ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

TEXTILE WASTE MANAGEMENT IN ROMANIA IN THE CONTEXT OF THE CIRCULAR ECONOMY

DONDEA Maria-Felicia[1], VISILEANU Emilia[1], GROSU Marian Catalin[1], SCARLAT Razvan[1], VLADU Alina[1]

[1]The National Research and Development Institute for Textiles and Leather 16, Lucretiu Patrascanu street, cod 0300508, Bucharest, Romania, E-mail: office@incdtp.ro

Corresponding author: Visileanu Emilia, E-mail: e.visileanu@incdtp.ro

Abstract: *The circular economy in Romania's textile industry represents a sustainable resource management model that aims to reduce waste and maximize the value of materials throughout their entire life cycle. This concept promotes the reuse, repair, and recycling of textile products, in contrast to the traditional linear economic model based on "take, make, and dispose."*
In Romania, the textile industry has a long-standing tradition, but in recent years it has faced challenges related to managing textile waste. Selective textile recycling is essential to prevent pollution and conserve natural resources. This involves the separate collection of textile waste from consumers and sorting it based on the type of material and the degree of wear. The materials can then be reintroduced into the economic cycle in the form of recycled fibres, new products, or even fuel for energy production.
This article explores the potential and challenges of implementing a circular economy in Romania's textile sector, focusing on sustainable resource management and waste reduction. The study highlights the limitations of the current linear economic model, which heavily relies on the consumption of non-renewable resources and generates a significant amount of textile waste. It emphasizes the need for a transition to circular practices, including reuse, repair, and recycling, to improve sustainability.

Keywords: *TIR, TMW, reuse, repair, recycling.*

1. INTRODUCTION

The Circular Economy is a new model of production and consumption (fig.1). The evolution of industrialization over the past 100 years has been based on a linear production model: raw material – processing – consumption – waste. This leads to rapid resource depletion and an explosive increase in waste.

The Circular Economy (CE), developed on the principle that "everything is an input for something else," is the key to sustainability [1]. The transition from a linear economy to a circular economy is one of the key priorities in pursuing the Sustainable Development Goals (SDGs), where governmental institutions play a fundamental role, supported by developed digital technologies [2]. The EU Strategy for Sustainable and Circular Textiles addresses fast fashion, textile waste, and the depletion of unused textiles while ensuring that their production respects human rights [3]. The textile industry consumes 98 million tons of non-renewable resources annually, such as oil and raw materials for fertilizers and treatment chemicals. Simultaneously, the volume of textile waste is

considerable, with only 13% of the materials used for clothing being recycled, and even these are mainly directed towards low-value applications [4].

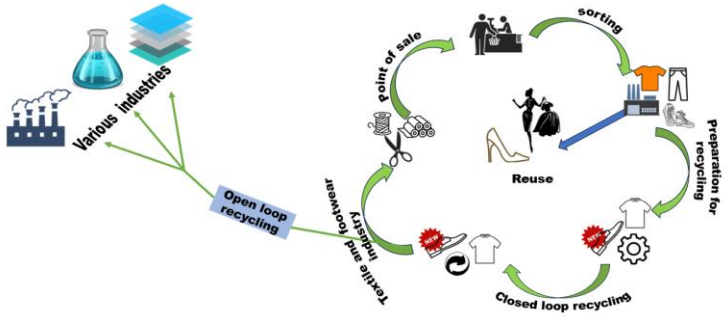

Fig. 1*: The Circular Economy principle*

Currently, global textile consumption has the third-largest negative impact on the environment and climate change, following food, housing, and transport. Textiles rank third in water and soil consumption and fifth in raw material use and greenhouse gas emissions [3].
Europeans consume nearly 26 kg of textiles and discard around 11 kg of textiles each year. Used clothing can be exported outside the EU, but the majority (87%) is incinerated or sent to landfills. To reduce the environmental impact of this phenomenon, the EU aims to decrease textile waste and increase the lifespan and recycling rate of textiles. This is part of the plan to achieve a circular economy by 2050 (European Parliament, 2024).

In Romania, approximately 160,000 tons of textile waste are discarded annually, according to the Romanian Association for Textile Reuse and Recycling (ARETEX). Out of the total generated textile waste, 6-10% is recyclable under current legislative and market conditions, and this percentage could increase to 25% with developed selective collection and a robust reuse and recycling industry supported by large sorting capacities based on composition and quality, along with an Extended Producer Responsibility (EPR) structure (ARETEX source)

Currently, most textile waste in Romania ends up in landfills or is used for energy recovery. On the other hand, Romania reuses approximately 8-10% of its reusable potential and recycles 2-4%. Of the volume currently collected separately for reuse, about 30-35% is reusable. However, separate collection is relatively low, amounting to 6,000-9,000 tons per year. The current collection rate in Romania is 0.5-0.7 kg per person per year, while in Western countries, the collection ranges between 6-14 kg per person per year.

