = BT - NT \text{ (kg)} \quad (12)$$

8. Calculation of the quantity Ok (kg) and the percentage of waste generated from the cutting process POk (%), is according to formulas (13) and (14), respectively:

$$Ok = KMg + Kld + KOb \text{ (kg)} \quad (13)$$

$$POk = Ok / (BT + Kld + KOb) \cdot 100(\%) \quad (14)$$

For examining the practical applicability of the methodology, a clothing manufacturing company from the Republic of North Macedonia was selected. The company has 170 employees and produces dresses, skirts, shirts, and blouses, with an average monthly capacity of 16,000 garment units. It is a successful company that, even during the COVID-19 pandemic, operated at full capacity without any lockdown. The research was conducted during the period from May 1 to May 30, 2024.

RESULTS AND DISCUSION

During the study, 9.224 garment units were produced using 3.299 kg of textile material. Only one model (M_4) used knitted fabric; the rest used woven fabric. The dominant raw materials were 100% viscose, 100% Tencel, and 100% cotton. Only one (M_4) of the eight models under consideration is made from knitted fabric, requiring 492 kg of knitted material composed of 95% viscose and 5% elastane. The remaining models are made from woven fabric (2807 kg). Among the woven fabrics, the predominant raw composition is 100% viscose (4043.3 kg), followed by 3805.4 kg of 100% Tencel fabric, 1179.9 kg of 100% cotton, and 195.7 kg of other or mixed raw compositions. For the production of the first six

Determination of the Amount of Cutting Waste and Its Characterization

models, both main material and lining were used, while for models M₇ and M₈, only the main material was used.

Table 2. Import data

Model	Order quantity	Imported quantity (m)	Imported quantity (kg)	Type of fabric	Raw material content
M ₁	2464	2842	806	Woven	67% Lyocell, 33% Linen
		200	18	Woven	100 % cotton
M ₂	1533	2042.9	613	Woven	100% Tencel
		268	43	Woven	100% cotton
M ₃	1848	1762.5	541	Woven	100% Tencel
		299	14	Woven	100 % cotton
M _{4se}	573	1205	492	Knitted fabric	95% viscose, 5% elastane
		89	18	Woven	100% cotton
M ₅	505	1026.8	305	Woven	100% viscose
		131.9	30	Woven	100% cotton
M ₆	764	1271.5	385	Woven	100% viscose
		192	34	Woven	100% cotton
M ₇	312	520	239,2	Woven	100% viscose
M ₈	1225	2252	900,8	Woven	100% viscose
Sum	9224	7867	3299		

Table 3. Obtained results according to the proposed methodology

Model	NT (kg)	KLd (kg)	KOb (kg)	KMg (kg)	Ok (kg)	POk (%)
M ₁	624.35	14.96	20.77	136.59	172.33	21.38
	14.16	0	0.36	3.48	3.84	21.35
M ₂	503.40	3,53	4.50	101.58	109.60	17.88
	35.97	0,25	0.56	6.23	7.03	16.35
M ₃	285.72	2,55	10.74	240.76	254.05	46.96
	11.96	0.04	0.15	1.85	2.04	14.58
M ₄	406.75	8.26	8.35	68.65	85.25	17.33
	15.70	0.09	0.23	1.98	2.30	12.79
M ₅	242.10	3,94	6.28	51.89	62.11	20.36
	25.37	0.23	0,49	3.90	4.62	15.4
M ₆	300.63	5.72	4.70	65.81	76.23	19.8
	4.55	0.09	0.04	1,34	1.47	4.32
M ₇	178	2.53	2.82	55.53	60.89	25.46
M ₈	729.35	8.02	20.72	142.56	171.29	19.02
Sum	2874.61	50.21	80.71	745.56	1013.05	Average: 19.5

The results obtained based on the proposed methodology are shown below in Table 3. The total amount of generated waste is $POk = 19.5\%$. An unusually high percentage of waste was observed in model M_3 , which is attributed to the specific construction of the model and the fact that the pattern pieces were aligned in only one direction on the cutting layout.

During the research period, a total of 1013.05 kg of cutting waste was generated in one company, of which 85.25 kg was knitted fabric waste, and the rest was woven fabric waste. Regarding the raw composition, 21.3 kg was waste from 100% cotton fabric, 370.52 kg from 100% viscose fabric, 363.35 kg from 100% Tencel fabric, and the remainder was waste from fabrics and knits with various raw compositions. All the generated cutting waste was disposed of at the local landfill.

CONCLUSION

This methodology enables a quick and easy determination of the quantity as well as quality of cutting waste at the point of its generation, i.e., within the company. By applying this methodology, the necessary data for more efficient management of cutting waste are obtained. This methodology could be the subject of further research for its improvement or conversion into a software tool that would contribute to changing the way textile waste is managed, particularly cutting waste, which represents a valuable resource that can be utilized but still ends up in local landfills. Solving this problem requires the involvement of all relevant institutions: companies, municipalities, and governments.

REFERENCES

1. S. Zhezhova, A. Janevski, S. Jordeva, and S. Golomeova, Saska, 2020, Важноста на текстилната индустрија за економијата на Република Северна Македонија. *Годишен зборник, Економски факултет*, Vol. 21, pp. 63-71.
2. S. Zhezhova, S. Jordeva, S. Golomeova Longurova, and A. Janevski, 2020, Textile industry in North Macedonia, *Tekstilna industrija*, vol 68, (3), pp 44-51.
3. S. Jordeva, E. Tomovska, D. Trajkovic, 2015, Current State of Pre-Consumer Apparel Waste Management in Macedonia, *Fibres & Textiles in Eastern Europe*, Vol. 23 (1)(109), pp.13-16.
4. [https://biznisregulativa.mk/Upload/Documents/Poziciski%20dokument%20Carina%20Tekstile n%20otpad\(3\).pdf](https://biznisregulativa.mk/Upload/Documents/Poziciski%20dokument%20Carina%20Tekstile n%20otpad(3).pdf), available 14.02.2024.
5. V. Dobilaite, G. Mileriene, M. Juciene, V. Saceviciene, 2017. Investigation of current state of pre-consumer textile waste generated at Lithuanian enterprises, *International Journal of Clothing Science and Technology*, Vol. 29 (4), pp. 491-503.
6. <https://eur-lex.europa.eu>, available 11.03.2024.
7. Larney, M., Van Aardt, A. M. (2010). Case study: Apparel industry waste management: a focus on recycling in South Africa, *Waste Management & Research*, Vol. 28 (1), pp. 36-43.
8. S.M. El-Haggar, 2007, Sustainable industrial design and waste management: Cradle-to-cradle for sustainable development. *Elsevier Academic Press*, Cambridge, MA.

Determination of the Amount of Cutting Waste and Its Characterization

9. S. Zhezhova, S. Jordeva, and S. Golomeova Longurova, V. Srebrenkoska, and V. Dimitrijeva-Kuzmanoska, (2022) Analysis of the situation with textile waste. *In: Contemporary trends and innovations in the textile industry*.
10. S. Jordeva, E. Tomovska, K. Mojsov, S. Golomeova Longurova, S. Maksimov, 2018, Sustainability of the textile waste stream in Republic of Macedonia, *Advanced technologies*, Vol.7 (1), pp.74-78.