RECYCLING OPPORTUNITIES FOR TEXTILE WASTE IN LATVIA
TEKSTILA ATKRITUMU ATKĀRTOTĀS IZMANTOŠANAS IESPĒJAS LATVIJĀ

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Abstract. *Textile industry is experiencing rapid growth due to changing consumer and fashion patterns. For example, in 2015, EU citizens bought about 12.66 kg of textile items per person. This generates a large amount of textile waste every year, making impact on environment and human health. Therefore, targets in European Union and national level are being set to reduce the amount of textile waste going to landfill. To achieve them, it is necessary to recycle textile waste into new products. The aim of the article is to research possible solutions for textile waste recycling, including the example of Estonia, as well as to create an engineering solution for textile waste recycling in Latvia to achieve goals of Directive (EU) 2018/851.*

Keywords: *textile waste, recycling, re-use, waste-to-product.*

Introduction

Textile is a flexible material consisting of natural or man made fibers. Natural fibers are obtained from plants and animals. Plants fibers are strong cellulose fibers that can be obtained from bark, leaves and seeds but animals fibers are mostly from wool. While man made fibers can be natural and synthetic polymers. Silk-like fibers are natural polymers and consist of cotton linters/wooden pulp (cellulose). Other natural polymer is rayon. Rayon fibers are made from purified cellulose, usually from wood pulp, which is chemically converted into cellulose acetate. Usually man made fibers from natural polymer are containing cellulose. Polyester fibers are one of the most used synthetic fibers. Other synthetic fibers are nylon, polyurethane, acrylic fibers and many more [1].

Textile waste includes pre-consumer waste that are created during fibre, textile and clothing production, and post-consumer waste, created during consumer use and disposal. Pre-consumer textile waste is generated in the fashion supply chain before the textile reaches the consumer. It is estimated that 10–20% of textiles are wasted during the manufacturing process. Post-consumer textile waste is generated and collected after the consumer has used and disposed of it. Post-consumer textile waste is referred to any types of clothing or textiles that are no longer used by the consumer due to damage, wear, out of fashion or any other problems in the materials that end the willingness to use the products by the consumer. Third is specific type of textile - textile waste in industrial appliances. They are generated from industrial applications such filters, conveyor belts, geotextiles, wiping rags, etc [2].

The textile industry is booming around the world, and as the global grows every year, the demand for textiles also grows. Between 2000 and 2014 global textile production has increased by more than 100%. If compared to the time 20 years ago, nowadays a person wears their clothes for half the lifetime of textile [3]. For example, in 2015 EU citizens bought 6.4 million tonnes of new clothes which is about 12.66 kg per person. But the textile sector is not just about buying and using them, it is a complex formation that not only has environmental impact at the time of production and waste generation. Textiles account for 2 to 10% of Europe's total environmental impact [4]. But with the production of clothing from recycled textile waste can save on average 75% of water, 88% of energy and 80% of CO_2 emissions in the production

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process than produced textiles in the traditional way [5]. According to the Directive (EU) 2018/851 definitions, textiles falls into the household municipal waste group [6].

Textile waste is also covered by a number of EU directives and targets. Directive (EU) 2018/851 raises targets for re-use and recycling in order to move to an European circular economy with a high level of resource efficiency. It set such targets in relation to the amount of municipal waste to be recycled and reused - the preparing for re-use and the recycling of municipal waste shall be increased to a minimum of 55 % by weight by 2025; 60% by weight by 2030 and 65% by weight of 2035 [6]. Specifically, for textiles is requirement that every EU Member State ensures separate collection of textile waste from 2025 onwards. As mentioned above, textile production and waste generate emissions. Therefore, the textile industry is also in line with the EU's goal of being climate-neutral by 2050. This means that the EU will have zero GHG emissions in 2050. This objective is at the centre of the European Green Agreement [7] and is in line with the Paris Agreement [8].