Globally, all waste management systems are currently guided by the "polluter pays" principle. The European Union adopted this principle for waste management 40 years ago, starting from the idea of determining who the polluter is.

2. MATERIALS AND METHODS

To identify the current pathways for managing textiles intended for reuse, recycling, and disposal, textile waste collected by social organizations (TIR) and specialized companies (TMW) were involved.

The obtaining of each textile product's characteristics was made in two steps: 1) the scanning of each piece of textile, by a volunteer using the NIR handheld device, to assess its

composition; 2) organoleptic examination of the characteristics of the related piece of textile-like product type, age group, colour and presence of disruptors, degree of degradation, etc, that were captured in the app on the electronic device through a short predefined multiple-choice survey, using an application designed by Matoha Instrumentation Ltd.

The research laboratories typically use FT-IR and NIR spectroscopy devices to determine the chemical composition of a textile material:

1. ***FTIR*** (Fourier Transform Infrared Spectroscopy) is a method applied for analysing both organic and inorganic materials. This method analyses the chemical structure of a material by examining its chemical bonds and composition.
2. ***NIR*** (Near-Infrared Spectroscopy) is a method based on the structure-spectrum correlations present in the measured spectral response, caused by the overtones of fundamental vibrations in the regular IR region.

2.1 Textiles Intended for Reuse (TIR)

TIR (Textiles Intended for Reuse) waste fractions refer to categories through which collected used textiles are sorted for various reuse and recycling purposes. These textiles are sold on different local and global markets, are specific to each sorting facility, and are regularly updated based on market demand, resale prices, waste transport regulations, and other factors.

The analyses were conducted in two stages: January 2024 (batch I) and May 2024 (batch II). The batch I consisted of 1500 kg of used clothing, with 8720 pieces of clothing weighing an average of 172 grams per item. Batch II consisted of 1520 kg of used clothing, with 5396 pieces weighing an average of 280 grams per item. The activities in both stages were carried out by staff from INCDTP, who were trained by Fashion for Good, Netherland.

The TIR samples analysed were selected from textile waste after the so-called "main sort" and consisted of 4 fractions:

I. Wearable textiles sorted for reuse within the EU;
II. Wearable textiles sorted for reuse outside the EU;
III. Non-wearable textiles intended for wipers, downcycling, and fiber-to-fiber recycling;
IV. Non-wearable textiles directed towards energy recovery through incineration or disposal.

2.2 Textile Municipal Waste (TMW)

Additionally, the issue of the post-consumer textile fraction (as the last link in the chain in the current linear economy) destined for municipal waste landfills was analysed. These textiles are disposed of together with mixed waste (TMW). After selection and sorting by categories, the TMW textile fraction is analysed in terms of the type of clothing/non-clothing, structure, and blend of component fibres, as well as the level of degradation, providing insight into the possibility of "downcycling" reuse. The batches were analysed to identify the textile fractions.

The analyses were conducted in two stages: January 2024 (batch I) and May 2024 (batch II). Batch I consisted of 1055 kg of used clothing, 381 pieces of clothing weighing an average of 419,9 grams per item. Batch II consisted of 1350 kg of used clothing, with 684 pieces weighing an average of 377 grams per item.

Each batch consists of two types of waste:

1. those collected more or less separately, identified as textile bins (TB);
2. those found directly in mixed solid waste, identified as textile non-bins (NB).

3. RESULTS AND DISCUSSIONS

The results obtained by analysing the components of the TIR and TMW waste batches (both batches) identified the following aspects:

3.1. Fibrous composition

Fibre composition is a criterion for classifying textile materials based on the type of fibre from which they are made. Each fabric or knitted material of a given composition has specific uses.

Figure 2 graphically represents the results obtained from the analysis of clothing items (TIR), showing that the majority is composed of fibre blends, followed by those made from single fibres such as cotton, polyester, viscose, or acrylic.

In the analysis of clothing items from the TMW category, it was observed that garments composed of fibre blends predominate, followed by those made from single fibres such as cotton, polyester, viscose, and acrylic.

Viscose is an artificial fibre produced from natural raw materials, such as cellulose from wood. It has properties similar to cotton, being a pleasant and soft material. Unfortunately, it is also characterized by low durability and a tendency to wrinkle significantly.

Polyester is known for its exceptional durability and resistance to wrinkling, shrinking, and stretching. It withstands regular wear and tear, making it suitable for durable clothing items. Initially, consumers were enthusiastic about polyester's improved durability profile compared to natural fibres, and these benefits still hold today. However, in recent decades, the harmful environmental impact of this synthetic fibre has been detailed, and consumer attitudes towards polyester have significantly shifted.

