# QUALITATIVE AND QUANTITATIVE ANALYSIS OF THE PRE-CONSUMER TEXTILE WASTE IN NORTH MACEDONIA

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Textile waste in North Macedonia participates with 4.7% in the total composition of the municipal solid waste which is completely landfilled. The purpose of this paper is investigation of the textile waste quantity and quality as a pre-condition for its further management. The results obtained show domination of the apparel cutting waste, the total amount has an average value of 2792.7 tons per year. The further analysis shows that cotton waste is the most represented with 46.4%, then waste from artificial and synthetic fibres with 41.4%. During the research period (2015-2020), 1.42 kg/capita (on average) of pure pre-consumer textile waste with retained physical and mechanical properties is generated annually.

**Keywords:** quantity, quality, pre-consumer waste, cutting waste.

## Introduction

The apparel manufacturing industry in North Macedonia has seen a continuous decline in recent years, as has the quantity of the textile waste streams generated from the production processes. Despite the reduced production, the percentage of the generated waste is still high, as a result of frequent changes in the fashion world. Waste is defined as a problem for many reasons, namely: negative impact on the environment, creation of landfills and costs of their management.

Textile waste is classified into three groups:

1. Textile waste generated before use (pre-consumer) - it represents the production waste generated during the processing of fibres while forming yarns, fabrics, knitted and non-woven textile products, including residues from cutting materials (pattern waste, damaged fabrics and end-of-rolls wastes);
2. Textile waste generated after use (post-consumer) – it represents all types of clothing or textiles for households that no longer have use value for consumers and which are thrown away, regardless of whether it is spilled, damaged, superficially or simply outside. fashion trends;
3. Industrial textile waste - the waste generated in the production of textile for commercial or industrial purposes, including textile waste from the manufacturing of carpets and curtains and hospital waste.

Textile waste also has its ecological and economic component. All stages of reconstruction of textile waste used for the production of new products or energy, enable the preservation of non-renewable natural resources [1]. In the Republic of North Macedonia there is still no legal possibility for manufacturers sell the waste they generate at a lower price than the prices used for customs clearance in the regular procedure. As a result, the generated waste is disposed of in landfills. According to the latest data, textile waste in North Macedonia participates with 4.7% in the total composition of the municipal solid waste, which is completely, 99.4%, disposed of in landfills [2]. In most companies, 94.19%, apparel waste is collected with municipal solid waste by governmental waste service companies and disposed of in landfills [3]. The total annual corporate costs of landfills range up to 1.5 million euros [4]. But despite this fact, waste management has had low costs compared to the company's overall budget. For 44.3% of companies, waste disposal costs have been less than 1% of the budget, and for 34.18% they were between 1 - 2% of the budget. Merely 5.06 % have had disposal costs over 5%of above 5% [5]. In 2008, Fletcher set out the most popular global principle for textile waste management known as the three "Rs": reduce, reuse and recycle. This is in line with the current objectives of European Union's waste policy, whose main objective is to prevent waste, to promote reuse, recycling and recovery in order to reduce the negative environmental impacts. As a result, EU attitudes towards landfilling are becoming increasingly stringent. The European Parliament resolution on the Thematic strategy on the recycling of waste (2006/2175 (INI)) calls for the quantities of waste for disposal to be reduced to a minimum. Because textiles are almost 100% recyclable, nothing in the apparel manufacturing industry should end up in waste. For successful recycling, textile waste must be sorted by colour and raw material composition. This is important for textile companies that have a manufacturing process from fibres to a ready-made product.

