Analysis of textile waste streams for regional planning: the Lombardy region case study

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Abstract

Textile waste management is becoming a topic of great interest, because of the high environmental impacts of the textile industry and because of the spreading of business models that encourage a short service life of textile products, especially of garments [1]. These aspects of high concern brought the European Commission to adopt the “EU Strategy for Sustainable and Circular Textiles” [2] and to develop new policies. The Waste Framework Directive [3] establishes the mandatory separate collection of textiles as a fraction of the municipal waste by 2025 for Member States. In addition, the institution of Extended Producer Responsibility (EPR) schemes for textile products is proposed [4]. The amount of textile waste that will be collected and that will need a proper management is going to increase in the following years. For this reason, the quantification and the mapping of this waste stream are very important to plan efficient waste management system addressed to textiles.
Different researches proposed case studies about textile waste management, investigating different scenarios of separate collection, reuse and recycling rates [5, 6] or focusing on the composition of the textile waste [7, 8]. The quantification of textile waste streams through a material flow analysis can be the first step to assess the environmental impacts of textile waste management in a life cycle perspective [9].
Previous studies are mainly focused only on one type of textile waste stream, usually the municipal textile waste separately collected. The goal of the present work is to give a picture of all the textile waste streams at a regional scale. To this purpose, Lombardy (Italy) was identified as case study. First, the methodology adopted for the data elaboration is explained. Then, different analyses are carried out to understand which are the main characteristics of the current textile waste management system in Lombardy in order to support future policies. In the end, future research pathways are suggested.
The first step is the selection, through a screening of the European list of waste [10], of the types of textile waste to include in the analysis. In the present work, pre-consumer, post-consumer and textiles from the mechanical treatment of waste were considered, as summarised in Table 1.

Table 1 – Textile waste streams considered in the analyses.

Type of textile waste	Waste description and code according to the European list of waste
Pre-consumer textile waste	Waste from unprocessed textile fibres (04 02 21) Waste from processed textile fibres (04 02 22)
Post-consumer textile waste	Clothes from separate collection (20 01 10) Textile products from separate collection (20 01 11)
Textiles from waste treatments	Textiles from the mechanical treatment of waste (19 12 08)

The analysis was carried out with data referred to year 2021.
For each type of textile waste, several data were provided by ARPA Lombardia (the Regional

Environmental Agency), in particular: (i) the amount of waste produced with the list of producers; (ii) the amount of waste collected by waste transporters and received by the treatment plants; (iii) the amount of waste that each waste producer or treatment plant sent to other plants; (iv) the amount of waste treated by each receiving plant. To avoid the double counting of waste streams, the data referred only to transport operations were not considered. For each treatment plant, the amount of textile waste received, sent to other plants, and addressed to recovery or disposal was identified. For each treatment plant, the mass balance was verified. The sum of the quantities was calculated in order to obtain the total streams for each type of textile waste analysed.

The waste in input to the plants was split between “primary flow” (waste received from primary producers) and “secondary flow” (waste received from other plants). The primary flow was then split according to the geographical origin of the waste producer. Similarly, the waste stream sent outside the plants was split according to the location of the receiving subject. In addition, the waste generated in Lombardy and directly sent outside the region by waste producers was considered. The different treatment operations were defined according to [11] and grouped in four categories: (i) disposal; (ii) energy recovery; (iii) material recovery; (iv) preliminary operations or storage. The sum of the amount addressed to these operations is the total of the waste treated.

The results of the waste flows for the three different types of textile waste are summarised in Figure 1. The amount of pre-consumer and post-consumer textile waste received in input by plants in Lombardy resulted quite similar (35.1 kt and 38.5 kt respectively), while textiles from waste treatment were lower (10.5 kt). 70% of the total pre-consumer textile waste comes from Lombardy, while for the post-consumer waste this share is higher (87%). For textiles from waste treatment, instead, 55% came from other Italian regions. For post-consumer textile waste, the amount of waste sent outside the regional boundaries was very relevant (30.6 kt, corresponding to 73% of the total post-consumer waste), while for the other two types of textile waste almost all the waste in input was treated by the plants in Lombardy.