With the increase of waste, the relatively low recycling rate of 15-20% of total textile waste in the European Union [9] solutions are being sought at national and company side to reduce the amount of waste that are going to landfill and increase the level of waste hierarchy.

The aim of the article is to create a solution for textile waste in Latvia, based on the possibilities of recycling textile waste and the example of Estonia to achieve goals of Directive (EU) 2018/851.

1. Materials and methods

The article presents the results of the research on the possibilities of recycling textile waste in Latvia. The article analyzes the available scientific literature on the possibilities of textile waste recycling, as well as looks at examples of textile waste recycling from other countries, e.g. in Estonia.

In this article is searched information about the possibilities on recycling textile waste in ScienceDirect database. To select a relevant possibilities of recycling textile waste among the identified pieces of literature, there are set up the following selection rules:

- Does the recycling option apply directly to textile waste?
- What textile material is recycled?
- Is the possibility of recycling textile waste realized in real life or only in laboratory conditions?
- What are the conclusions of these recycling options?

Based on the found information, which corresponds to these questions, textile waste recycling options have been selected.

As Estonia is a neighboring country of Latvia and both countries have similar geographical, social and economic conditions, the examples of Estonia have been used to determine the possibilities of textile waste recycling in Latvia. To analyze recycling possibilites fo textile waste in Estonia is used information which is available on internet and is corresponded to the keywords - recycling, examples, companies and textile waste - as well as on the information from site visits in Tartu city.

In order to find out whether it is necessary to recycle textile fibers in Latvia at all, need to find out the amount of textile produced and recycled in Latvia. In order to do this, at first it is necessary to know the waste codes in Latvia, which can be done using Latvian legislation, more precisely the Regulation No.302 of Cabinet of Ministers (19.04.2011) on waste classification and properties that make waste hazardous, waste classification codes have been established. Annex 1 to the Regulation contains a table entitled "Waste Classifier", where are all the used waste codes in Latvia. Further, the national waste database "3-Waste" is used, which contains information on the amount of generated and recycled textile waste, based on waste codes. In the article also is used the assumption of Ltd "Eco Baltia Vide" about the amount of

textile waste from the amount of unsorted municipal waste. At the end, a solution is created for Latvia based on the obtained information.

2. Results and discussion

2.1. Literature review

Textile waste can be recycled into fibers. Textile waste recycling can be used for natural and man made fibers. Further, textile waste can be recycled in two different ways - mechanically and chemically.

At first previously sorted textile waste is cut into pieces in mechanical treatment. The cutted pieces are chopped into fibers. Metal garment elements are separated from the shredded material by means of magnets. If it is necessary, another textile fiber is added to the fiber mass. Next, the crushed fibers are placed in a wind chamber, where the mass of the fibers is equalized and cleaned by air. During carding, the fibers are separated, drawn in parallel, combed, too short, damaged, unrefined fibers and impurities are removed. The last step is the spinning of the yarn, from which the fabric can be further formed.

Using mechanical treatment, textile waste is used in the production of thermal and acoustic insulation materials. The properties of thermal insulation materials depend on the porosity and tortuosity of the material (ratio of pore length to thickness) and, as textile fibers have interconnected voids, it has become one of the raw materials for the production of thermal insulation materials. Thermal insulation panels can be produced from several textile waste - wool, cotton, acrylic, jeans, etc. Thermal conductivity values from textile waste materials range from 0.044 to 0.103 W / m K [10].

The materials must be porous for good acoustic insulation properties. As porous textile fibers can absorb sound energy, they can be used as good sound absorbing materials. Insulation material from waste of polyester fibers can be used in acoustic insulation materials since the sound absorption of such material is in the range of 55% to 75% [11].

If only textile fibers of a certain length and characteristic can be used in the manufacture of thermal insulation materials, then all textile waste may be used for the production of energy. Pellets can be made to use textile waste and to improve the combustion properties of fuel. Based on energetic potential of pellets from textile waste, especially cotton waste, is comparable to other fuels such as wood pellets and woodchips. The minimum heat calorific value of pellets is 16.80 MJ/kg [12].