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**Table 1.** Export of apparel from North Macedonia in the period from 2015 to 2020

| | | Quantity (tonnes) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Year | | | | | |
| No. | Name | 2020 | 2019 | 2018 | 2017 | 2016 | 2015 |
| 1 | Men's cotton shirts | 1214.6 | 1717.7 | 1992.9 | 2219.3 | 2321.7 | 2168.5 |
| 2 | Men's synthetic pants | 967.7 | 1220.8 | 1218.2 | 1337.6 | 1245.6 | 1130.9 |
| 3 | Women's shirts and blouses made of artificial and synthetic fibres | 470.3 | 605.1 | 802.9 | 897.4 | 1023.8 | 1098.7 |
| 4 | Women's synthetic pants | 384.8 | 495.7 | 547.5 | 606.9 | 780 | 905.2 |
| 5 | Men's jackets and suits made of artificial and synthetic fibres | 557.8 | 669.3 | 692.9 | 910.3 | 751.7 | 642.7 |
| 6 | Women's cotton shirts and blouses | 299.2 | 440.5 | 544 | 621.9 | 497.5 | 565.5 |
| 7 | Men's cotton pants | 700.5 | 865.8 | 912.8 | 944.4 | 1023.2 | 1000.7 |
| 8 | Women's synthetic pants | 811.3 | 882.1 | 1142.9 | 813.2 | 823.3 | 834.8 |
| 9 | Sweatshirts and T-shirts, knitted or crocheted, made of other textile fibres | 328.9 | 410.8 | 427.6 | 495.8 | 601.5 | 698.5 |
| 10 | Women's synthetic shirts and blouses, knitted or crocheted | 314.2 | 395.9 | 562.6 | 769.9 | 900.5 | 919.2 |
| 11 | Cotton sweatshirts and T-shirts, knitted and crocheted | 959.1 | 899.5 | 830.5 | 694.7 | 757 | 885.7 |
| 12 | Women's jackets and suits made of artificial and synthetic fibres | 218.2 | 238.7 | 268.5 | 277 | 357.1 | 304.9 |
| 13 | Women's cotton shirts and blouses, knitted or crocheted | 752.1 | 920 | 1072.5 | 967.6 | 1101.6 | 997.7 |
| 14 | Women's cotton jackets and suits | 58.8 | 87.8 | 123.3 | 111.7 | 165.3 | 197.4 |
| 15 | Men's cotton jackets and suits | 165.2 | 280 | 265 | 246.5 | 293.9 | 351.4 |
| 16 | Other women's cloth made of artificial and synthetic fibres | 217.6 | 249.4 | 247.9 | 297.7 | 249 | 307.2 |
| 17 | Dresses made of synthetic fibres | 114.1 | 177.3 | 284.3 | 254.5 | 265.9 | 205.1 |
| 18 | Skirts and skirt-pants made of artificial or synthetic fibres | 64.1 | 81.8 | 120.1 | 124.9 | 122.7 | 163.5 |
| 19 | Women's pants made of other fibres | 250.1 | 299.3 | 312.3 | 304.5 | 338.8 | 299.2 |
| 20 | Other men's cotton cloth | 212.3 | 277.8 | 305.7 | 318.7 | 402.3 | 399.6 |
| 21 | Women's coats made of wool or fine animal hair | 144.1 | 212.3 | 242.3 | 253.9 | 249.1 | 181.5 |
| 22 | Men's pants made of wool or fine animal hair | 15.3 | 24.1 | 21.9 | 28.8 | 63.7 | 69.2 |
| 23 | Women's coats, knitted or crocheted, made of other textile fibres | 53.8 | 85.3 | 87.3 | 129.9 | 118.2 | 173.8 |
| 24 | Men's cotton underpants, knitted or crocheted | 138.1 | 148.3 | 122.7 | 149.2 | 177 | 253.8 |
| 25 | Cotton skirts | 19.6 | 30.3 | 39.1 | 22.1 | 41.9 | 73.6 |
| 26 | Women's silk shirts or blouses | 2.9 | 9.2 | 12.6 | 16.6 | 21.2 | 34.5 |
| 27 | Women's jacket and suits made of wool or fine animal hair | 46.9 | 62 | 67.6 | 69.4 | 86.5 | 85.1 |
| 28 | Cotton terry | 172.3 | 328.9 | 298.6 | 340.3 | 324 | 361.8 |
| 29 | Cotton dresses | 55 | 82.2 | 102 | 84.4 | 97.1 | 88.7 |
