Boussu, J Fashion Technol Textile Eng 2021, 9:6

Journal of Fashion Technology & Textile Engineering

Short Communication

A SCITECHNOL JOURNAL

Textile Industry: Transition to a Circular Economy Model

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Abstract

Fabrics are an essential and integral part of all human activities. They are not only used for clothing purposes but also used for bed linen, towels, upholstery, curtains, etc. Off late the specialized fabrics are also being used for reinforcement of constructions and structures. Due to increased demand for various types of fabrics for diverse applications, synthetic and chemically derived fabrics are also being produced in quantities amounting to millions of metric tons all across the world.

Introduction

In the past two decades, the demand and sales of clothing have almost doubled. This trend is continuing and the global consumption of apparel is projected to increase by nearly forty million tons in the coming decade with a concomitant increase in the by-product and waste generation. As a result of textile manufacture, packaging and usage, wastage amounting to millions of tons is being generated annually all across the world [1]. Moreover, there is a reduction in the frequency of garment wearing and an increase in the rate of discarding of the used apparel and textiles and this is mainly happening due to fast-evolving fashion sense, rapid changes in the style quotients and low pricing of production. It has been previously estimated that only 18% of the total clothing mass is reused and recycled while substantially high quantity amounting to 57% is being discarded into the landfills. Another study estimated that the global fiber production is 53 million tons out of which only 12 % is recycled and the rest is discarded [2].

The disposal of the solid wastage generated from textiles has become a major environmental concern. It was estimated that nearly twenty percent of the Earth's pollution is attributed to the textile industry. Several repercussions and consequences are arising out of the disposal of textile discard [3]. The disposal of synthetic textiles leads to the release of microplastics into the environment which is not biodegradable and could be ingested by the aquatic fauna, enter the human food chain and pollute the ecosystem. These discards pose health hazards to humans and cause abiotic stress to the agricultural ecosystems. These textile-generated pollutants, due to their unique physicochemical properties such as large surface-to-volume ratio and chemical configuration, can adsorb other pollutants and pathogenic organisms and transfer them to various trophic levels in the ecosystem [4]. The indiscriminate usage of industrial harmful toxic chemicals during the manufacture of synthetic fabrics are released into the environment polluting the freshwater and land ecosystems. The water pollution caused by textile manufacture effluents results in high Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD). The CO_2 and N_2O that are produced during textile manufacture are associated with greenhouse gas emissions causing global warming. Additionally NOX, SOX and particulate dust are also generated from the textile industry which adds to the air pollution [5]. Textile waste also releases gaseous forms of pollutants such as CO_2, methane and ammonia. Per every ton of textile production, seventeen tons of carbon-di-oxide are generated. Nearly 1200 million tons of CO_2 equivalent greenhouse gases are produced annually.

In the circular economy model, the textile waste can be utilized for the derivation of useful products and utilities for not only the generation of the economy but also safe diversion reducing the adverse environmental impact. This forms a circulation of textile products and materials [6]. Circular economy functions on concepts of reuse, resell, recycle, sharing and rental services. A circular economy also limits resource exploitation and development of innovative technologies and supplementary business models thus increasing employment and revenue generation.

New technologies are being developed to make textile wastage biodegradable. The crystallinity, hydrophobicity and the steric effects of the side groups in the textile polymer backbone could be designed in such a way that the textile becomes accessible to the cleaving enzymes and moisture such that they are rendered biodegradable and the final monomers are assimilated by the degrading microbe [7]. The oligomers and the monomers assimilated within the microbes are then converted into CO_2 and H_2O in the aerobic organism and CO_2, CH_4, and H_2O in anaerobic organisms. This results in greater mineralization that is environmentally beneficial. Recently smart wall insulation materials were developed from waste textiles and were found to be resistant to damage. Heavy metals accumulated in the textile sludge are far beyond the permissible limit set and pollutes the environment. The development of intelligent wall insulation materials from waste textiles can play a key role in civil engineering and health monitoring [8]. This technology yields strong materials nearly 10% higher when compared to other materials. Textile sludge ash is being used as an additive and substitutive ingredient in concrete and cement-based constructions, blocks, and bricks. Nowadays it is being recommended for the increased usage of the synthetic fibers as fillers and in the compounding of the polymers in concrete matrices for reinforcement. In addition to this, there are several applications of textile discards such as stabilization of soil erosion, mechanical cleaners, air filtration, soundproofing, liquid filtration in the chemical industry as chemical catalysts and in protective clothing. To reduce the environmental pollution from synthetic textiles, it is now recommended to opt for natural fibers such as hemp, jute, sisal and cotton and their usage in blending into polymers and production of biodegradable products.

The textile industry is a significant contributor to the economy of a nation due to potential export opportunities, employment generation, foreign exchange. However, this also leads to resource depletion, environmental pollution, and greenhouse gas emissions. Therefore, a circular economy model is preferable in the textile industry for overall sustainability and development, recycling of resources, saving and safe ecosystems [9]. Recently the environmental dimension

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Received: June 11, 2021 **Accepted:** June 26, 2021 **Published:** July 02, 2021

research in the textile industry had been given adequate importance and standardized for implementation as a policy. Policies need to be developed taking into account the economic and social perspectives, cost analysis, employee welfare and safety. There is more focus on the investigation and validation of social and economic indicators in textile industries. Therefore transitioning from linear to a circular economy in textile business models requires substantial changes at both production and consumption levels.

The reuse and recycling of the textile material, fabric recycling, fiber recycling, monomer and polymer recycling and energy recovery could not be widely implemented due to technical constraints, complex separation procedures, low quality of the desired output, supply chain limitations, high-cost involvement, low collection volume, inefficient sorting of the grades and transportation. Ensuring the complete processing of textile wastes into socially useful materials and products is the emerging challenge in the textile industry. This will help to eliminate the adverse impact on the environment and save precious environmental resources with the maximum economic outcome [10]. To achieve this adoption of digital technologies in the textile industry is very important as this allows streamlining the processes of production, operation, disposal and processing of products. Technologies for mechanization and automation of waste sorting, removal of metals and zippers from clothing reduces the volume of textile waste that goes into landfills and may help reduce the adverse impact on the environment.

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