2.2. Examples of textile recycling in Estonia

In Estonia, most textile waste is recycled mechanically. There are few companies that are recycling textile waste. One of them is run by designer Reet Aus. The company manufactures clothing based on textile waste recycling, incorporating the principles of circular economy into the brand. Since 2012, the company owned by Reet Aus has been cooperating with the clothing manufacturer in Bangladesh. For design clothing production they use pre-consumer waste what arises in the garment factory in Bangladesh. As a result of the cooperation, an innovative production process has been created, where the principles of value added processing are used in production, thus increasing production efficiency and reducing the impact on the environment. Each piece of clothing by Reet Aus corresponds to UPMADE® certified - it can be identified by a label attached to the clothing. The certification of UPMADE® is made to create the method of eco-friendly garments from materials left over in manufacturing [5].

Since 1995, the Estonian company Toom Tekstiil AS has been manufacturing thermal insulation material from textile waste. In the process of thermal insulation, several processes are used to produce products. In the production process, it is important that the raw materials do not have zippers, buttons and other accessories, also materials cannot be too strong, for example, denim is not suitable for the production. As well as in the production of Toom Tekstiil

AS are used pre-consumer textile. In the first stage, raw material is grinded into the fibrous material by the special blades. In the second stage of production, the fibers are joined together to form panels of a certain thickness and width. The material is then treated with various chemicals to prevent the formation of pests and molds, as well as to ensure the fire resistance of the materials. The company can produce up to 4000 tons of nonwovens per year [13].

2.3. Recycling opportunities for textile waste in Latvia

Currently, there are lot of problems with textile waste – no seperate colletcion system yet in post-consumer waste, due to human behavioral habits, textile waste ends up in landfills and not in charities that provide quality textile waste collection, no manufacturers that provide mechanical and chemical treatment of textile waste, in particular post-consumer waste. Only a few companies recycle textile waste, i.e., they create new design style clothes and textile items from textile waste. For example, eco fashion designer Velga Krukovska with brand „Velga Code" creates design clothes from pre-consumer and post-consumer textile waste [14], brand „Zīle" produces clothes from recycled jeans [15] and the weaving studio „Lude" creates blankets, carpets and rugs from leftover clothes [16].

According to the Regulation No.302 of Cabinet of Ministers (19.04.2011) on waste classification and properties that make waste hazardous, waste classification codes have been established. Textile waste is indicated by codes: 040221 - waste from unprocessed textile fibers and 040222 - waste from processed textile fibers from category 0402 - waste from the textile industry; 150109 - fabric packaging from category 1501 – packaging; 191208 - textile waste from category 1912 - waste from mechanical treatment of waste; 200110 – clothes and 200111 – textiles from category 2001 - separately collected waste [17]. Textile waste is also included in unsorted municipal waste in category 200301 - unsorted municipal waste.

According to Ltd „Eco Baltia Vide" assumption every year 5% is is deposited in landfills [18]. Table 1 shows the total amount of generated textiles, including that 5% of the total unsorted municipal waste is textiles, and the total amount of recycled textiles from 2012 to 2018 [19].

Table 1. Generated and recycled textile waste in Latvia 2012-2018, t

	2012	2013	2014	2015	2016	2017	2018
Generated textiles	5457	5086	5528	4944	4025	4307	4400
Recycled textiles	1284	34	49	41	537	749	1661

Figure 1 shows textile waste recycling rates from 2012 to 2018. Although the recycling of textile waste has increased in recent years, it is still unstable.

As the amount of recycling fluctuates, it is necessary to find a solution for the long-term recycling of textile waste.

In order to set up a long-term textile waste recycling system, at first it is necessary to collect separate textile waste. In Latvia there are only few place where textile waste can be delivered separately but households do not have waste containers directly for textile waste, waste is thrown in a household waste container.