| 30 | Women's suits and jackets, made of other textile fibres | 21.5 | 30.7 | 25.8 | 32.5 | 83.7 | 79.8 |
| 31 | Women's pants made of synthetic and artificial fibres, knitted or crocheted | 260.8 | 265.7 | 228.7 | 188.6 | 147.9 | 144.9 |
| 32 | Male windproof jackets, made of synthetic and artificial fibres | 74.5 | 67.4 | 83.3 | 87.7 | 55.4 | 68.8 |
| 33 | Dresses, made of synthetic or artificial fibres, knitted or crocheted | 64.1 | 81.8 | 128.7 | 122.5 | 92.6 | 91 |
| 34 | Men's shirts, made of artificial fibres | 102.4 | 149.4 | 140.7 | 115.8 | 94.4 | 84.7 |
| 35 | Women knitted or crocheted pants, made of other textile fibres | 65.9 | 79.1 | 162.5 | 118.1 | 113.6 | 109.1 |
| 36 | Dresses, made of synthetic fibres, knitted or crocheted | 103.3 | 154.4 | 176.5 | 118.8 | 102.7 | 105.1 |
| 37 | Women's jackets and suits, made of synthetic fibres, knitter or crocheted | 131.6 | 92.1 | 122.7 | 135 | 154.9 | 146.2 |
| 38 | Women's pants, made of wool or fine animal hair | 19 | 28.1 | 36.9 | 30.5 | 34 | 34.4 |
| 39 | Sweaters with or without fastening, pullovers, vest, made of synthetic or artificial fibres, knitted or crocheted | 104.2 | 85.7 | 98.1 | 148.6 | 134.9 | 81.6 |
| 40 | Women's cotton jackets and suits, knitted or crocheted | 85.9 | 94.5 | 127.9 | 172.7 | 172 | 158.5 |
| 41 | Dresses, made of artificial fibres | 100.6 | 135.5 | 99 | 106.6 | 62.8 | 87.7 |
| 42 | Synthetic skirts, knitted or crocheted | 17.8 | 33.9 | 67 | 44 | 39.3 | 63.6 |
| 43 | Women's cotton underpants, knitted or crocheted | 64.8 | 71.2 | 62.9 | 76.4 | 106.9 | 95.3 |
| 44 | Men's cotton windproof jackets | 5 | 12.3 | 5 | 23.4 | 44.1 | 51.2 |
| 45 | Men's jackets and suits, made of wool or fine animal hair | 15.5 | 25.3 | 29 | 21.6 | 27.1 | 27.4 |
| 46 | Women's coats, made of synthetic or artificial fibres | 44.5 | 81.9 | 69.2 | 83.6 | 105 | 135.8 |
| 47 | Skirts, made of other textile fibres | 18.7 | 23.2 | 30 | 33 | 44.1 | 41.1 |
| 48 | Women's shirts and blouses, made of other textile fibres | 75.6 | 36.7 | 17.7 | 25 | 21.4 | 24.6 |
| 49 | Male sets, made of synthetic fibres | 14.9 | 21.3 | 18.7 | 17.7 | 13.2 | 15.6 |
| 50 | Women's shirts and blouses, knitted or crocheted, made of other textile fibres | 12.3 | 13.9 | 8.1 | 9.6 | 8.5 | 39.4 |
| 51 | Other men's clothing, made of other textile fibres | 56.7 | 45 | 42 | 27.4 | 18.2 | 22.6 |
| 52 | Other men's clothing, made of synthetic or artificial fibres | 246.1 | 271 | 299.9 | 334.8 | 269.4 | 377.1 |
| 53 | Other women's cotton cloth | 27.6 | 41 | 59.5 | 47.1 | 46.8 | 58.3 |
| 54 | Dresses, made of other textile fibres | 24 | 21.2 | 29.2 | 22.1 | 15.4 | 13.5 |
| 55 | Men's coats, made of synthetic and artificial fibres | 23.3 | 49.7 | 44.9 | 70.1 | 38.4 | 62.2 |
| 56 | Terry, made of other textile fibres | 319.1 | 125.1 | 231.4 | 227.2 | 321.5 | 391.2 |
| 57 | Skirts, made of wool or fine animal hair | 10.4 | 26 | 22.2 | 12.8 | 16.4 | 13.8 |
| 58 | Men's coats, made of wool or fine animal hair | 22.9 | 23.3 | 38.7 | 61.7 | 56.5 | 113.7 |
| | **Total (tonnes)** | **11841.9** | **14384.3** | **16174.7** | **16824** | **17642.2** | **18136.6** |

