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Environmental impact of Recover cotton in textile industry

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ABSTRACT

A comparative evaluation of the life cycle assessment (LCA) of Recover cotton, obtained from recycled garments, and virgin one, cultivated from traditional and organic crops, has been made based on the quantification of environmental impact categories, such as abiotic depletion, global warming, water use, acidification and eutrophication potential. LCA data reported in the literature for the steps of cultivation, ginning/cutting, and dyeing were compared in order to clearly show the environmental advantages of moving from traditional practices, to organic cultivation and the use of Recover cotton, a novel procedure that involves the production of cotton yarns from coloured and well characterized recycled materials. Studies made evidenced that the use of organic cotton cultivation avoids the use of pesticides and chemicals, reducing environmental impacts, but maintaining those related to ginning and dyeing steps. However, the use of Recover cotton avoids the impact of both, cotton cultivation and dyeing steps, based on an appropriate selection of raw materials obtained from textile wastes, being only increased the energy costs of cutting/shredding processes as compared to ginning ones. In short, it can be concluded that the use of Recover cotton for the production of high quality textiles involves an added value of the products from an environmental point of view, being costs and electrical consumes also reduced and providing a second life for produced textiles.

1. Introduction

Cotton is the most consumed natural fibre in textile and clothing industry, with a worldwide production of 24.5 million tonnes in 2013. Cotton crops are distributed around the world principally in dry areas where other commodities grow on with difficulties. China (26.4%), India (20.5%), USA (13.9%), Pakistan (8.5%), Brazil (6.3%), Uzbekistan (4.1%), Australia (3.8%), and Turkey (3.3%) are the main producers of cotton lint (FAOSTAT, 2016). The environmental impacts associated to cotton production and yarn spinning are heterogeneous and complex, even in numerous cases there is no data available in the literature. Previous studies shown that water consumption, land occupation, emissions, and usage of chemicals are the most critical aspects to be evaluated during the cotton production step (PE International, 2014a; Baydar et al., 2015).

Cotton cultivation requires huge amounts of water, including green water, which arises from precipitation, but also blue water, from artificial irrigation, which is estimated as a 73% of the production. Actually, a 2.6% global water use is consumed in the production of cotton and it reduces freshwater reserves causing drought problems in the cultivation areas and a general damage of the water environment (Chapagain et al., 2006). The average fraction of total damage attributable to water consumption for cotton production is 17%; however, the irrigation requirements for cotton production significantly differ with the country, being from <1% for Brazil, to 77% for Egypt (Pfister et al., 2009)

The impacts of spinning and textile production, including weaving, cutting, and sewing, are noticeably elevated, considering the high amounts of electricity required, which considerably increases CO_2 emissions and acidification potential (GHK, 2006). However, the environmental impact of the aforementioned steps is relatively low as compared with cotton dyeing, one of the most contaminant parts in the whole textile process. It involves the use of big amounts of energy, water, steam, and assorted chemicals like bleaching agents, dyes, wetting agents, soap, softener, and salts, in order to obtain the required colour (Yuan et al., 2013; Roos et al., 2015). Moreover, high amounts of wastewater are generated in dyeing plants with deleterious effects to the environment (Roos et al., 2015), causing contamination of continental waters which is especially important concerning toxic dyes (Zhang et al., 2015).

In the last decades, several initiatives have been developed to reduce the negative impacts of cotton production. In such a frame, the cultivation following organic farming practices avoids the use of fertilizers, herbicides, and insecticides (PE International, 2014a).

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The total pesticide consumption involved in the cotton cultivation is estimated as an 11% of the world consumption, being around 50% in developing countries. So, the practice of organic agriculture strategies allows to drastically reduce the use of chemicals and the deleterious environmental impacts related to acidification and eutrophication potentials (Bevilacqua et al., 2014).

A novel Recover strategy has been recently developed for the production of cotton yarns from recycled materials (HIFESA, 2016). In this strategy, cotton growing is avoided, reducing the consumption of water, fertilizers and pesticides. Moreover, dyeing steps is neither required because the final colour of cotton fibre is related to the colour of the raw materials; thus, the use of water, dyes, wetting agents, softener, and any other related products is also avoided. The use of Recover technology avoids all the environmental impacts related to the cotton cultivation and dyeing of yarns, while as counterpart it involves the addition of a cutting/shredding step of recycled clothes previous to the spinning step, which have similarities with conventional ginning process. The ginning process of cotton consists of the separation of lint, seeds, and other plant residues, and it can be done by different ways, from manual to mechanised techniques which usually include high energetic steps, like drying, cleaning and pressing (Bajaj and Sharma, 2012).

