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Environmental analysis of different end of life scenarios of tires textile fibers

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Abstract

End-of-Life Tires (ELT) are one of the main source of waste in End of Life Vehicles (ELVs). Textile fibers represent about 10% in weight of the ELT and every year, in Europe, about 320,000 tons of dirty fibrous material must be disposed as special waste. Studies show that the fibrous material can be used in second life applications, reducing the environmental impacts of tires disposal, but none of these researches quantitatively evaluate the achievable benefits. This study presents a comparative evaluation of the environmental impacts of the tires considering different scenarios for the end of life of the textile fibers material.

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Keywords: " End of life tires; environmental impact; second application."

1. Introduction

About 9 million end-of-life vehicles (ELV) for year are recycled in the EU countries, and even if this value has strongly increased after 2000, yet approximately 15% of ELV materials are still considered waste and generally goes to landfills. Currently only thirteen Member States over 27 met the 85% target of ELV materials re-use/recovery while the European environmental legislation on this matter [1] requires the reduction of this waste to a maximum of 5% by January 2015. To reach this ambitious goal, all the sector operators (producers, distributors, dismantlers, etc.) must be committed and are encouraged to improve: a) the treatment of end-of-life vehicles, b) the development of methods for re-using, recycling and recovering end-of-life vehicles and their components, c) sustainable circular economic models for recovery and recycling of ELV waste.

End-of-Life Tires (ELT) are one of the main source of waste in ELVs. The global tire output is estimated in 1.5 billion units/year and subsequently just as many will fall into the category of ELTs. In Europe, today the amount of ELT that needs to be processed is 2.6 million tons/year, 95% of which may go for recovery of reusable material (39%) or energy recovery (37%) [2,3,4]

In Italy every year about 35 million tires (400,000 tons) from cars, two-wheelers, trucks, industrial agricultural vehicles, arrive at the end of their life; around 20,000 tons still finish to landfill [5].

Over the last 20 years recovery rates for ELT have dramatically increased in Europe mainly thanks to Extended Producer Responsibility (EPR) schemes that are one of the main economic instruments to implement the waste hierarchy (COM(2011) 571). At the same time the cost of recycling to the consumer has decreased due to advent of better recovery approaches and technologies.

ELT may be source of several valuable secondary raw materials. The output of the treatment process of ELT is shredded material of various sizes and types, depending on the intended uses: rubber chips or granules (70%), steel fibres (5-30%) and textile fiber (up to 15%). Unlike rubber and steel that are currently being reused in various application fields, textiles represent a special waste (CER code 19.12.08) to be disposed. In 2013, approximately 60% of dirty fibrous material collected by Ecopneus was sent to energy recovery in

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furnaces for the production of cement, 25% was used as fuel for electricity production while the remaining 15% is destined for disposal in landfills [3].

Textile fibers represent about 10% by weight of the end-of-life tires (ELT) and every year, in Europe, about 320,000 tons of dirty fibrous material must be disposed as special waste. This results in negative impacts on the environment, in terms of GHG emissions and pollution, economic losses and public costs.

This study presents a comparative evaluation of the environmental impacts of the tires considering different scenarios for the end of life of the textile fiber material. In particular it has been demonstrated that it's possible use the fibrous material and the related changes in the disposing process of tires.

2. Context of research

In Italy the law defines the legal framework and assigns the responsibility to the producers (tire manufacturers and importers) to organize the management chain of ELT. The crucial steps are collection, sorting, transformation and recovery in authorized treatment companies. The treatment and the recovery process of ELT is primarily aimed at recovering of triturated rubber in various sizes and types, which represents the main portion of the ELT material. During the treatment of tires, other two sub-products are generated in significant quantities, namely steel and textile fibers.

In recent years, progresses in the recovery of ELT have been done; currently the main markets for recycling are energy recovery (as fuel in the cement kiln) and the recovery of as secondary raw material. One of the sectors in which recycled rubber is mostly exploited is civil engineering [6]: modified asphalt mixtures; additives for concrete; lightweight fillers in infrastructure; safety barriers, bumpers, artificial reefs, etc. Currently steel fibers from waste tires are sent to electric arc furnaces where it is used as secondary raw material by melting or to replace anthracite and coke as reducing elements of metal oxides. However, growing the interest towards sustainable building in smart cities, some studies have shown affordable use of steel fibers from waste tires as reinforcement in concrete [7].

As regards the recovery of textile fibers, the main problem for recycling is the contamination of rubber that does not allow to obtain a pure product, economically and qualitatively usable. This cleaning practice is not usually adopted because there is not yet a market that justifies the effort and resources required for that. Moreover, there is a lack of available information on the characteristics of the textile fiber that composes the ELT that does not allow to identify suitable sectors for reuse. The main consequence is that both ELT treatment companies and end-users are discouraged to invest in fibers recycling; thus, the dirty fiber is landfilled or goes for thermal utilization (waste incineration plants or cement production furnaces). Even in the scientific literature, it is hard to find information about the possible reuse of ELT fibers. In 2000-2001, Bignozzi and co-workers published some research papers on the use of ELT fibers for modified mortars [8, 9]. The fibers, mainly consisting of a blend of polyester, rayon and nylon fibers, have yielded positive results by improving the mechanical properties of the mortar, but the solution did not achieve market success due to economic reasons. Czvikovszky [10] investigated the use of waste textile fibers as reinforcing material for polypropylene (PP) used in the production of car bumpers. Even in this case the fibers have given positive results giving the modified PP a greater resistance to bending, increasing the modulus of elasticity and acceptable impact strength compared to conventional PP. Those works are the basis of further R&D activities that have been carried out by Steca and his coworkers in the past few years. The evolution of processing technologies, know-how and innovative ideas allowed to overcome all the major drawbacks and to pave the way for ELT fibers recycling.

Fiber modified compounds can create a huge added-value for plastic producers. The mixing of ELT fibers may require only partial modifications to existing extruders and so minor investments that will be soon recovered by higher profitability; in fact, the value of items can be higher because of their greater mechanical strength and durability. This makes the modified compound of considerable technical-economical interest for manufacturing of a wide range of plastic products, such as: carters, automotive components, containers, pallets and so on.

The value of roads and infrastructures realized with the new modified asphalts will be much higher because of longer lifetime (we can estimate a life time of the pavement of about 6-7 years compared to 5-6 current). Besides, the better performance makes the new conglomerates applicable to very different climatic conditions and therefore ensures a wider market and replication across the EU. The new asphalt will be extremely appealing for construction companies for their mechanical properties and will tremendously reduce the public procurement costs of roads and infrastructures rehabilitation and maintenance.

3. Used tires characteristics and valorization

The article shows how reducing the landfill material is possible to reduce the impacts of the end of life tire (ELT). It is therefore necessary to define how to use the waste material in the second raw material, demonstrating the sustainable reuse of recycled fibers in two promising applications: reinforced plastic compounds and bituminous mix for new asphalts. In both cases the use of recycled ELT fibres will reduce the pressure on primary raw materials and enhance the use of alternative compounds. This will reduce the overall GHG emissions, pollutants and environmental pressure due to land occupation and extraction of non-renewable raw materials. Enhancing ELT materials recycling and promoting economically affordable models will also help to stimulate the ongoing ELT recovery market, will prevent further illegal dumping and will encourage the reclamation of existing stocks. Through the use of Life Cycle Assessment, methodology it is possible assess the impacts of a product (in this case of ELT) during the entire the life cycle, from cradle to grave[11]. Results of recently conducted LCA studies