Next step is to create seperation manufactory for textile waste, which ensures the separation of unsorted textile waste from total municipal waste. It is currently planned that the company Ltd. "Eco Baltia vide" will take the sorted textile waste to Tukums, where the company's sorting branch is located [18]. Similar procedures should be performed for other waste managers in Latvia.

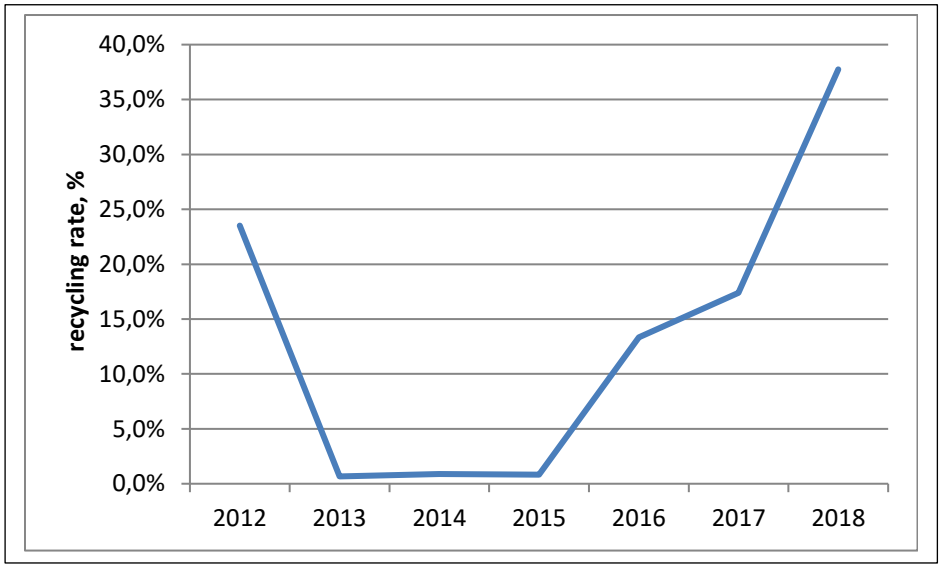

Figure 1. Recycling rate in Latvia from 2012 to 2018, %

Further it is necessary to create companies with processing technologies. It is also possible not to make new companies, but also to adapt existing companies to textile waste recycling.

Based on the example of Estonia and available information, textile waste in Latvia could be recycled into thermal insulation material. Figure 2 shows a production scheme of a thermal insulation material using textile waste. But since the production of thermal insulation materials requires fibers of a certain length and properties, the production of thermal insulation materials results in residues that form another product line, which is the use of waste in the production of pellets.