Life-cycle assessment (LCA) is an useful methodology, regulated by the ISO 14040:1996 and ISO 14044:2006 (ISO, 1997, 2006), employed for the assessing of potential environmental impacts associated with a product by the evaluation of relevant inputs and outputs throughout it product life, from production and acquisition of raw materials, industrial treatment, and final disposal. LCA data are commonly provided by consultancy companies or research institutes, and there is little peer-reviewed literature available on this topic. An LCA study has been carried out for textiles made by different materials as polyester, nylon, acryl, and elastane, being cotton the fibre with a higher impact on the environment (van der Velden et al., 2014). The worldwide cultivation of cotton creates important troubles for a correct evaluation of LCA, because its cultivation is a complex system, due to the high dependence to environmental conditions at different regions, but also due to differences within a year, and from year to year. Thus, global impacts of cotton cultivation are difficult to be estimated due to the high variability of each specific cotton crop. Nevertheless, several studies have been published for the LCA of cotton from different perspectives, focused in a specific part of the whole process, such as: growing, spinning, weaving, dyeing, etc. Impact of cotton cultivation, under conventional and organic agriculture, has been exhaustively evaluated using LCA (Babu and Selvadass, 2013a; PE International, 2014a; Baydar et al., 2015), as well as different dyeing and finishing process (Babu and Selvadass, 2013b; Yuan et al., 2013). In spite of that, there are scarce LCA studies about the reuse/recycling of clothing waste (Woolridge et al., 2006; Morley et al., 2006), and in our knowledge, there are not reported LCA studies based on the use of recovered cotton for the industrial production of cotton yarn.

The main objective of this study has been the evaluation of the environmental impact of cotton yarn production from Recover cotton, being compared the obtained LCA data from a specific plant in Spain with those obtained from the published literature about the production of cotton yarn obtained from virgin cotton produced through conventional cultivation and organic agriculture.

2. Methods

2.1. Recover cotton procedure

As an example of cotton yarn production from recovered fibres, the process in use in a plant located in Spain was used to evaluate the LCA of this system and to compare the obtained data with those published in the literature for cotton yarn obtained from virgin cotton.

Hilaturas Ferre (Banyeres de Mariola, Spain) is a family business since 1914 dedicated to cover the entire production process from spinning to weaving at full industrial scale, with 24300 m^2 of facilities, and more than 140 employees (HIFESA, 2016). A new generation of Upcycled Textile System has been recently designed by Hilaturas Ferre for the production of high quality cotton yarn from recycled materials well classified by their colour. A summary with the main steps involved in the production of Recover cotton fibres is shown in Fig. 1. In this strategy, pre-consumer textile clips are mainly collected and carefully sorted according to their quality and colour as a raw material from different textile plants from all around the world. Small amounts of post-consumer garments

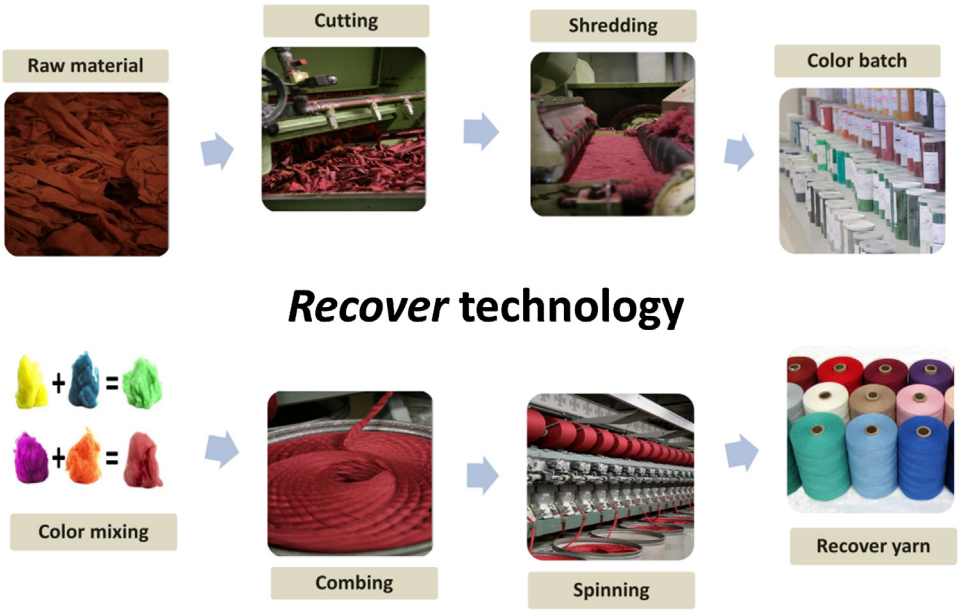

Fig. 1. Main steps involved in the production of Recover cotton fibres.