But in addition to sorting, the important factors for a successful recycling process are also the quantity and quality of the generated textile waste. There are only a few studies on this topic in the Republic of Northern Macedonia. The latest analysis [6] presents the results for the generated textile waste until 2014. The aim of the research is to perform an analysis of the generated textile waste of Macedonian companies in the period from 2015 to 2020, based on statistical data analysis.

Analysis of the quantity and quality of generated pre-consumer textile waste in the period from 2015 to 2020

The generation of pre-consumer textile waste primarily depends on the volume of clothing production. The latest analysis shows that in 2017, 871 companies engaged in the production of clothing were registered in North Macedonia, with more than 30,000 employees. [7]. The textile industry participates in the total gross domestic product with about 13%, and in the total export with 27%. [8]. Almost 100% of companies are export-oriented, while just over 90% work on the CMT (cut, make and trim) system.

Data from the Central Bureau of Statistics were used to estimate the amount of pre-consumer textile waste generated, as well as to characterize it according to the raw material composition [9]. Based on the data from these documents, a tabular presentation of the export of textile products according to the raw material composition was prepared (Table 1).

On average, about 15,833 tons of clothes were exported annually from North Macedonia (Table 1). The most common was cotton clothing with 46.4%, followed by clothing made of artificial and synthetic fibers with 41.5%. Silk clothing had the smallest share in total exports with 0.10%, while clothing made of wool and fine animal hair participates with 2.8%. The average value of exported clothes was over 400 million euros. Clothing made of

artificial or synthetic fibers had the highest export value (Table 2).

**Table 2.** Value of exported apparel from North Macedonia (in million euros)

| | Year | | | | | |
|---|---|---|---|---|---|---|
| | **2020** | **2019** | **2018** | **2017** | **2016** | **2015** |
| **Total value** | 312.1 | 381 | 409.7 | 424.6 | 430.9 | 446.2 |
| **Cotton fibres** | 119.4 | 156 | 167.4 | 173.2 | 183.3 | 192.7 |
| **Synthetic or artificial fibres** | 153.4 | 181.4 | 195.3 | 204.1 | 195.1 | 192.6 |
| **Wool or fine animal hair** | 9.1 | 13.8 | 14.7 | 16.1 | 17.3 | 17.4 |
| **Silk fibres** | 0.4 | 0.9 | 1.2 | 1.6 | 2 | 3.5 |
| **Other textile fibres** | 29.7 | 28.7 | 30.8 | 29.4 | 32.9 | 39.8 |

The highest export volume index was registered in 2015. As a result of the Covid-19 pandemic, exports in 2020 decreased by 37.7% compared to 2015, or by 17.7% or 26.8% compared to the previous two years, 2019 and 2018, respectively. But despite that, the percentage of waste that was generated during the cutting process ranged from 10 to 20%. According to the data from Table 1, the waste generated by the cutting process had an average quantity of 16,756.4 tons. Annual analyses are shown in Figure 1.

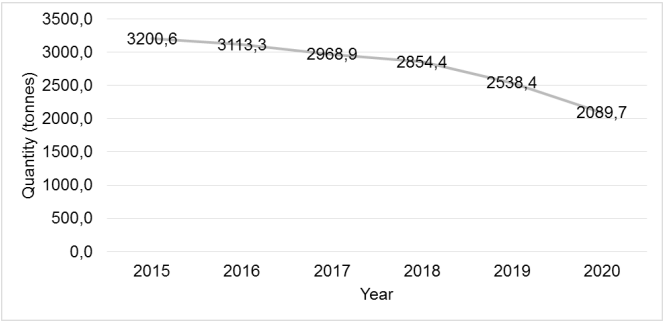


**Figure 1.** Quantity of pre-consumer textile waste in the period from 2015 to 2020

In the period from 2015 to 2020, out of the total average quantity of generated pre-consumer textile waste, which was 16,756.4 tons, 7,788.1 tons was cotton waste, 6,940.5 tons was waste from artificial and synthetic fibres, 1,548.3 tons was waste from other textile fibres, 471.3 tons was waste from wool or fine animal hair, and 17 tons was waste from silk fibres.