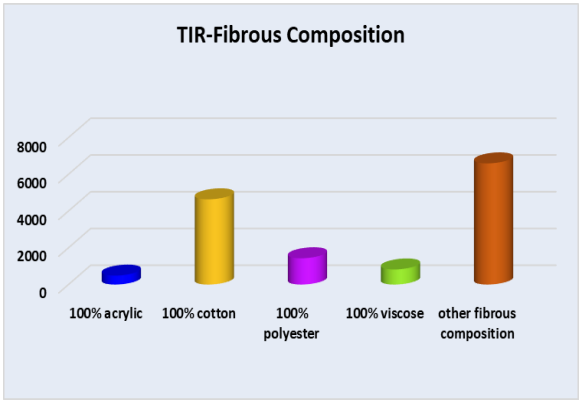

***Fig. 2**: The fibrous composition of garments in the TIR category*

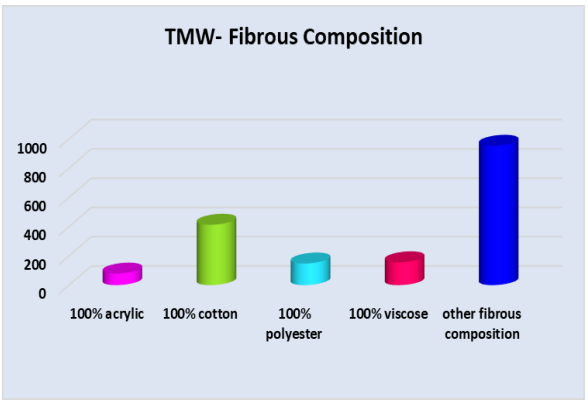

***Fig. 3**: The fibrous composition of garments in the TMW category*

3.2. Material structure

The structure of textile materials is the most relevant characteristic for evaluating their potential use as raw materials for mechanical recycling. The specific features of knitted or woven products differentiate them: thread density in the two systems, weight per square meter, elongation, flexibility, tensile strength, abrasion resistance, thickness, shrinkage, bend resistance, degree of coverage, etc.

Figure 4 graphically represents the analysis of clothing items in the TIR category, highlighting that knitted garments predominate over those made from woven fabrics.

For the TMW category, it was demonstrated that the predominant structure of clothing items is knitted, followed by items made from woven fabric.

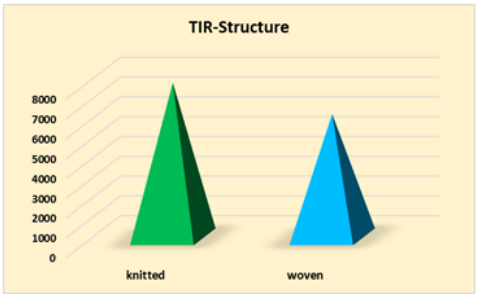

Fig. 4: *The structure of garments in the TIR*

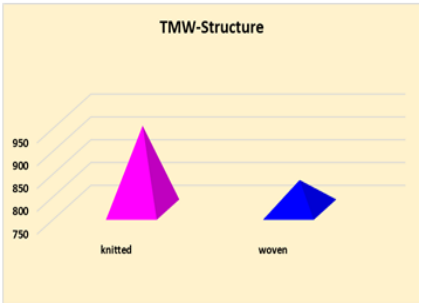

Fig. 5: *The structure of garments in the TMW*

3.3. Grade of reuse

Clothing articles were classified based on their degree of wear using well-established criteria, where: Grade 1 represents items with the highest degree of wear, and Grade 5 represents items in near-perfect condition.

In the case of the TIR category, the analysis of data revealed that most clothing items primarily fell into Grade 4 and Grade 3 of wear, followed by Grade 2 and Grade 1. This highlights the consequences of the fast fashion phenomenon, which has led to a reduction in the lifespan of products (a design, creation, and marketing approach in a fashion that emphasizes the rapid and inexpensive availability of fashion trends to consumers).

For the clothing items analysed in the TMW waste category, it was found that the primary degrees of wear are Grade 2 and Grade 1, followed by Grade 3 and Grade 4.