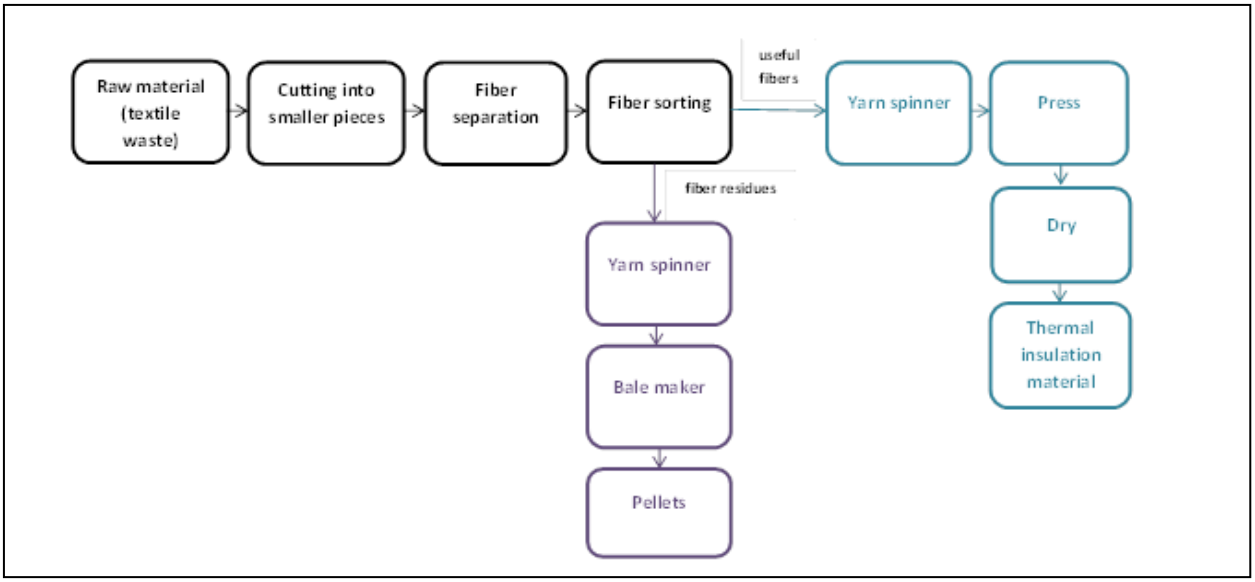

Figure 2. Engineering solution for the use of textile waste in Latvia

As it is shown in Figure 2, one manufacturer can get two products. One would be a high value added product - a thermal insulation material - and the other would be pellets derived from fiber residues. The first steps in the process are the same - at first the raw material, which in this case is textile waste, is cut into smaller pieces, then the pieces are divided into fibers.

Further it is specified which fibers can be used in the production of thermal insulation material and which in the production of pellets.

The next stage in the production of thermal insulation is the yarn spinner, when the fibers are connected together. This material is then pressed and compacted. If it is necessary, the material is dried until the final product is formed - thermal insulation material.

However, as textile residues are formed during the thermal insulation process, they can be used in the production of pellets. Yarn spinner takes place here as well, then bales are formed. A resource is then extracted for energy production, which is stored in a dry place until used, and these pellets are burned in conventional biomass furnaces.

One of the most important advantage is that such a solution can be used for pre-consumer and post-consumer textile waste. Also the advantage of such a solution is that it is possible to use all textile waste, creating the principle of zero waste production. Another advantage of this solution is that can be used the same technologies that are used making products from traditional resources. However, the solution includes energy recovery from waste, which is the second lowest level in the waste hierarchy.

After the establishment of a factory using textile waste the last step is to do successful marketing in order to have a market for such a product.

Conclusions

Textile waste is a serious problem in the world. Most of it is disposed of as household waste and ends up in landfills. Therefore recycling and re-use of textiles is a very important aspect of reducing waste that are going to landfill. The available literature provided general recycling processes as well as reusability of different materials.

There are three types of textile waste – pre-consumer, post-consumer and industrial waste. Ther article looked at pre-consumer and post-consumer waste.

The mechanical treatment is usually used for recycling textile waste. Using mechanical treatment can made thermal and acoustic insulation material as well resource for energy production. Also can be used chemical treatment – the most common product, that are obtained from chemical treatment, is gas from pyrolysis.

In Estonia textile waste is used for making design clothes and it is recommended for mode industry in Latvia to create design clothes. In Estonia textile waste is also used for thermal insulation material, therefore in Latvia it is recommended use textile waste to produce thermal insulation material.

In order to ensure the successful implementation of the Directive (EU) 2018/851, it is necessary to ensure the establishment of a separate textile waste system, to provide sorting centers for textile waste, to create and support of textile companies, and make successful marketing.

The engineering solution is developed based on the production of thermal insulation material. But as residues are generated during the process, they can be used in the production of pellets, thus creating the principles of circular economy and zero waste.

Such a solution could reduce the amount of textile waste that is sent to landfill. However, in order to obtain an accurate model of the solutions, it would be necessary to look at textile waste statistics, cost models and how the environmental impact is reduced.

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