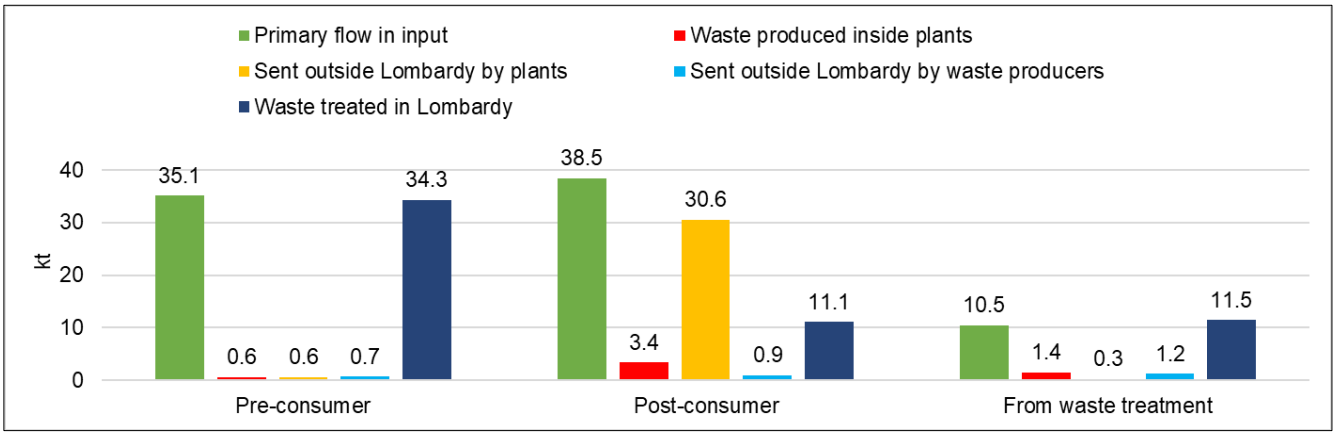

Figure 1 – Waste flows for each type of textile waste.

Among the waste treatment operations, 48%, 82% and 28% of the treated waste was addressed to material recovery respectively for pre-consumer waste, post-consumer waste and textile waste from previous treatments. Preliminary operations or storage covered an important share of the treatment operations (51%, 17% and 39% respectively for the three waste categories). Only for textiles from previous waste treatment the energy recovery was relevant (33%). To gather information about the material recovery processes, some interviews to the main textile waste management companies of the region have been carried out. For post-consumer textile waste, about 70% of the material recovery consists in the preparation for reuse (sanitization, sorting and sale on the global second-hand market),

and around 30% consists in recycling (mainly downcycling to produce industrial wipes, insulation or filler materials). About the pre-consumer textile waste, the recovery processes consist in a sorting step, where impurities are removed, and bales of homogeneous composition are obtained. The bales can be directly sold to downstream customers or sent to an unraveling process, where the textile fibres are opened in order to mechanically recycle them.
After the definition of the textile waste streams in Lombardy, different analyses about the number of the plants and about their size were carried out (Table 2). In total, in Lombardy in 2021, 180 subjects declared to manage the textile waste streams considered in this work. 79% of these subjects treated only one type of the aforementioned textile waste streams, 18% managed two types of textile waste, 3% treated three of them. Most of the plants treated pre-consumer waste, as can be seen in Table 2.
The plants were classified into classes according to the amount of managed waste (0-100 t, 100-300 t, 300-500 t, 500-1000 t, > 1000 t). For all three types of textile waste, most of the plants were in the first class, with less than 100 t managed in 2021 (Table 2).
In order to consider the size, the plants were ordered decreasingly according to the amount of waste managed. Then, the number of plants that contributed to at least 50% of the total waste managed was identified. This indicator was called N50. The share between N50 and the total number of plants is reported in Table 2. The low values of this share for all the waste types confirms that in Lombardy there are few plants that contribute to manage most of the waste. For instance, for post-consumer textile waste, only 6% of the plants treated half of the total waste in input to the plants of the region.

