Development and testing of a sorting and quality assessment method for textile waste

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ABSTRACT

Due to the high resource consumption and environmental impacts of textile production, better handling of discarded materials has a great environmental improvement potential. A uniform definition of textile waste and a stringent sorting procedure is a precondition for thorough investigations of discarded textiles. A review of waste sorting studies showed that only a few included textiles, and mainly considered content and not quality. A lack of definition and quality assessment causes a high risk of mistakes when assessing the potential of textile waste prevention. This study establishes a method for sorting and quality assessment of textiles in household waste, validated through dialogue with professional textile sorting centres. It also suggests a minimum waste sample size. The quality assessment is based on analysis of product types, manufacturing methods, fibre composition and a product condition assessment based on 17 criteria. The developed method was applied in a case study and compared with other sorting methods. It showed that 61% of the clothing in residual waste and 83% in small combustibles and that 78% of the household textiles in residual waste and 85% in small combustibles was reusable or recyclable. The comparison with existing methods showed that sorted quantities varied significantly when different sorting methods were applied even when the sorting was done on the same sample. This study suggests a new standard for defining and assessing categories and qualities of used textiles, adapted to real contemporary sorting technologies, and tested on waste samples.

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1. Introduction

The textile sector is one of the most polluting industries in the world. In the EU alone, clothing and household textiles are the fourth most polluting products, seen from a lifecycle perspective (Beton et al., 2014). Globally, 3% of all greenhouse gas emissions are caused by the production and use of textiles (Laitala et al., 2012). Textile production is connected to major environmental costs in terms of the consumption of energy, water, chemicals and nutrients, as well as increased impacts on land areas in connection with cotton cultivation (WRAP, 2012). In Denmark and Sweden, the consumption of clothing and household textiles has increased, respectively, by 62% (2003–2008) and 40% (the period 2004–2014) (Tojo et al., 2012; Palm et al., 2014). In general, the consumption of textiles is rising, not only because of an increase in the population, but also because increased prosperity has also meant that countries such as China are beginning to approach European and American levels in this regard (Bartle, 2010).

Despite the large environmental impact of textiles, textile waste has only within the recent years started being governed as a part of the waste area (Danish EPA, 2012). Therefore, there is a need to investigate how textiles are handled in the best possible way in environmental terms within the waste sector. Textiles presumably constitute a smaller waste fraction, but the potential contribution to climate change from production is very high per weight unit (Palm, 2011), which means that the potential for environmental improvement is also high, even if in small quantities. This environmental improvement potential can be realised by ensuring that textiles are collected, reused, recycled and disposed of in the best possible way (Farrant et al., 2010). Only few studies were found that have included textiles waste and in most cases only quantities of disposed textiles were considered (e.g. Hedeman et al., 2006; Saidan et al., 2016; Wagland et al., 2012). Knowledge about the quality of the disposed textiles is thus very limited, though it is crucial in order to assess whether textile materials can be reused, recycled or actually treated as waste. Merely two Swedish studies and one Norwegian study have examined their quality in terms of

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residual waste and small combustibles. The Swedish studies showed that 59% and 61% of the textiles could be reused, and in the Norwegian study this figure was 28% (Avfall Sverige, 2013; Hultén et al., 2016; Laitala et al., 2012).

Quality is determined by the condition of the individual product, how it has been produced and fibre composition. Furthermore, quality depends on whether materials are assessed in relation to their use in the investigating country or whether they are sorted and dispatched to the international market – and at what sorting centre they are separated. Therefore, it is essential to know the basis of the quality assessment. Particularly for lower quality clothing and household textiles, sorting centres' marketing approaches vary, which is essential for whether items will be reused, recycled or regarded as waste. What can be reused or recycled changes over time, which contributes further to the need to know the criteria for quality assessment. These criteria are also crucial for the development of collection systems and recycling technologies, so the separation of textiles from the waste must be carried out with this in mind.

Still, the majority of existing sorting guidelines for household waste only cover textiles as a fraction, i.e. without definition or consideration of their applicability, and deficient definitions make it unclear what the textile fraction includes (e.g. Nordtest, 1995; ASTM, 2003, 2008). Moreover, the use of the textile quantities in additional analyses becomes complicated and it is impossible to compare sorted quantities across studies. In the few guidelines and methods found that contain any form of quality assessment criteria are simplified to an extent that makes it difficult to assess their objectivity (e.g. Avfall Norge, 2015; Avfall Sverige, 2013; Hultén et al., 2016). When sampling small waste amounts, it is very important that the results are presented not only by weight, as a single heavy product can constitute a large proportion of a category and thus give a distorted impression of differences in terms of quality.

Thus the overall purpose of this study is to develop and test a method for studying the quantities and quality of textiles in household waste, in order to reduce the amount of items disposed of alongside general household waste. The specific objectives are to: (i) define what constitutes textile fraction and quality, (ii) develop a quality assessment that includes product type, manufacturing method and fibre composition, (iii) test and evaluate the method in a specific waste sorting campaign, and finally (v) compare the results by using methods described in the literature. This study showed that the lack of a clear definition, sorting method and quality assessment presents a high risk of errors when assessing amounts and potential of improving the separate collection of textiles in the waste. This study provides such new definitions and methods tested on waste samples.

2. Materials and methods

2.1. Definition of textile fraction and quality

2.1.1. Definition of the textile fraction

The textile definition shown in Table 1 is based on EU Nomenclature Chapters 61–63 and is applied through sorting campaigns and dialogue with professional textile sorting centres (Appendix A, Table A1). Hereby, a functional definition that enables data collection (quantities and quality) for use in mass flow analysis, environmental assessments and other analysis work has been

Table 1
Overview of the definition of textile fractions in residual waste, divided into three sub-fractions: Clothing, Household textiles and Other textiles. The 'Other textiles' fraction contains all textile products that are not included in the other two fractions.

Clothing	Household textiles	Other textiles
25 product types:	13 product types:	Types of products included: duvets, shoes, belts, toys, yarn hats, caps, flags, bean bags, cushions, textile pieces and parts of soft furniture (couch cushions or couch cover)
1. T-shirts	1. Linens	
2. Tops	2. Decoration pillowcases	Belts, shoes and bags made of leather are also included
3. Blouses	3. Bedcovers	
4. Shirts	4. Curtains	Product types not included:
5. Trousers	5. Towels	• Carpets with underlay
6. Shorts	6. Dishtowels	• Upholstery, if not for the entire couch, box mattresses or armchairs
7. Winter clothing (with and without insulation)	7. Facecloths	• Any kind of obvious production waste, e.g. fibres, balls of cotton
8. Dresses	8. Potholders	• Any kind of disposable personal hygiene products, disposable diapers as well as disposable napkins, table cloths and gloves
9. Skirts	9. Rags	
10. Vests	10. Tablecloths	
11. Jackets	11. Place mats	
12. Infants' clothes, incl. socks & gloves	12. Plaids	
13. Workwear	13. Pieces of household textiles	
14. Apron	Household textiles matching the listed products made in leather are also included	
15. Swimwear	Home-made products are included as well	
16. Underwear		
17. Nightwear		
18. Bathrobes		
19. Socks		
20. Gloves		
21. Scarfs & ties		
22. Handkerchiefs		
23. Costumes		
24. Parts of clothing		
25. Pieces of clothing		
Clothing matching the listed products made in leather is also included		
Home-made products are included as well		