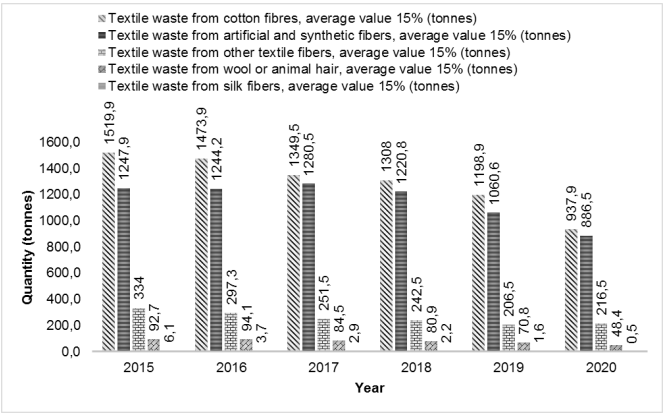


**Figure 2.** Quality of the generated pre-consumer textile waste in the period from 2015 to 2020

During the research period, the presence of cotton waste was significantly reduced. Thus, in 2020, cotton waste participated with 44.9% in total waste or 6.26% less than in 2015, when the percentage of cotton waste in total textile waste was 47.9%. In 2017, there was a decrease in the presence of cotton waste in the total textile waste of 4.02% compared to 2016, when this percentage decrease was 1.25% compared to 2015. In 2019, the presence of cotton waste increased by 3.81% compared to 2017. In 2020, the presence of cotton waste decreased by 4.87% compared to 2019. (Figure 3).

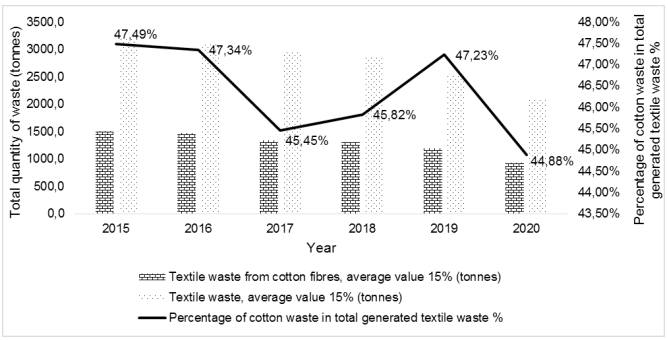


**Figure 3.** Quantity of cotton pre-consumer textile waste in the period from 2015 to 2020

Unlike cotton waste, the presence of waste from artificial and synthetic fibres in the total textile waste has increased significantly from 39% in 2015 to 42.4% in 2020, an average increase of 8%. The highest increase was registered in 2017 with 9.5% compared to 2015. The next two years, 2018 and 2019, there was a decrease by 0.7% and 2.34%, respectively. In 2020, there was a small increase of presence in total amount of waste of 1.14%, compared to 2019 (Figure 4).

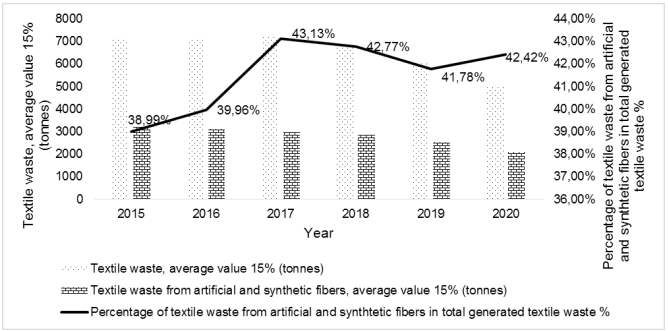


**Figure 4.** Quantity of pre-consumer textile waste from artificial and synthetic fibres in the period from 2015 to 2020

In 2020, the amount of waste from fine animal hair in total the waste decreased by 20.7% compared to 2015, the waste from silk fibres by 90%, while the waste from other textile fibres decreased by 10.44% in 2015 to 8.14% in 2019. In 2020, the presence of the waste from other textile fibres in total amount of waste was 10.36% (Figure 5).