Table 2 – Number and size of the plants for each type of waste. The % of plants on the total is shown for each size class. With N50 is indicated the number of plants that contributed to reach 50% of the total waste, after that the plants were ordered in decreasing order according to the amount of waste managed.

Type of textile waste	N° of plants	0-100 t (%)	100-300 t (%)	300-500 t (%)	500-1000 t (%)	> 1000 t (%)	N50 / N tot (%)
Pre-consumer	132	55%	19%	9%	11%	6%	8%
Post-consumer	72	67%	6%	4%	8%	15%	6%
Textile from waste treatment	20	45%	10%	25%	5%	15%	10%

In the end, the textile waste composition was estimated. Since pre-consumer textile waste comes from the manufacturing processes of textile fibres, its composition was estimated from data about the Italian textile industry production in 2021 [12]. The composition of post-consumer textile waste was assumed from the literature [13]. The third type of waste (textiles from mechanical treatment of waste) is likely to come from previous operations on other textile waste streams. To verify this hypothesis, a screening about the sources of this type of waste in Lombardy was carried out. It was found that 79% of the textiles from waste treatment came from plants managing other types of textile waste streams (94% from pre-consumer and 6% from post-consumer). The remaining 21% was assumed to have unknown composition, because there were no data to support any assumption about this. So, the composition of the last type of textile waste was calculated as a weighted average of the previous two. Based on these assumptions, the composition of the different waste streams resulted as represented in Figure 2. Synthetic fibres are an important fraction for all the three types of waste streams (29% of pre-consumer, 24% of post-consumer and 23% of textiles from waste treatment). Cotton covers a more important share in post-consumer textiles (26%) than in the other two streams. Blended fibres are mainly present in post-consumer textiles (29%), where the presence also of non-textile materials (11%), such as buttons or zippers, is not negligible. A large part of pre-consumer waste and of textiles from waste treatment has still an unknown composition. The assumptions about the waste composition should be validated in

future works with direct investigation and samplings of the waste in input to the plants.

Future developments of this work are the investigation of the various disposal or recovery processes in Lombardy, with the collection of data about the specific processes. Subsequently, the Life cycle assessment methodology could be used to estimate the environmental benefits and burdens of the regional textile waste management system.

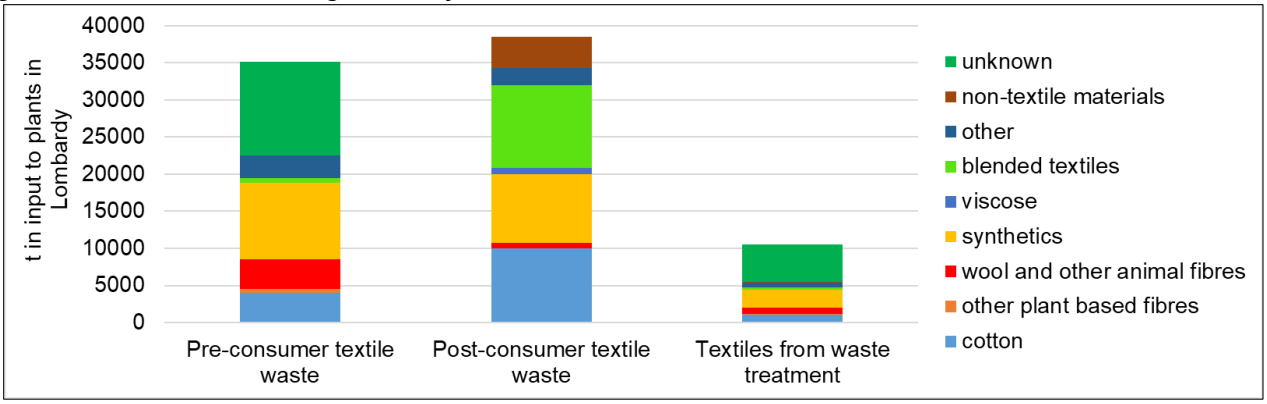

Figure 2 - Composition of the three different textile waste streams.

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