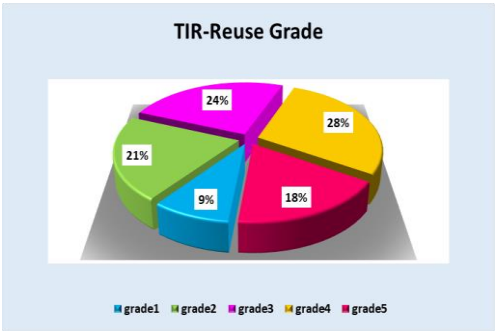

Fig. 6: *The reuse grade of garments in the TIR*

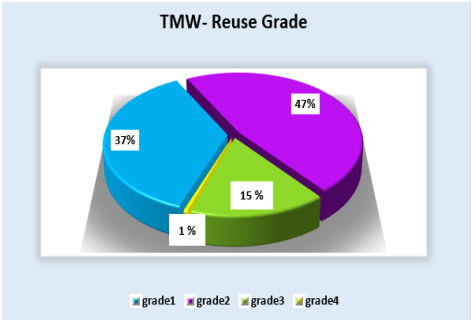

Fig. 7: *The reuse grade of garments in the TMW*

3.4. Color

In our study, the color of clothing items was considered to be the predominant color. If defining a single predominant color was not possible, the item was classified as multicolored. From the data analysis, it can be observed that in both the TIR and TMW waste categories, most clothing items are multicolored. This is followed by predominant colors such as blue, black, beige, grey, and white. Multicolor items limit the potential applications after mechanical recycling. In contrast, single-color items, after recycling and transformation into fibres, provide designers with multiple combination options that extend their range of use.

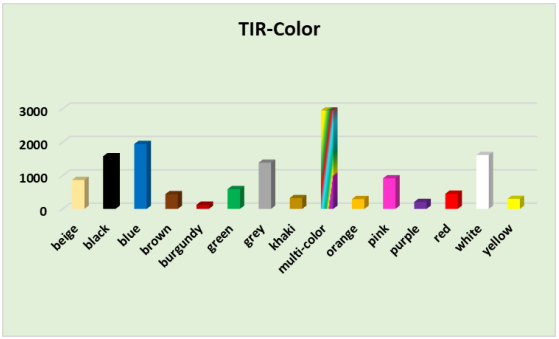

***Fig. 8**: The colour of garments in the TIR*

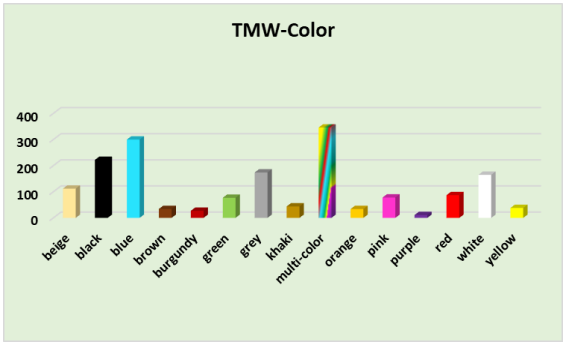

***Fig. 9**: The colour of garments in the TMW*

4. CONCLUSIONS

The study underscores the urgent need to improve the selective recycling system in Romania, where the textile waste recycling rate is alarmingly low, ranging between 6 - 10%.

The fibre composition of textile materials, mainly fibre blends, and woven structures, complicate the recycling process, requiring specific treatments and complex processing technologies for each type of waste.

Additionally, the analysis of the wear degree of clothing items highlighted the negative impact of fast fashion, which promotes short product lifespans and contributes to increased waste volumes. This trend is further exacerbated by the preference for multicoloured items, which limits efficient recycling options compared to single-colour items made from a single fibre type, offering more reuse possibilities.

Implementing a circular economy in Romania's textile sector is not only necessary for environmental protection but also a strategic opportunity to develop new markets and create new jobs, thereby contributing to sustainable economic growth. This transition requires a firm commitment from all involved institutions to ensure the effective and responsible management of textile resources in the future.

REFERENCES

[1] S. Longo, M. Cellura, L. Q. Luu, T. Q. Nguyen, R. Rincione, and F. Guarino, "Circular economy and life cycle thinking applied to the biomass supply chain: A review," *Renewable Energy*, vol. 220, Art. no. 119598, 2024. [Online]. Available: https://doi.org/10.1016/j.renene.2023.119598

[2] R. Medaglia, G. Misuraca, and V. Aquaro, "Digital government and the United Nations' Sustainable Development Goals: Towards an analytical framework," in *Proc. 2021 Int. Conf. on Digital Government Research*, pp. 473–478, 2021. doi: 10.1145/3463677.3463736.

[3] I. Papamichael, I. Voukkali, P. Loizia, T. Rodríguez-Espinosa, J. Navarro-Pedreño, and A. Zorpas, "Textile waste in the concept of circularity," *Sustainable Chemistry and Pharmacy*, vol. 32, Art. no. 100993, 2023. doi: 10.1016/j.scp.2023.100993.

[4] European Parliament, "EU Strategy for sustainable and circular textiles in 'A European Green Deal'," *Legislative Train Schedule*, Jun. 20, 2024. [Online]. Available: https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-eu-textiles-strategy