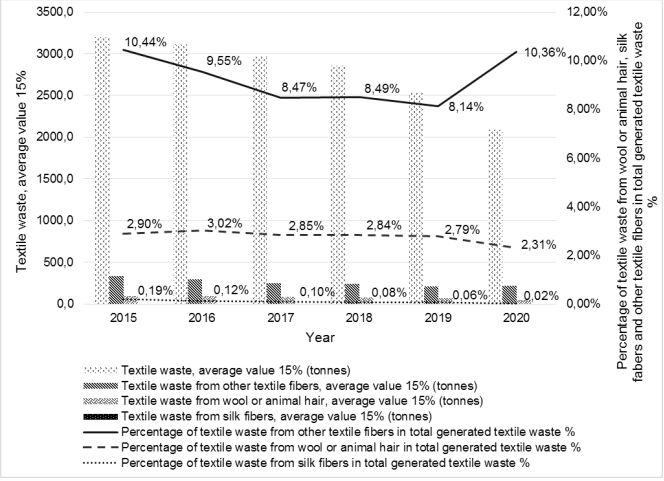


**Figure 5.** Quantity of pre-consumer textile waste from wool or animal hair, silk and other textile fibres in the period from 2015 to 2020

The analysis shows that, on average, 2,794.2 tons of pure pre-consumer textile waste with retained physical and mechanical properties was generated annually (1.42 kg per capita).

In economically developed countries in Europe, most of the textile waste is post-consumer waste, while the amount of pre-consumer waste is marginal, because the majority of the garment production is based in non-European countries. Therefore, the greatest attention is paid to the collection and sorting of post-consumer waste. The main method for the elimination of textile waste in Europe incineration, because the European Parliament by a resolution prohibits the disposal of recyclable waste [10]. Landfills are officially closed in France, and the same trend exists in Germany [11]. In developing countries, for example, in Turkey, 62% of textile waste was sold to recycling companies, while only 16% ended in landfills [12]. In Lithuania only 12.1% of the total amount of textile waste was recycled. 14.4% of textile waste was sold to textile waste collection companies, 24.7% to recycling companies and 0.8% to individuals. 47.6% of the textile waste was disposed of in landfills [13].

## Conclusion

A significant amount of the pre-consumer textile waste has been generated in the last six years. However, as a result of the Covid-19 pandemic, the amount of waste generated in 2020 decreased compared to previous years. The study showed that in total amount of textile waste, waste from artificial and synthetic fibres is most often present. Such a high prevalencecauses environmental problems. Because of this, it is inevitable to think about waste recycling. However, the analysis of the quantities of textile waste is a necessary precondition for a successful recycling process. There is still no detailed analysis of the quantities and flow management of textile waste in North Macedonia. This should be the subject of further research towards the development of waste management policy.

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**Izvod**

# KVALITATIVNA I KVANTITATIVNA ANALIZA PRE-POTROŠAČKOG TEKSTILNOG OTPADA U SEVERNOJ MAKEDONIJI

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Tekstilni otpad u Severnoj Makedoniji učestvuje sa 4,7% u ukupnom sastavu komunalnog čvrstog otpada koji se u potpunosti odlaže na deponije. Cilj ovog rada je istraživanje količine i kvaliteta tekstilnog otpada kao preduslova za njegovo dalje upravljanje. Dobijeni rezultati pokazuju dominaciju krojnog otpada, čija ukupna količina ima prosečnu vrednost od 2792,7 tona godišnje. Dalja analiza pokazuje da je otpad od pamuka najzastupljeniji sa 46,4%, sledi otpad od veštačkih i sintetičkih vlakana sa 41,4%. Za istraživački period (2015-2020 godine), na godišnjem nivou stvara se (u proseku) 1,42 kg pre-potrošačkog tekstilnog otpada po stanovniku, koji je čist i sa zadržanim fizičkim i mehaničkim svojstvima.

**Ključne reči:** kvantitet, kvalitet, pre-potrošački otpad, krojni otpad.