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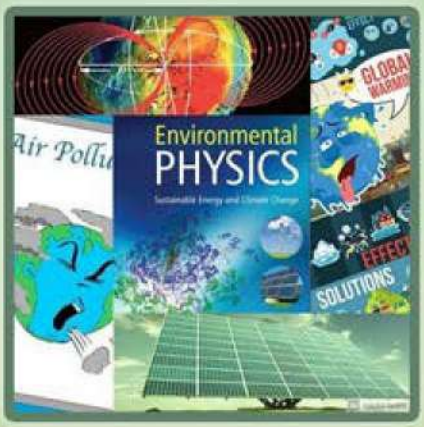

IV International Conference on Physical Aspects of Environment

ICPAE 2025

PROCEEDINGS

Zrenjanin, Serbia, August 29-30, 2025.

University of Novi Sad
Technical Faculty
"Mihajlo Pupin"
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Proceedings

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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

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INVITED LECTURES

Conference Proceedings
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Technical Faculty "Mihajlo Pupin", Zrenjanin & Faculty of Sciences and Mathematics, Niš

Determination of the Amount of Cutting Waste and Its Characterization

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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:

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

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:

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

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:

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

(%) of removed defects PLd:

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

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

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

5. Then follows the determination of:

the gross cut quantity BT (kg):

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

quantity of removed defects KLd (kg):

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

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 (M4) 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

models, both main material and lining were used, while for models M_7 and M_8, 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	$\boldsymbol{NT}$ (kg)	$\boldsymbol{KLd}$ (kg)	$\boldsymbol{KOb}$ (kg)	$\boldsymbol{KMg}$ (kg)	$\boldsymbol{Ok}$ (kg)	$\boldsymbol{POk}$ (%)
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. 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.

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